Co-operative ICT-supported learning

A practical approach to design

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Abstract: Education is changing, following changes in society. The focus is shifting from teaching towards learning. And Informatics, more particularly Information and Communication Technology (ICT), is integral part of that learning. How to design effective learning situations? And how to design in such a way that the educational process of change is successful? Results are presented from an action research project in the Netherlands and a working party of the International Federation for Information Processing.

1 Changes in society and in education

In the society of developed countries the demand for educated personnel is increasing because of a more knowledge intensive economy. In the Netherlands, for example, in 2003 a shortage of 200.000 higher educated workers is expected [SE99] developing into an expected shortage of 400.000 in 2007.

These much needed "knowledge workers" are expected to be able to apply knowledge in real life working situations in which Information and Communication Technology (ICT) plays an important role. Their capabilities are not restricted to applying knowledge from a specific discipline that they have studied, but extend towards other "competences" such as working in a team and problem solving. Here the word `competence` is used with the broad interpretation that is common in the British tradition. In Europe over the last years the interest for "competences" has been steadily increasing [Re99], [Sc00].

Functions and jobs are not for life, but change. Also the shortage on the job market is such that students enter employment before they have graduated, while older employees re-enter the job market and need updating of qualifications. Life long learning therefore is becoming more and more important [LD96], [OE00a]. In fact, learning in many instances is combined with working [OE00b].

Businesses go international and education is following this trend [Ca00], [EU00]. In Europe internationalisation of education is stimulated by the Bologna declaration which initiates a new, Europe wide structure of Bachelor and Master Degrees [EU99]. Educational institutions are entering into international networks. Not only do international competitors appear on the educational market, also other suppliers than the traditional institutions are trying to get their share of this market [Ha00].

The growing competition and the changing demands from society put pressure on educational institutions to change their traditional way of working. Because of this pressure a shift can be observed from traditional teaching to more constructivist types of educational situations: the focus is shifting from teaching to learning.

2 Focus is shifting from teaching to learning

Society demands new "competences" from its workers, whether these are designers, researchers, advisors, etc. There is pressure on education to allow students to develop these "competences" during their study, both in initial study and in life long learning. The traditional "know what" of graduates is not sufficient any more, it should be enhanced with "know how", "know why" and "care why" [McD00]. Teaching of subject content only addresses the "know what". To also develop other "competencies" students should work on typical professional tasks in a realistic setting. In this way students may learn the "know how", the "know why" and learn to "care why", all of them "competences" needed for functioning effectively in a fast changing professional environment [DLW93], [McC00]. It is clear that Informatics, or more particularly ICT, plays an important role in these realistic settings, not only as a tool empowering the individual, but also as a tool empowering working in teams.

How to design effective learning situations? This question was central in the action research project 'Task based team learning with ICT' (1999 – 2001), jointly executed by the University of Utrecht (IVLOS) and the Professional University of Utrecht (Cetis), and sponsored by the Dutch national initiative SURF Educatie<F>. In this project students in either full-time or part-time studies are seen as junior-professionals developing their career. This approach ties in with developments in life long learning where the students are professionals who want to extend their "competences". A range of learning situations was identified building one upon the other that would allow students to develop all required competencies. Characteristic of the learning situations is that these are realistic mirrors of professional situations graduates will encounter when starting there working life. Teamwork is integral part of these learning situations.

Typology of learning situations:

Assignment based: the student/professional functions in a reproductive role in which standard problems are recognised and solved in a standard way; the student/professional assesses way of working and result against standards.

Task based: the student/professional functions in an executive role in which typical, task related problems are solved using task oriented methods; the stu-

dent/professional assesses method selection, way of working and result against standards.

Problem based: the student/professional functions in a tactical role in which non-standard problems are solved using adapted methods; specifications for the result have to be developed; the student/professional assesses specifications, method selection, application, way of working and result against standards.

Situation based: the student/professional functions in a context determined, strategic role in which worth-while problems have to be identified, just as suitable methods for solving; the student/professional assesses selection of problem and methods, application, way of working and results against standards.

In most learning situations team work is implemented to enhance learning.
Characteristics of these typical learning situations are summed up in Table 1.

Let us examine two of these typical learning situations in more detail: Task based learning and Situation based learning.

Learning situation	Student responsible for	Available to student	Way of working	Student role	McDuffy
Assignment based	Execution Assessment	Problem Result standard Standard method Assessment standard	Prescribed	Reproductive	What Know
Task based	Method Execution Assessment	Problem Result standard Method meta-standard Assessment standard	Adapted	Executive	How Know
Problem based	Result Method Execution Assessment	Problem Result meta-standard Method meta-standard Assessment standard	Dependent on problem and context	Tactical	Why Know
Situation based	Problem Result Method Execution Assessment	Problem meta-standard Result meta-standard Method meta-standard Assessment standard	Dependent on situation	Strategic	Why Care

Table 1. Characteristics of typical learning situations

2.1 Task based team learning

The project 'Task based team learning with ICT' offers learning environments in which students will work on a task (in relation to a profession or a function) co-operating with other students in a team to produce the requested result. ICT plays an important role in this, both as professional tool and as communication tool. Task based team learning has three dimensions: task, team learning and ICT.

Task
In their educational career students work on tasks that have an evident relationship with the profession or the function in which the student will work after completion of the study. In the project 'Task based team learning with ICT' students are either educated as medical doctors (University of Utrecht) or as economic or business professionals (Professional University of Utrecht). Task based learning implies a functional approach to education and educational development. Tasks are modelled after professional tasks and belong to a profession, a function or a distinct problem area. In some disciplines this will be easier to achieve than in others, but the idea is that the activities of the professional, be it a general practitioner in medicine, a physics researcher or a business process advisor, are central in the educational design.

Task oriented learning puts activities, productivity and creativity of students in the forefront, with a lot of room for student initiative. This didactic approach is linked with the constructivist and social-constructivist insights on effective and efficient learning, based on student motivation. The aim of task oriented learning is to facilitate development of capabilities of the student in a task domain.

Team learning
Team based learning is closely connected with the constructivist approach of learning. Students work together on a complex professional task, and in different roles. These roles are related to the content of the task. A choice of which role to play is depend on the capabilities of the student and on what capabilities the student wants to develop.

Co-operation of students in groups will not necessarily be effective. Johnson and Johnson differentiate the following levels of effectiveness [JJ94]:

- *Pseudo group*: there is no incentive for co-operation, group members do not help each other, but work to create disturbances and misunderstandings; the group result is less than the sum of the potential results of the group members.
- *Traditional group*: group members are in principle willing to co-operate, but do not see much gain in this co-operation; the work will be structured in such a way that most things can be done individually; members only feel responsible for their own part of the group work, but will share information on how task can be undertaken. the group result is more or less the sum of the potential results of the group members.
- *Co-operative group (team)*: group members work to attain a common goal and to maximise own and collective success of high quality; social competencies are developed and applied, effectiveness of group and group members is analysed and re-

medial actions are undertaken; the group result is more than the sum of the potential results of the group members.

- *High performance group:* this is a co-operative group in which members have great commitment to both their own personal development and that of others, and also have great fun working in the group.

Effectiveness of co-operation in groups can typically be enhanced by the following measures [JJ94]:

(1) Arrange for high quality, face-to-face interactions,
(2) Arrange for positive dependency of group members on each other so that they can experience the positive effects of peer explanation and peer support; arrange for decisions to be taken by the group (not by the teacher coach) on the basis of consensus.
(3) Arrange for individual responsibility within a group context; each member of the group should be responsible for own performance and for the performance of the group as a whole.
(4) Let students develop competencies for co-operation through meaningful group tasks, positive feedback and decision making on the basis of consensus.
(5) Let students monitor their own and the groups work; without monitoring the group cannot be sure that it is performing well.

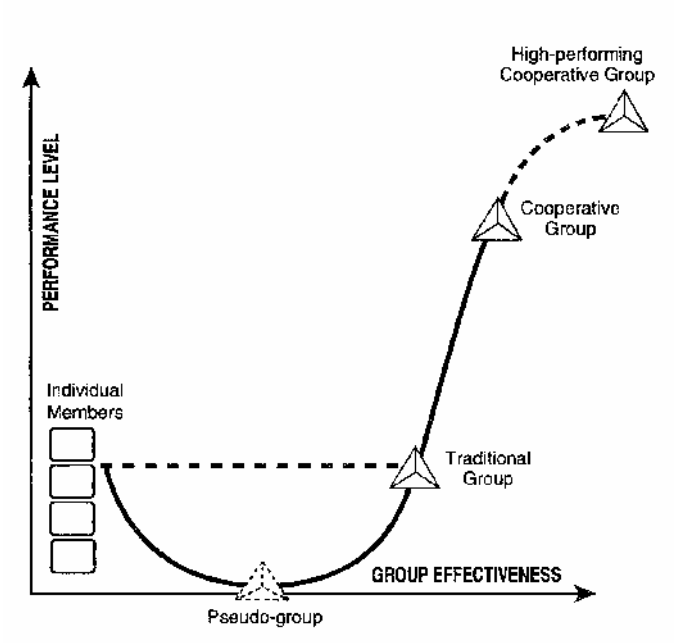

Figure 1. Group Performance Curve [JJ94]

ICT
Task based and team based learning are impossible without ICT. Performance of tasks in normal professional life depends on ICT tools. In performing their task students will use the same ICT-tools as the professional: generic tools (Office Suite, Webbrowser, etc.), but also discipline specific tools that are used in professional practice. Team based learning has to be supported by groupware tools.

In task based learning it is essential that use of ICT is a necessity for effective performance. If students perceive use of ICT as forced, both in task performance and in team support, they will work around using it. Design of task based team learning situations should take account of this.

2.2 Situation based team learning

In situation based learning students are placed in a real business or organisational environment where they are expected to identify and solve problems as these appear in reality (situation based learning). Such a situation based learning environment may be referred to as a Virtual Company or virtual organisation. In its purest form a Virtual Company is a learning student organisation, an organisation in which both the knowledge of the workers (students) and the knowledge of the company will be developed. A Virtual Company is a realistic business setting in which students play different roles, based on reality.

Virtual Company
Aim of the Virtual Company is to offer students a realistic setting for working and learning. Realistic means that students can identify themselves with specific, recognisable roles from business reality. The Virtual Company is a didactic concept. One of the important characteristics of the virtual company is authenticity. The ideal starting point is a factual business assignment that allows professional competencies to be developed in actual business context. If, for one reason or another, artificial assignments are given, the learning situation develops in the direction of simulation and/or gaming and critical authenticity may be lost. So, acquisition of virtual business assignments should be in the focus of a Virtual Company. Another important characteristic of the Virtual Company has to do with control: is it teacher or student centred? The first thought might be that teacher control of competency development of students is the natural approach. On second thought, however, second line control through quality criteria leaves more room to students for role differentiation and role identification.

Characteristic components of a Virtual Company
A Virtual Company as learning organisation characteristically has the following components:

- *Business aim*: the business aim is twofold; on the one hand design and realisation of products and services of innovative character, on the other hand development of generic knowledge about this design and realisation, and the management thereof (learning organisation).

- *Business organisation*: the business organisation is team based with participating management.
- *Working method*: the working method is project oriented and allows optimal realisation of business aims; the working method guarantees quality of the result.
- *Business culture*: business culture is one of shared responsibility and participation.

Example: GiPHouse
An example of a Virtual Company 'GiPHouse', a professional student software house, was reported in [We95]. GiPHouse projects serve customers both from Nijmegen University and from businesses. Customers do not have to pay for the developed systems, but still have to invest quite a lot of time. Clearly they only are willing to do so, if the results are of real value in their work. It takes an academic year to complete a project. In September projects are accepted and by Christmas the system design will have been completed by teams of third-year students (GiPHouse 2). These teams will have been managed by a Project Manager (PM) and Quality Assurance Managers (QAM) who are fourth-year students (GiPHouse 4). Second line quality assurance will also have been implemented by Project Steering Groups, consisting of PM and QAM's, fourth-year students (GiPHouse 4). After Christmas the design is realized by a team of second-year students (GiPHouse 1), managed and subjected to quality control by third-year students (GiPHouse 3). By the end of May, after an acceptance test by the customer, the systems are delivered. Working in the student software house is a part-time job. During each semester students have other courses to follow and therefore are forced to do effective time management.

GiPHouse business aim: realisation of software systems
GiPHouse has been succesfull the realisation of systems for customers. Some examples:
- A system for scheduling and administration of Go-tournaments; it keeps track of results, produces ratings etc. An intricate scheduling algorithm is at the hart of this system. The system is in use at international Go-tournaments in Europe.
- Knee Joint Animation System for the academic hospital in Nijmegen where research is done on a functional model of the knee joint and its ligaments. A visualisation of this model allows surgeons to decide on their strategies in knee surgery. The animation system allows to simulate results by changing the parameters in the model and to visualise these.

GipHouse business aim: knowledge development in a network
Students in GiPHouse learn to "help themselves". They start their projects with a general description of half a page, the address of the customer, a GiPHouse manual explaining the basics of the organisation and some GiPHouse standards. After that it is up to the students to find suitable techniques to tackle their project, to organize, plan, manage their teams etc. However, students who have been involved in earlier phases of GiPHouse, bring their knowledge over on younger students, thus providing a real learning network. Integral part of this network is the GiPHouse Director who is a professor sponsored by a well-know Dutch software house (Origin) with extensive experience in development of large software systems and quality control. Because of the management structure new GiPHouse standards are developed by students for later use

GiPHouse business organisation
GiPHouse is a flat organisation mainly managed by the students themselves iin GiPHouse 3 and GiPHouse 4 (See Figure 2 for an overview of the business organisation). The managing of GiPHouse to success is a complicated and critical process. It has taken several years to find the right set of checks and balances for realising both the production goal and the learning goals of GiPHouse. Students find GiPHouse to be a demanding exercise, but are very satisfied by their accomplishments, both with respect to the product, a real-life software system, and with respect to what they have learned.

GiPHouse working method and business culture
GiPhouse has been modelled after modern, innovative software development businesses. The working methods are geared towards effective project work and the business culture is one of participation and shared responsibility.

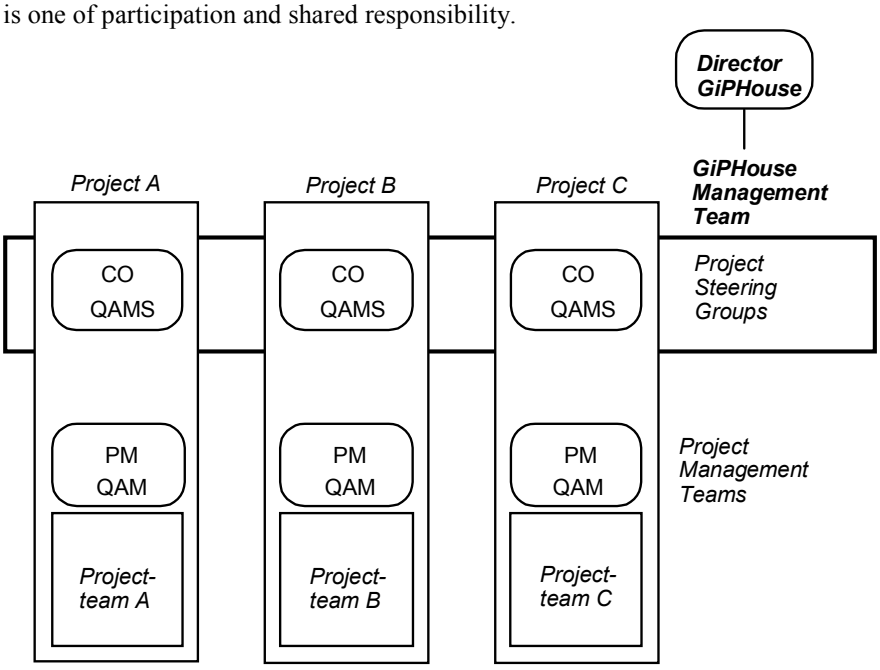

Figure 2. GiPHouse business organisation

Example: OTO
Another, very recent example of a Virtual Company is 'OTO', a design project of the Dutch Open University [Cr01]. Overall aims of 'OTO' are:
(1) To identify in participation with an external customer possible changes in the existing customer business organisation in relation to information systems used,
(2) To re-design, develop, implement and evaluate new relationships between customerbusiness processes and information systems,

(3) Developing new and maintaining old customer relations,
(4) Developing and sharing knowledge with respect to (1) and (2) within 'OTO',
(5) All students work on BSc level,
(6) All students work for 400 hrs in 'OTO',
(7) 'OTO' is a result oriented, project oriented working environment,
(8) Assessment of competences is integral part of the working environment.

3 Design of learning situations

In the first part of this paper we have discussed the characteristics of typical learning situations. Now let us assume that new learning situations have to be designed for a substantial part of the curriculum. These new learning situations will then have an effect, further reaching then initially assumed, on:

- The organisation of education,
- The role of students and teachers,
- The ICT infrastructure.

The approach of the institution towards changes determines what learning situations can be realised.

3.1 Design is linked with institutional approaches to change

Approaches of educational institutions to change are related to the situation in the particular institution and more specifically to the growth of ICT in this institution. Typical approaches are described in the IFIP publication 'ICT in Higher Education' [We00a]. Each approach is linked with a typical learning situation that can be successfully realised within the approach:

- Emerging: Assignment based learning,
- Applying : Task based learning,
- Integrating: Problem based learning,
- Transforming: Situation based learning.

Emerging
This approach is linked with an institution in the beginning stages of ICT development. The institution begins to purchase some equipment and software. In this initial phase, administrators and teachers are just starting to explore the possibilities and consequences of adding ICT for institutional management and the curriculum. The institution is still firmly grounded in traditional, teacher-centred practice. In this approach ICT is used to at the level of basic skills and awareness of the uses of ICT. This curriculum assists movement to the next approach (Applying) if so desired.

Applying
This approach is linked with an institution in which new understanding of the contribution of ICT to learning has developed. In this approach administrators and teachers use ICT for tasks that are carried out in institutional management and in the curriculum. Teachers still largely dominate the learning environment. In this approach

	Vision	Learning Pedagogy	Development Plans and Policies	Facilities and resources
Emerging	Dominated by individual interest Limited Pragmatic	Teacher centred Didactic	Non-existent Accidental Restrictive policies No planned funding	Stand-alone workstations for administration Individual classrooms Computers and printers Word processing Spreadsheets, databases, presentation Institution administration software Games
Applying	Driven by ICT specialist	Factual knowledge based learning Teacher centred Didactic ICT a separate subject	Limited ICT resource lead Centralised policies Hardware and software funding Automating existing practices	Computer lab or individual classrooms for ICT specific outcomes Computers, printers and limited peripherals Word processing Spreadsheets, databases, presentation ICT software Internet access
Integrating	Driven by subject specialists Discrete areas	Learner centred learning Collaborative	Individual subject plans include ICT Permissive policies Broadly based funding, including teacher training	Computer lab Networked classrooms, intranet and Internet ICT and learning resource rich learning centres Range of devices, including: digital cameras, scanners, video and audio recorders, graphical calculators, portable computers, remote sensing devices Video-conferencing Word processing, spreadsheets, databases, presentation software Range of subject orientated content Multimedia authoring, video/audio production Range of subject specific software
Transforming	Leadership Acceptance by entire learning community Network centred community	Critical thinking and informed decision making Whole learner, multi-sensory, preferred learning styles Collaborative Experiential	ICT is integral to overall institutional development plan All students All teachers Inclusive policies All aspects of ICT funding integral to overall institution budget Integral professional development	Whole institution learning and ICT infrastructure and access to technology resources a wide range of current devices. Emphasis on a diverse set of learning environments. All of the above and Web based learning spaces Brainstorming Conferencing and collaboration Distance education Web courseware Student self-management software

Understanding of the curriculum	Professional development for institution staff	Community	Assessment
ICT Literacy Awareness of software Responsibility of individual teachers	Individual interest	Problem driven Accidental	Equipment based Budget orientated Discrete subjects Didactic Paper and pencil Controlling Closed tasks Responsibility of individual teacher.
Applying software within discrete subjects Use of artificial and isolated contexts	ICT applications training Unplanned Personal ICT skills	Seeking donations and grants	Skills based Teacher centred Subject focused Reporting levels Moderated within subject areas
Integration with non-ICT content Integrated learning systems Authentic contexts Problem solving project methodology Resources based learning	Subject specific Professional skills Integrating subject areas using ICT Evolving	Subject based learning community providing discrete, occasional assistance, by request. Global and local net-worked communities	Integrated Portfolios Subject oriented Learner centred Student responsibility Multiple media choices to demonstrate attain-ment Moderated across subject areas Social and ethical as well as technical
Virtual and real time contexts, new world modelling ICT is accepted as a pedagogical agent itself The curriculum is delivered by the web as well as by staff	Focus on learning and management of learning Self-managed, personal vision and plan, institution supported Innovative and creative Integrated learning commu-nity – students/teachers co-learners	Broad based learning community actively involved business, industry, universities, vocational institutions, voluntary organisations. Global and local, real and virtual Institution is a learning resource for the commu-nity – physically and virtually	Continuous Holistic – the whole learner Peer mediated Learner centred Learning community involvement Open ended Project based

Figure 3. Approaches to institutional change

the institution best choice is to increase the use of ICT in various subject areas with specific tools and software. This approach assists movement to the next approach (Integrating) if so desired.

Integrating
This approach is linked with an institution that now has a range of technologies both in laboratories, classrooms and administrative offices. The institutional staff explores new ways in which ICT changes their personal productivity and professional practice. The ICT-curriculum begins to merge subject areas to reflect real-world applications.

Transforming
This approach is linked with an institution that has used ICT to creatively rethink and renew institutional organisation. ICT becomes an integral though invisible part of daily personal productivity and professional practice. The focus of the curriculum is now learner-centred and integrates subject areas in real-world applications. ICT is taught as subject area at the professional level and incorporated into all vocational areas. The institution has become a centre of learning for the community.

More detailed descriptions of the different approaches are given in the matrix of Figure 3.

3.2 ICT curriculum linked with each approach

In the IFIP-publication 'Information and Communication Technology for Secondary Education, A Curriculum for Schools' [We00b] each institutional approach (emerging, applying, integrating, transforming) is linked with a student informatics and ICT curriculum:

- Emerging: A. ICT Literacy,
- Applying : B. Application of ICT in Subject Areas,
- Integrating: C. Integration of ICT across the Curriculum,
- Transforming: D. ICT Specialisation.

The above mentioned IFIP-publication on ICT in secondary schools [We00b] also provides a curriculum for the professional development of teachers for each institutional approach:

- A. Emerging ICT Skills and Knowledge,
- B. Applying ICT to the Teachers' Subject Area,
- C. Integrating ICT to improve Learning and the Management of Learning,
- D. Supporting *Integration* by a "Resource Person" for Teachers and Students

3.3 Successful design is complex

The design of the new learning situations integrating ICT is a complex business with effects that tend to reach further than expected. Effective design will involve:

- Strategy of change,

- Educational model,
- Design process,
- Design result,
- Control and maintenance.

In all these aspects ICT appears as an integral part.

The action research project 'Task based team learning with ICT' (1999 – 2001), jointly executed by the University of Utrecht (IVLOS) and the Professional University of Utrecht (Cetis) has identified specific success factors that influence the success of the design. These factors apply in all institutional approaches (emerging, applying, integrating and transforming) although some will become more important with each next approach. When a success factor is not applied, the factor will turn into a risk factor. Success can still be attained, but to beat the odds will be more difficult.

Success factors: Strategy of change

- Design of learning situations has to be learned by doing:
  - Allow staff to develop design competencies,
  - Make design into a structured process,
  - Design for gradually ascending ambition levels.
- Organise success:
  - Secure motivation by all concerned as a key to success,
  - Organise the planning and quality assurance.
- Build on a sound foundation:
  - Bring an operational ICT-policy in place,
  - See to it that all concerned are ICT and design competent.
- Success needs looking after:
  - Arrange for support and maintenance,
  - Organise knowledge development and sharing of knowledge.
- Secure financial resources for investments and exploitation,
- Take responsibility and aim for quality.

Success factors: Educational model

- The educational model has broad support and is internalised,
- The educational model has operational connections to professional practice,
- Learning situations are created in which students may function as junior professionals,
- Let students solve realistic problems from professional practice involving use of ICT,
- Create learning situations in which self-assessment against realistic and operational standards is the rule,
- Design a realistic professional career for the students and include student reflection on which direction this career should develop.

Success factors: Design process

- The organisational setting is clear and there is an agreed framework for design tasks,
  - The process of giving out design tasks is transparent

    - Task execution and result delivery are organised is a way that suits the complexity of the task,
    - Educational manager and design team take collective responsibility for the design process,
- The design task is performed by a team supported by ICT.

Success factors: Resulting design
- Concrete, operational criteria have been developed for the quality of the result of the design process,
- The design result complies with these criteria.

Success factors: Support and maintenance
- Results of the design process are kept for later inspection and learning,
- There is periodic maintenance planned, both in time and resources.

Acknowledgements

In this paper results have been presented from:
- The Business Plan of the Dutch Digital University,
- The work of the International Federation for Information Processing (IFIP) Technical Committee 3,
- The action research project 'Taakgericht Teamleren met ICT'.

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