The role of artifacts as scaffolds in competency-based, ICT-supported learning environments

A design-oriented, explorative case study in higher education

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Introduction and central concepts

This paper reports the results from the first iteration of a design-based research project carried out in the context of competency-based, ICT-supported, higher professional education. According to The Design-Based Research Collective (2003), design-based research 'must lead to sharable theories that help communicate relevant implications to practitioners and other educational designers'. This 'desire to increase the relevance of research' is also acknowledged in a recent book edited by van den Akker, Gravemeijer, McKenney and Nieveen (2006, in press). As a first step towards these shareable theories, an explorative case study is carried out.

The research described in this paper takes place in the context of higher education. Dutch higher education is undergoing a transformation: there is a shift going on in Dutch higher education from traditional, teacher centred education to student centred learning activities. The trend is to structure these activities in real-life tasks, projects or case situations in which Information and Communication Technology (ICT) is integrated (van Weert and Pilot, 2003)'. The above shift, though not necessarily accompanied by ICT, is in higher education primarily represented by competency-based education. Competency-based education is relatively new. Schlusmans, Slotman, Nagtegaal and Kinkhorst (1999) indicate that competency-based learning has taken off since 1996. Since the rise of competency-based learning, it has been defined many times, here a general definition will be used: 'a competency should at least be interpreted as a combination of knowledge, skills and attitudes' (Boon & Van der Klink (2001) in Onderwijsraad, 2002). Competency-based education aims to develop the competencies a professional will need in his/her future profession in a systematic way.

In compentency-based education, students are working on real-life tasks, projects or case situations, with the intention to reach results that are comparable to results which may be expected from junior professionals in the professional practice in question. There is a fit between the underlying ideas of competency-based education and the learning outcomes as described by Simons, van der Linden and Duffy (2000) in relation with the concept of 'new learning', namely outcomes that are durable, flexible, functional, meaningful, generalizable and application-oriented. They relate these characteristics to the more knowledge oriented learning outcomes. They also state that new learning asks for new kinds of learning outcomes, like collaboration- and regulation-skills. Ten Cate, Snell, Mann and Vermunt (2004) make a similar distinction, they distinguish the cognitive component of the learning process (content) and the metacognitive component (how). Simons et al. are of the opinion that learning process-oriented skills, like for example collaboration and regulation-skills, should be integrated with the process of learning domain-specific aspects, and call this 'process-oriented instruction'. This type of instruction is indeed the intention of the real-life tasks, projects and case situations from competency-based education as mentioned above.

While working on the above tasks, projects or cases, students are learning: their learning process is intertwined with the work process. Since we are mostly dealing with complex tasks, which require collaborative effort, we arrive at a dilemma. To be able to reach the expected professional results, students need collaboration- and regulation-skills, but these skills are also the intended learning outcomes. So students need to be able to collaborate and regulate to work on complex tasks, but at the same time that is what they are supposed to learn. Or in terms of Simons et al (2000): learning to collaborate and learning from collaboration, which can be extended towards regulation, learning to regulate and regulate to learn.

When students are ineffective in collaborating on and regulating real-life tasks, projects or cases, this effects the intertwined learning process. On the one hand, these effects are positive: struggling with difficulties and overcoming them, constitute part of the learning that takes place in competency-based education. However, there are also adverse effects. When overcoming difficulties regarding collaboration and regulation are outside their zone of proximal development, that is outside the area in

which students are challenged to learn (retrieved from Wikipedia), they will not advance in the working process, nor in the intertwined learning process.

To overcome the above dilemma, within educational theory and practice there is the useful notion of 'scaffolding'. Pea (2004) suggests a framework for defining scaffolding, which deals with the what, why and how of scaffolding. With respect to the what and why Pea follows Wood et al. (1976) and defines scaffolding situations as those in which a learner gets support to perform a task beyond his/her own reach if pursued independently. Simons et al. (2000) indirectly refer to scaffolding by stating that 'the more learning, thinking and regulation skills the learner acquires, the more freedom he gets to regulate his own learning and thinking'.

Suitable scaffolding will help students to enter their zones of proximal development. It lightens the burden of overcoming problems related to collaboration and regulation, and thus frees up space for working and learning the more domain-specific matters. However, we are walking a tightrope here. Strijbos, Martens and Jochems (2004) formulate a related matter as followed: 'An unresolved issue is when, how and what kind of pre-structuring is used to support interaction. Too much structure may result in 'forced' artificial interaction, but no structure at all may result in fragmented interaction or a situation where interaction could be seen as an optional activity instead of an essential process'.

The last central concept of this research is ICT-support. In current competency-based education, ICT-support is increasingly used to support students while working and learning on the real-life tasks, projects or case situations. Simons (submitted) identifies seven promising ways to use ICT in vocational education, which are based on seven basic principles on which digital pedagogy can be built (Simons, 2002). Three of these principles are relevant here, namely: (1) ICT can support the process of 'creation'; (2) ICT can make thinking, learning and collaboration processes more visible and (3) Through ICT it becomes possible to increase the flexibility of learning, learning that is independent of time and place.

(Potential) objects of design

In the previous section, the context and central concepts of this explorative case study were introduced. In this section, the design perspective that is taken in this case study will be discussed.

Since the case study is carried out from a design-oriented perspective, it is necessary to specify which potential objects of design are within the focus of this research. This necessity is part of the broad definition of design research which can be found in the introduction of van den Akker et al (2006): 'a series of approaches, with the intent of producing new theories, artifacts, and practices that account for and potentially impact learning and teaching in naturalistic settings' (*underlining for emphasis in this context*). The following three notions are discussed at this point:

1. Curriculum representations (van den Akker, 2003)
2. Collaboration and regulation activities
3. Artifacts.

Curriculum representations

The first notion is introduced to specify *where* the objects of design can potentially be designed, perceived and used. Van den Akker (2003) has outlined 'some basic notions on curriculum and curriculum development' and presents us with a typology of curriculum representations (*see table 1*). In this typology, the representations which are considered relevant here are made **bold**. The concept of the 'curriculum' is interpreted here as a single, well-defined module or learning unit.

Intended	Ideal	Vision (rationale or basic philosophy underlying a curriculum)
	Formal/Written	**Intentions as specified in curriculum documents and/or materials**
Implemented	**Perceived**	**Curriculum as interpreted by users (especially teachers)**
	Operational	**Actual process of teaching and learning (also: curriculum-in-action)**
Attained	Experiential	Learning experiences as perceived by learners
	Learned	Resulting learning outcomes of learners

Table 1: Typology of curriculum representations (van den Akker, 2003)

The objects of design in this context are potentially designed and offered on the level of the intended, formal/written curriculum. In this context, an important part of the formal/written curriculum is the set-up and support of the ICT-support in question. The objects of design will potentially be perceived by users at the level of the perceived curriculum. Van den Akker emphasizes the role of the teachers. However, competency-based education is student-centred in nature, therefore in this context the curriculum as interpreted by the students is considered as equally important. Additionally, the perspective of the student is taken as the focus in this research. The objects of design will potentially be used at the level of the operational curriculum by students in the working process, with which their learning process is intertwined. The following remarks deal with the other curriculum representations. The underlying principles of competency-based learning and 'new learning' as described before, represent the 'ideal curriculum'. The attained curriculum, both the experiental and the learned, are used to add depth to the observations which will be made from the formal/written, perceived and operational perspective.

Goodyear, Avgeriou, Baggetun, Bartoluzzi, Retalis, Ronteltap and Rusman (2004) make similar distinctions as van den Akker and also make a direct relation between designing a learning environments and the concept of artifacts which will be introduced below: 'we should try to create a supportive 'space' of well-designed tools and artefacts, while recognizing that students will configure their own personal 'learnplace' in ways we cannot predict'.

Collaboration and regulation activities

The second notion is introduced to specify *in which type of activities* the objects of design can potentially play a role. The focus of this research is on collaborative and regulative activities which are necessary to coordinate the process of working on real-life tasks, projects or case situations. In the previous section, process-oriented skills (Simons et al., 2000) and meta-cognitive components of the learning process (ten Cate et al., 2004) were introduced. Additionally, we turn to theory from the field of computer-supported cooperative/collaborative work (CSCW), where similar processes have been studied for quite a while. Schmidt and Bannon (1992), Schmidt (2000) and Schmidt and Wagner (2004) use the term 'coordinative practices' through which workers' coordinate, align and integrate their various individual activities'. Schmidt and Wagner also state that artifacts play a crucial role in coordinative practices; the artifact is the next notion that will be introduced.

Artifacts

And last but not least, the objects of design themselves, namely 'artifacts'. Though it should be noted that the intended final results of this research, in which this case study is a first step, are strictly speaking not the artifacts as described below. The intended final results are *shareable theories about these artifacts*.

There is much literature about this concept. For example Norman (1991) uses the term 'cognitive artifacts' which he uses for artifacts which affect our cognitive performance and make us smarter and faster. When dealing with artifacts that involve writing, there are others that write about the effect on cognitive processes, like Emig (1983) who is of the opinion that writing serves learning in a unique

way since 'information from the process is immediately and visibly available as that portion of the product already written'. She thinks that the importance of such a familiar and available medium which makes it possible to re-scan and review cannot be overstated. Smith (1994) describes how artifacts undergo transformations and undergo different states while groups collaborate. He distinguishes intangible information (both in a private and a shared form), which can be transformed into tangible information, sometimes via an intermediary ephemeral state. Both in the ephemeral state and the tangible state, there are artifacts, though ephemeral products are destroyed or lost in the process. In the tangible state, there are two types of artifacts: target products, that represent successful completion of the group's task, and instrumental products that support the group's work. Wenger (1998) characterizes artifacts also with social aspects, stating that although artifacts can appear self-contained objects, we should not overlook that they are in fact nexus of perspectives. He considers artifacts as boundary objects, not only designed for use, but also for participation. Others like Sellen & Harper (2002) and Schmidt & Wagner (2002) also follow this notion.

For this research a theory-based approach is combined with a pragmatic approach. For the theoretical foundation, ideas from Wenger, Sellen & Harper and Schmidt & Wagner as mentioned above will be followed. An addition, the digital didactical principles from Simons (2002 & submitted) come into play. The artifacts potentially offer support in the process working on real-life tasks, projects or cases, with which the learning process is intertwined, and are therefore considered as 'scaffolds'. Consequently, from a pragmatic, design-oriented perspective, it is convenient to take only the physical artifacts into account. Besides, artifacts have a very promising relation with ICT, since they can for example be disseminated, created, shared, annotated, saved for future reference and so on, with the help of ICT-support. Moreover, the ICT-support itself is considered as an artifact. The following type of artifacts, or more precisely shareable theories about this type of artifacts, are considered as the potential objects of design in this research:
Artifacts with a physical form, which are designed to be perceived and used, to support coordinative practices while working on real-life tasks, projects or cases in competency-based, ICT-supported higher education.

In this case study, an exploration of the above described artifacts is made. The focus of this exploration is to analyse the artifacts within the context of the task they are designed for and used in. The aim is to make a typology of the above artifacts, which will be made from a design-perspective.

Method

In this section the research method will be described. A mixed-method approach was taken, which is quite usual in design-based research (DBR). We found when conducting design-based research, one is faced with many challenges, as the Design-based Research Collective (2003) also observes. We decided that we would not sweep the methodological challenges and necessary compromises that were made, under the proverbial rug, they will be dealt with below.

Design-based research, case study or contextual inquiry?
The research described in this paper started out as the first iteration in a design-based research project. However, compromises had to be made. The intent of DBR is to "investigate the possibilities for educational improvement by bringing about new forms of learning in order to study them" (Cobb, Confrey, diSessa, Lehrer and Shauble, 2003). However, during the early stages of development of the educational setting, the object of study in this research, it turned out that from a 'pure' DBR perspective, the influence on the intervention was inadequate. The design process continued in the iterative fashion usual to DBR, but went off in a direction independent of the original research purposes. At that moment it was decided to regard the educational setting which would be developed, as the context for carrying out case study research. Yin (1989) defines a case study as 'an empirical inquiry that investigates a contemporary phenomenon within a real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used'.

It should be noted that McKenney, Nieveen and van den Akker (2004) take a more balanced approach towards the above matters. They would regard this case study as an 'analysis cycle' in design research, which is conducted to 'understand how to target a design' and 'primarily features assessment of harmony (or discord) between the aforementioned intended, implemented and attained curriculum'.

For deciding which techniques to use for this case study or analysis cycle, we turned to the domain of Human-Computer Interaction (HCI), which has a longstanding research tradition with regard to designing. A common method in the early stages of design, which is the phase this research in when seen as part of the overall research-project, is contextual inquiry. According to Beyer and Holtzblatt (1993) 'contextual inquiry provides techniques to get data from users in context: while they work at real tasks in their workplace'.

Context of the case study
The research is carried out in an educational setting which is developed and implemented as a pilot which precedes possible wider implementation. The educational setting consists of 9 weeks of education: 6 weeks of blended education (face-to-face education blended with ICT-supported education) and 3 weeks ICT-supported education (without face-to-face education).

The educational setting is designed to involve students from four different programs of two different educational institutes. The following four programs and two institutes take part: Physiotherapy (9 students), Speech Therapy (3 students) and Nursing (5 students) of a College of Higher Professional Education (Hogeschool Utrecht) and the Medical program SUMMA of the University Medical Center Utrecht School of Medical Sciences (16 students). Since the participating students are educated towards four different professions, a multiprofessional educational setting is created. In total, 33 students participated. They are divided into three tutor-groups. A tutor from each of the educational programs is involved (4 tutors).

The educational setting is based on competency-based educational principles. In this competency-based setting, the professional products and services the students are asked to work on, were for example making multiprofessional treatment plans and conducting multiprofessional meetings about stroke-patients, which require a multiprofessional approach.

Programs involved	Physiotherapy, Nursing, Speech Therapy and Medicine
Institutes involved	College of Higher Professional Education (Hogeschool Utrecht) University Medical Center Utrecht School of Medical Sciences
Type of education	Blended: mix of face-to-face and ICT-supported education
Type of professional results	Professional results like making multiprofessional treatment plans and conducting multiprofessional meetings about stroke patients
Number of students	33 students
Number of weeks	6 weeks blended, 3 weeks ICT-supported

Table 2: Summary of the context

Data collection
To explore artifacts in a physical form which are designed, perceived or used to support coordinative practices from a design-perspective, the following data was collected. An overview is given below, including the relation with the curriculum representations.

Data		**Curriculum**
Educational material	All educational material both paper and digital, including the set-up of the CSCL-environment	Formal/written
Observations (audio + photos + notes)	Organized face-to-face meetings (20 hours): 3 weeks tutor-group 1 (phase 1) 3 weeks tutor-group 3 (phase 2)	Perceived Operational

Student material (paper)	Individual and group material from 1 student from each participating program (4), from each tutor-group (3) → 12 students in total	Perceived Operational
Monitoring the CSCL-environment	Monitoring the use of the CSCL-environment and collecting the material (9 weeks)	Perceived Operational
Interviews	Semi-structured, individual interviews with the 12 students Semi-structured, individual interviews with 1 tutor from each participating program (4)	Perceived Operational Experiental Learned
Evaluation Questionnaires	Evaluative questionnaires, partly relevant for the research purposes described in this article (30)	Experiental

Table 3: Summary of the collected data

The face-to-face meetings which are organized as part of the education, therefore excluding meetings which students organized on their own initiative, were observed. The education can be divided into two phases: during the first phase only the students from the College of Higher Professional Education participated, during the second phase the Medical students joined in. During the first phase one tutor-group was observed, during the second phase another tutor-group was observed (2 tutor-groups in total). During these observations notes and photos were taken and audio recordings were made. From each tutor-group, students from each program (3 tutor-groups*4 programs = 12 students in total) were asked to hand in all the individual and group material made during the education like notes, flip-overs, meeting minutes and meeting reports.

During the whole education students were supported by ICT: standard e-mail facilities and a CSCL-environment (Synergeia[1] with standard functionality like document sharing and an electronic discussion board). All material which was placed in the CSCL-environment was also collected. Besides, the above students were asked to forward e-mails which they sent to each other.

After the six weeks of blended education, semi-structured interviews were conducted with the above students. Also, semi-structured interviews were carried out with the participating tutors, one tutor from each program.

Besides, all participating students were asked to fill in evaluative questionnaires. It should be noted that this questionnaires were not specifically designed for the research purposes as described in this article, but to evaluate the educational setting on behalf of the subsidizer.

Data analysis

In this section, the analysis of the data and the results of the analysis will be described. The analysis at this stage of the research consisted of the following main steps:

Step 1. Make an overview of the real-life (sub)tasks students were asked to carry out.
Step 2. Identify and describe physical artifacts which potentially support coordinative practices from the different curriculum perspectives.
Step 3. Make a preliminary typology of the artifacts in question.

The above analysis is founded in theory and concepts of 'task analysis'. Task analysis is quite common in the HCI-domain, but the significance is also recognized in the educational or instructional design-domain: 'in order to design instruction that will support learning, it is essential that we understand the nature of the tasks that learners will be performing' (Jonassen, Tessmer & Hannum, 1999). The analyses which are carried out here start with a global tasks analysis (step 1). Consequently, the focus is on the role of the artifacts within the context of these tasks (step 2). On the basis of these two analyses, a preliminary typology of the artifacts in question is made.

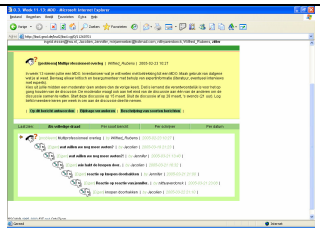
[1] for more information about Synergeia see http://bscl.gmd.de/

The above three steps constitute the 'contextual inquiry' as mentioned before, and will be described below, including illustrative examples of the first two steps (*examples 1, 2a, 2b and 2c*).

Step 1: Overview (sub)tasks
For step 1, gain an overview of the educational setting in question, a general analysis of all the real-life (sub)tasks was made. For each week a separate overview was created. Each (sub)task was identified and described on the basis of the formal/written educational material. For each (sub)task an expressive photo or screenshot from the operational curriculum was added. Below are two, sequential examples of (sub)tasks.

1. Example from the overview of (sub)tasks

Task description:	Brainstorm on multiprofessional meetings (MP Meetings)
Intended outcome(s):	Inventory of what, why, how etc. of MP meetings
Mono/Multi:	Monoprofessional
ICT/F2F:	ICT
Type of interaction:	Group
Type of guidance:	Student as facilitator
Previous task(s):	Find info on mp meetings
Following task(s):	Carry out mp meeting
Mediating artefact(s):	Electronic brainstorm
Task description:	Carry out mp meeting (role-play)
Intended outcome(s):	Competencies regarding MP Meetings Sufficient input for MP plan
Mono/Multi:	Multiprofessional
ICT/F2F:	F2F
Type of interaction:	Many-to-many (small group)
Type of guidance:	Tutor-guided
Previous task(s):	Brainstorm mp meetings Preparation of professional role Analysis case
Following task(s):	Reflection report Second mp meeting
Mediating artefact(s):	Personal notes Group preparation (if available)



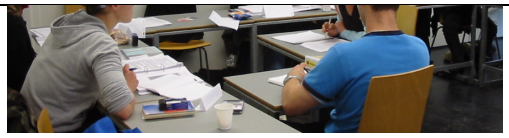


Table 4: example of global tasks analysis (step 1)

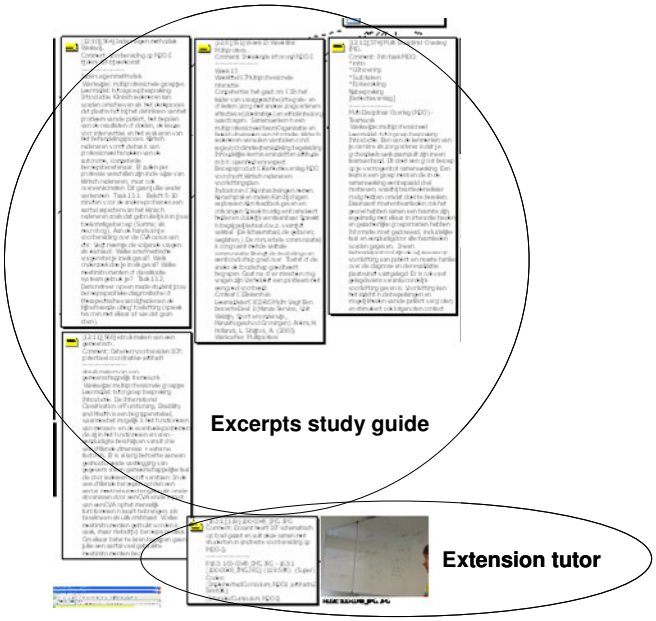
On the basis of this global analysis, a selection of (sub)tasks was made to study in detail. The selection was based on the following criteria:
- authenticity: (sub)tasks which are closest to the professional practice in question.
- (sub)tasks which represent a more or less complete sequence of steps when compared to the professional practice in question.

On the basis of the above criteria, two sequences were considered as suitable, namely all relevant (sub)tasks regarding a multiprofessional meeting (MP meeting) which should lead to a multiprofessional plan for the patient in question. Hereafter called MP meeting I and II (MP-I and MP-II). For the next steps, MP-I was studied in detail.

Step 2: Identify and describe physical artifacts which potentially support coordinative practices
For step 2, the identification and description of the physical artifacts which are presumed to support coordinative practices, three separate analyses were made:
1. Analysis of the physical artifacts at the formal/written curriculum-level, extended where necessary with substantial additions or alterations from the tutors at the perceived curriculum-level.
2. Analysis of the physical artifacts of the face-to-face meetings at the perceived (by students) and operational curriculum level.

3. Analysis of the physical artifacts in the CSCL-environment at the perceived (by students) and the operational curriculum level. It should be noted that 'in' is interpreted in the broadest sense here, it could for example be artifacts which are created in, printed out from, shared in, discussed in etc.

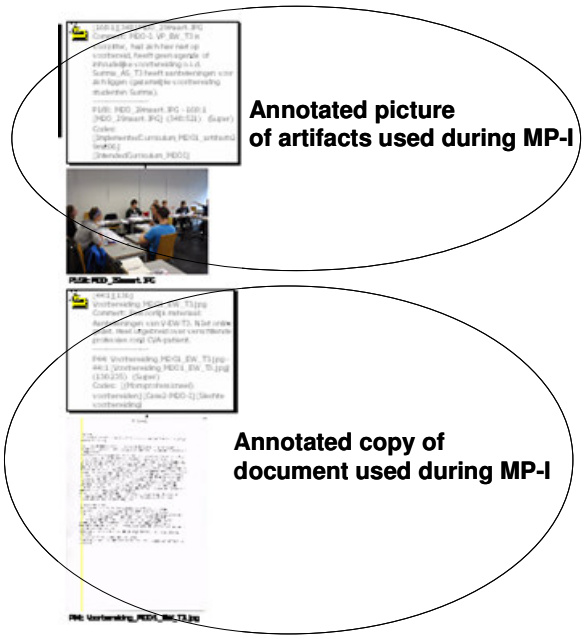
2a. Example from the analysis for identifying physical artifacts from the 'intended-formal/written curriculum', extended with the 'implemented curriculum as perceived by tutors'



On this example (*which is only illustrative!*) a part of the analysis which was made at this level is shown. Shown are 4 excerpts of the formal study guide of this educational setting. These excerpts all deal with the (sub)tasks of MP-I and are ordered sequentially in the analysis (from left to right). Also, an annotated picture is shown. This annotated picture is added because the tutor in question made a noteworthy extension to what was intended in the study guide. When there is no picture, this means the (sub)task in question was carried out essentially as intended.
This analysis was carried out to see which kind of artifacts are designed or chosen on the level of the formal/written curriculum to support the (sub)tasks of MP-I.

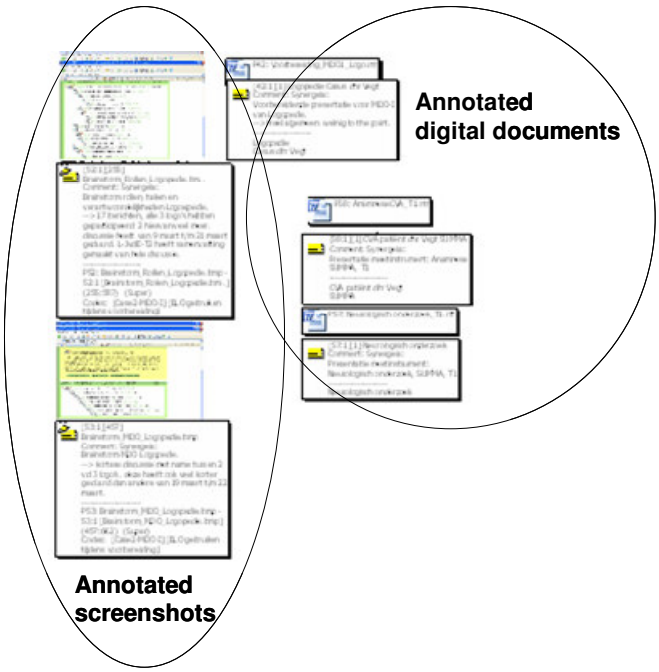
It should be noted, that for the above analysis, only the physical artifact which could potentially support coordinative practices from students working on the real-life task in question, like a study guide or a scheme on a whiteboard or an instruction in the CSLC-environment, were taken into account. The annotations were made on the basis of the observations (audio-recordings) and the interviews with students and tutors. This last remark also applies to the next two analyses.

2b. Example from the analysis for identifying physical artifacts from the face-to-face meetings of the 'implemented curriculum as perceived by students' and the 'implemented-operational curriculum'



On this example (*which is only illustrative!*) a part of the analysis which was made at this level is shown. Shown are an annotated picture on which artifacts are photographed which are used during MP-I and an annotated scan of copy of a document which was used during MP-I.
This analysis was made to see how students perceive and use artifacts which are designed or chosen, and which artifacts they create on their own initiative (during or for face-to-face meetings); within the context of the (sub)tasks of MP-I.

2c. Example from the analysis for identifying physical artifacts from the CSCL-environment of the 'implemented curriculum as perceived by students' and the 'implemented-operational curriculum'



On this example (*which is only illustrative!*) a part of the analysis which was made at this level is shown. Shown are annotated screenshots from electronic brainstorm-sessions in the CSCL-environment and annotated digital documents which were shared in the CSCL-environment.
This analysis was made to see how students perceive and use artifacts which are designed or chosen, and which artifacts they create on their own initiative (digital artifacts).); within the context of the (sub)tasks of MP-I.

Results and conclusions

Step 3: Make a preliminary typology of the artifacts which potentially support coordinative practices

For step 3, a preliminary typology was made, on the basis of the analyses as described in the previous section (*see table 5*). This typology has two main perspectives. On the one hand, the intended, formal written curriculum extended with the implemented curriculum as perceived by teachers. Hereafter this will be regarded as the intended curriculum by the educational program and/or the teachers in question. On the other hand, there is the implemented curriculum as perceived by the students and the learning part of the operational curriculum, hereafter referred to as the curriculum-in-action by students. In this generalisation, the direct interaction between teachers and students during the implemented curriculum, though highly relevant, is intentionally taken out of the focus of this research.

This typology is mainly made from a design-perspective. Or in other words, which classification will help when we want design such artifacts and capture systematic design guidance about them (the 'shareable theories').

The typology consists of two main parts: types for the curriculum as intended by the educational program and the teachers involved, and types for the curriculum-in-action (by students). On the intended-level, there are two types of artifacts: (1) Conditional artifacts with a physical form which are designed to specify the conditions students are expected to work in, and (2) Instrumental artifacts with a physical form which are designed and/or chosen to support the work itself. On the in-action by students-level, three types are distinguished: artifacts with a physical form which students perceive and use on the one hand, or create/chose on the other hand, (1) as input, (2) to support the throughput or (3) as output of the work process in question.

Intended curriculum (by educational program/teachers)	***Conditional artifacts***	Artifacts which help to define the boundary conditions of the working process.
	Ready-to-use artifacts/DIY-artifacts	
	Instrumental artifacts	Artifacts which help with the working process itself. There are different types, e.g.: template artifacts, sequencing artifacts, analytical artifacts, criteria artifacts and process artifacts. They can either be ready-to-use or they are more do-it-yourself in character and need effort from students before they are usable.
Curriculum-in-action (by students)	***Private/Shared/Collaborative***	
	input artifacts	Artifacts which are used as input for the working process, these are like the raw material or semi-manufactured products. which are needed to start working.
	throughput artifacts	Artifacts which are used to support the work process, but which are not results or output.
	output artifacts	Artifacts which can be considered as the output of the work process.

Table 5: Preliminary typology of artifacts

Now the above typology will be explained and examples will be given.

Conditional artifacts: this type of artifact is designed and offered to students to specify the boundary conditions of the working process. This type of artifact is closely related to terms like 'assignment' or 'task'. This type of artifact can take many forms like for example a study guide, an instruction in a CSCL-environment, the opening statement in an electronic brainstorm, the folder-structure in a CSCL-environment or an explanatory e-mail from a teacher. This type of artifact also deals with the structure or the planning in phases of the task, project or case in question. Conditional artifacts have to be very clear and above all consistent with each other, when these type of artifacts are not user-friendly or when they contradict each other, the boundaries start blurring and this will effect the working process. Conditional artifacts help with structuring and defining the space students have to work in.

Instrumental artifacts: these types of artifact are designed or chosen for students to be helpful in the actual working process. These type of artifacts can help to make learning environments more life-like, since many of these artifacts are the same or similar to artifacts which are used in the professional practice in question. When designing or choosing instrumental artifacts, this process can be considered as aiming for contextualization, which is according to Simons et al. (2000) a characteristic of good learning, provided that there is the right balance with deconxtualization.

The ready-to-use artifacts are situated on one end of the scale, while do-it-your self (DIY) artifacts are on the other end of the scale. When artifacts are DIY it means that students need to put in effort before they are ready to use. Instrumental artifacts can be classified at a next level, like template artifacts, sequencing artifacts, analytical artifacts, criteria artifacts and process artifacts. Further descriptions and examples are given below.

Template artifacts help students with envisioning (intermediary) results in the form of templates of these (intermediary) results of a working process. An example from the context of this case study is an outline of a multiprofessional treatment plan.

Analytical artifacts help with analysing or modelling during a working process. An example from the context of this case study is the ICF-framework (International Classification of Functioning, Disability and Health), the international standard to describe and measure health and disability.

Sequencing artifacts help students with determining in which order they have to carry out (sub)steps in the working process. An example from the context of this case is a presentation by an expert from the field about the process from intake, to diagnosis, treatment, till discharging a stroke-patient. It should be noted that these type of artifacts are those which help students to sequence their work within the structure or phases which are defined in the conditional artifacts.

Criteria artifacts help students with determining whether their (intermediary) results or activities have the required level of quality. An example from the context of this case study is a checklist for effective decision making in a team which aims to reach consensus.

Process artifacts are all kinds of artifacts which help students to manage the process of working. An example from the context of this case study is an example agenda of a multiprofessional meeting in the healthcare domain.

Input/Throughput/Output artifacts: these types are distinguished to help to compare whether the artifacts as described above are used as intended in the working process of students. Also, these types will help with identifying artifacts which are not based on the above described artifacts, but are chosen or created by students on their own initiative. The other characteristic which is considered relevant here is whether an artifact is private, shared with others or collaborative (chosen or created in collaboration with others). In the perception and use of the artifacts, students seem to act on artifacts in different ways. For example some instrumental artifacts elicit 'follow the recipe to the letter' behaviour from students, while others help students to think for themselves. Some seem to have a more convergent character, while others seem to support the more creative, divergent processes.

Discussion and future research

From the above described results of the preliminary typology and conclusions, many questions arise, like for example the following.

Conditional artifacts define the space students are expected to work (and learn) in, in this sense they are restrictive in nature. Instrumental artifacts can be less restrictive in nature. Could a right balance between conditional and instrumental artifacts contribute to balancing on the tightrope as referred to earlier, of pre-structuring to support interaction vs. too much structure?

Other, related questions can be posed, however, the main question in this research is: How can the typology and the accompanying thick, qualitative descriptions which are made, be developed into more structured design guidance?

The research described in this paper is considered as the first iteration of a design-based research project or in the terms of van den Akker et al (2004) an 'analysis cycle'. The preliminary typology as described above needs to be validated and elaborated on, which will contribute towards sharpening the above questions and answering them partly. A series of case studies or consequent 'analysis cycles' will take place. On the basis of the next iteration or cycles, what van den Akker et al. call 'prototyping stages' and (formative) evaluations are planned to take place.

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