

An On-Going Journey: Technology as a Learning Workbench

Betty Collis & Jef Moonen, 15 september 2005



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An On-Going Journey: Technology as a Learning Workbench

Reflection document by Prof. dr. B.A. Collis and Prof. dr. J.C.M.M. Moonen
on the occasion of their retirement as professors
in the Faculty of Behavioral Sciences of the University of Twente
on Thursday 15 September 2005

With appreciation to Petra Fisser, Johan Jonker, Jan Oosterhuis, Allard Strijker and Marita Wesselink-Fliervoet and also to the Dean of the Faculty of Behavioral Sciences, prof. dr. H. Coonen.

An On-Going Journey: Technology as a Learning Workbench

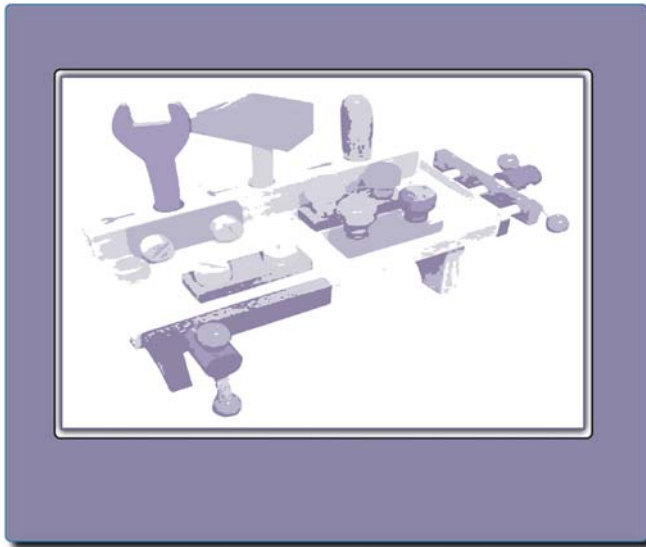
Today is 15 September 2005. Prof. Moonen (Jef) has already taken early retirement from the University of Twente, on February 1, 2004. Prof. Collis (Betty) will also take early retirement, on 1 December 2005. Given that our two retirements are close together and also that we as a personal pair and professional partnership share an on-going journey with technology and learning, we have organized one reflection document and one milestone event to mark our transitions.



Betty & Jef, 2005

What is remarkable about our shared journey is that since we met each other in 1987, we have repeatedly found that our ideas about computer-related technology for education, training, and performance support are fundamentally the same. Our work is dominated by a context-anchored perspective on learning that we call the contributing-student approach, and a technology-use perspective that we call the learning workbench. The technologies we have used for our studies and which have led to the workbench orientation have evolved from mainframe systems in the 1970s through stand-alone programs in the early 1980s; to increasingly complex software and multimedia in the 1980s and early 1990s; to network tools and systems; and since 1994, to the use of Web technology. Although the technologies have varied, our core belief remains the same:

For us, technology is not for “delivering” learning or for taking the humans out of learning, but is rather is a set of tools, a locally tailorable workbench, which offers affordances to empower people to share, build, support, and manage their learning together, in their common context.



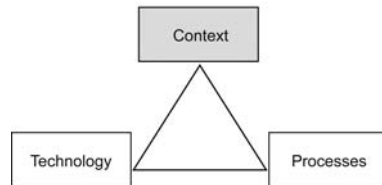
Technology as a learning workbench

Three lines of thinking come together in this statement: the importance of context, the importance of processes that put the user in control and contributing, and the idea that technology is a tool for the user's own problems and interests.

In terms of the importance of context, our major observation is:

Context: People in their contexts make it complicated

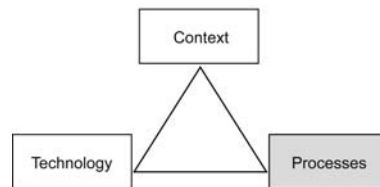
Learning-related processes supported by technology always take place within a complicated mix of personal, social, organizational, and cultural contexts. Thus there are no simple answers...



In terms of the processes that occur among humans in their different contexts, our major orientation is:

Learning-related processes: Instead of end users, co-creators:

A process (pedagogy) that involves the learners as co-creators of learning resources as products of their own learning, or design methods that involve the end users as co-designers, are powerful ways to use technology to optimize the fit of learning to the personal context. We call the pedagogy that aligns with this the contributing-student approach.

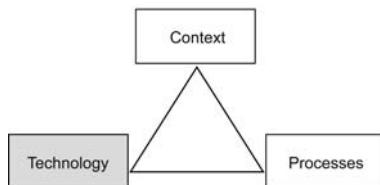


Finally, as we are educational technologists, we have an observation about technology applications for learning:

Technology: A solution, but to whose problem?

Technology is too often presented as a solution, but not to a problem that is meaningful to the intended users.

Using technology as a workbench supplies the user with tools to address his or her own problems and interests.



Inspired by these perspectives on context and user-controlled processes, the idea of technology as a learning workbench has been an on-going theme of our professional journeys for over 30 years, and of our shared personal journey for 18 years. We will expand on these ideas in two ways in this reflection. In Part 1 we discuss the contributing student and learning workbench ideas conceptually. In Part 2 we give a personal foundation for the ideas in this introduction and those in Part 1, based on highlights from our own work in both our separate pre-Twente years and our shared Twente years. In the brief final section, we give some closing remarks for this, our retirement document.

Part 1

Technology and Learning in a Knowledge Society

Collectively we are experiencing a change to a “knowledge society”; this change has a major impact in the ways in which we work and interact with each other. From an analysis of major characteristics of productive functioning in a knowledge society, we can see that network technology and digital workbenches of various sorts are increasingly important tools and extrapolate principles to guide interactions of learning and technology. From these observations, two major ideas emerge. The first is the idea that learning is more than acquiring knowledge for one’s self, but that it also involves participating in a learning community and contributing to its shared knowledge base. The second, related idea is technology as a learning workbench.

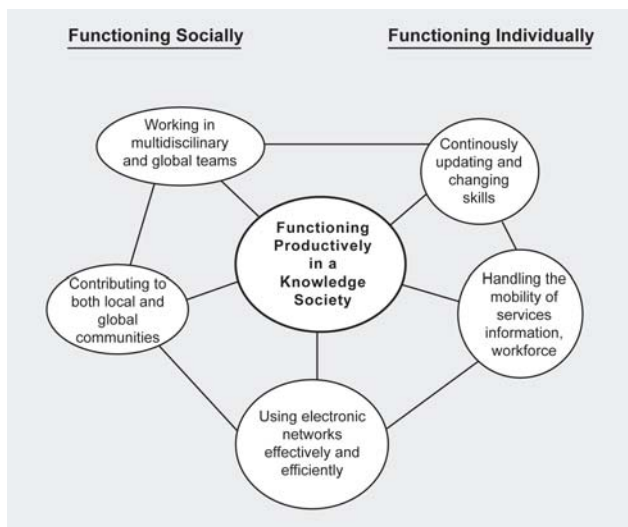
Productive Functioning in a Knowledge Society

In a knowledge society, low-cost access to information and communication technology (ICT) is a requirement and knowledge and creativity are key factors of successful participation (European Commission, 2005). In a knowledge society, citizens need “Open and timely access to information and knowledge, the capacity to absorb and interpret information, and avenues and opportunities to use knowledge for informed decision-making and for transformation to higher quality of lives” (Nath, 2005). The knowledge society is related to changes in society worldwide particularly globalization, information/knowledge intensity, and networking and connectivity. Characteristics of a knowledge society include: the increased mobility of services, information, and workforce; the need to derive local value from globally-available information, often in creative ways that go beyond expected performance; the need to work in multidisciplinary and distributed teams; the need to use information technology for knowledge management, sharing, and creation; the need to update and change one’s skills throughout one’s lifetime; and the need to “act autonomously and at the same time reflectively, joining and functioning in socially heterogeneous groups” (The World Bank Group, 2003, p. 17).

These skills involve personal competencies, social competencies, and the purposeful use of technology. The Ministry of Economic Development in New Zealand (2004) gives a concise summary of the skills needed to function productively in a knowledge society:

“Know-why and know-who matters more than know-what. Know-what, or knowledge about facts, is nowadays diminishing in relevance. Know-why is knowledge about the natural world, society, and the human mind. Know-who refers to the world of social relations and is knowledge of who knows what and who can do what. Knowing key people is sometimes more important to innovation than knowing scientific principles. In addition know-where and know-when are becoming increasingly important in a flexible and dynamic economy.”

The following figure shows a synthesis of key aspects of productive functioning in a knowledge society:



Key characteristics of productive functioning in a knowledge society
(adapted from Collis, 2005)

Thus, for the individual, productive functioning in the knowledge society requires more independence and, at the same time, new forms of interdependence. Network technology as well as new approaches to learning are essential for both.

Technology as a Workbench for the Knowledge Society

A workbench can be defined around its two main functional components: a platform of some sort on which to work, and tools that are appropriate to use on the workbench. For a workbench to be used in practice, it must also: be accessible to the potential user, meet the needs and capabilities of the potential user, and offer affordances that the user can capitalize on to achieve a desired result. A workbench comes to reflect the personal style of its user not only in the tools involved but also in the look and feel of the working setting. A digital workbench is therefore a working environment whose platform and tools are accessible via an electronic device and which can be tailorable by the user, who adds new tools, arranges the environment as he or she likes, shares the environment with others if desired, and who is able to reuse what is created on the workbench in other settings. We do not believe that having a digital workbench means that the user no longer makes use of other sorts of tools: at the same time as using a digital workbench, the user may be also be referring to other digital toolsets, to paper-based resources, and most importantly to other humans.

The idea of technology as a workbench reflects the ways in which technology is used in the knowledge society. When we look at learners in their larger contexts, we see that they are already using new forms of digital workbenches to: solve problems that are meaningful to them; create new processes for how they interact, communicate, organize themselves; amuse themselves; build new communities in which they define themselves; fill their time; and go about finding what they need. For example, Google is a workbench whose tool set is continually expanding in power and range. The use of Google and other search environments to find information meaningful to an individual's problem is now a common practice for citizens of all ages and for many different reasons, such as healthcare options, travel choices, banking and financial questions, information about government rules and processes, and access to the portals of any institution or group that could be relevant to them. Services and workbenches associated with repositories of objects of all types are used daily by millions.

But people use workbenches for more than information seeking; learners in their larger contexts are using digital workspaces in amazingly creative ways. The ease with which both content objects and tools can be downloaded are leading to new forms of creative expression and personally

tailored entertainment, but also to new issues relating to intellectual capital and the ownership of ideas. Weblogging ('blogging') has become an important form of social communication and creative self-expression for millions of people. Bruns (2003) notes that "we are now also witnessing the emergence of a wide range of p2p (person to person) publishing models. These range from solitary, diary-style Weblogs (blogs) to communal blogspaces which place individual blogs within elaborate interconnecting extrastructures, and beyond this to increasingly sophisticated Websites for the open publishing and discussion of special interest news. This form of communal publishing replaces traditional journalistic gatekeeping approaches with a new gatewatching model, and (implicitly or explicitly) applies the philosophy of the open source software development movement to news reporting and publishing, leading to what can be described as open news." Blogging is only one of the many variations of the rapid integration of tools for expression, sharing, and communication being used spontaneously throughout the world. The Creative Commons movement (<http://creativecommons.org/>) facilitates the process of allowing users to build legally upon the creations of others while acknowledging the right of the originator to be recognized in appropriate ways.

Other technologies place more emphasis on locating other people with similar interests and interacting with them in different ways. Distributed gaming with real-time multi-player interactions engages many people world-wide in ways that go beyond game playing in the traditional sense to the "vernacular creativity" (Burgess, 2005) of distributed, non-commercial content creation generated by collaborative artistic expression. Amazon's product-market site uses "personalized recommendations" to match the user to the choices of others who share similar interests with the user. Social networking tools such as Stumble Upon (<http://www.stumbleupon.com/>) allow the user to share her bookmarks and links with a digital community of "mutual friends" who together, regardless of time and distance, perform collaborative filtering of resources through their "thumbs up" and "thumbs down" ratings of, and comments on websites. More substantially, "social software", software that supports group interaction (Allen, 2005), is now seen as the medium for the "new democratic web" (Versluis, 2003-2004).

In the work context, researchers and work colleagues use shared workspaces and other common features on their agenda tools, portable phones, and palmtops to co-construct ideas and to manage their communal expression

of the results of their work-based learning experiences. In corporate settings, global networks and other forms of knowledge-sharing communities are key tools in learning from the tacit knowledge of others in the corporation. This learning comes from finding relevant examples and resources, asking others in the community for help or clarification, or by joining in debates and discussions on how to generate solutions for workers' real problems. In professional contexts, for learning communities or communities of practice, digital workbenches increasingly serve major roles in the ways in which people in a common company or professional group interact. The ongoing professional development of practitioners outside of a particular corporate setting is predominately a matter of life-long learning where there may or may not be professional accrediting bodies or societies to steer the learning process. Here, the role of communities of practice for learning becomes essential. Thus, communities of practice are important to ongoing professional development. A key strategy for such communities is the use of shared archives, such as those from online discussions, from workshops, from knowledge-management systems, or from other contributions from the members of the community of practice themselves (Wenger, 2005).

More and more, the tools and workbenches available to the end user allow him or her to bypass traditional gatekeepers in obtaining, producing, and distributing resources. And these tools are being used, now, by large numbers of people of all ages, without their ever having been taught to use them in structured educational practice.

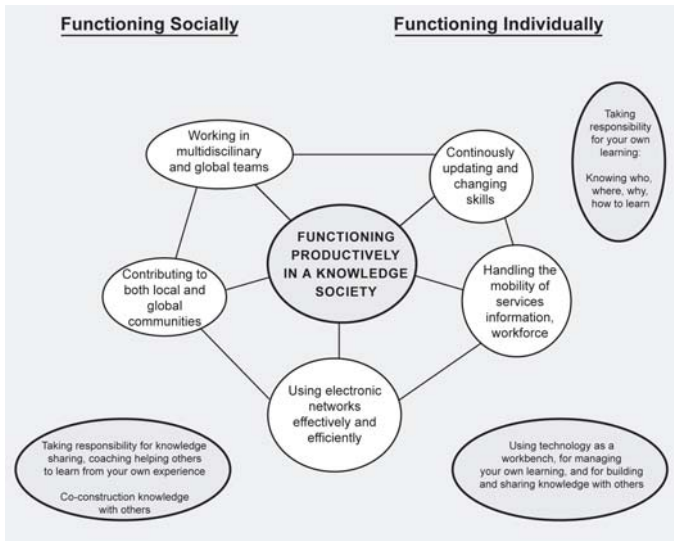
Learning for a Knowledge Society

Learning in a knowledge economy must equip the citizen to function productively in a society whose key requirements include those given in the previous section. In this section, we reflect on key attributes of learning that are needed to map onto the requirements of this knowledge society. In this context, we introduce the idea of the learner as contributor to the learning of others.

Learning as participation and contribution

Traditionally, much of formal learning has been characterized by an acquisition orientation, with the teacher or trainer being responsible for the

quality and quantity of what is to be learned. The World Bank (2003) contrasts traditional learning with learning for a knowledge society by describing the latter as moving away from the teacher and textbook as definitive sources of knowledge towards the teacher as a guide for the process of learners themselves finding and interpreting real-world information; and as moving away from learning as a product being delivered toward learning as the process of doing, participating as close to the real world as possible. The less mature the learner, the more scaffolding is required for this transition, but for professional-level learners the mapping expressed in the following figure identifies some key interrelationships between learning and productive functioning in a knowledge society.



Key aspects of learning in a knowledge society

The individual competencies in the figure relate to the individual's need to handle increasingly complex streams of information, and the insight to identify and apply what is relevant to his or her own work and life situation. These situations are also in rapid change; life-long learning is needed to evolve with new work and personal situations, and with new forms of mobility that call for regular redefining of one's skills and one's ways of looking at the world. However, productive functioning involves more than just taking care of one's own development: as both of the previous figures

illustrate, it also involves functioning as part of increasingly diverse and distributed knowledge communities.

To incorporate both the personal and interpersonal aspects of functioning in a knowledge society within structured learning situations, a pedagogical model is needed. A pedagogical model relates to the abstract concepts about the learning and teaching process that underlie an instructional approach. Sfard (1998) identifies two basic types of pedagogical models: the *Acquisition Model* and the *Participation Model*. Table 1 summarises Sfard’s interpretation of these two fundamental pedagogical models.

	Acquisition	Participation
Key definition of learning:	Learning as knowledge acquisition and concept development; having obtained knowledge and made it one’s own; individualized	Learning as participation, the process of becoming a member of a community, “the ability to communicate in the language of this community and act according to its norms” (p. 6); “the permanence of having gives way to the constant flux of doing” (p. 6)
Key words:	Knowledge, concept, misconception, meaning, fact, contents; acquisition, construction, internalization, transmission, attainment, accumulation;	Apprenticeship, situatedness, contextuality, cultural embeddedness, discourse, communication, social constructivism, cooperative learning
Stress on...	“The individual mind and what goes into it” (p. 6); the “inward movement of knowledge” (p. 6)	“The evolving bonds between the individual and others” (p. 6); “the dialectic nature of the learning interaction: The whole and the parts affect and inform each other” (p. 6)
Ideal	Individualized learning	Mutuality; community building
Role of instructor	Delivering, conveying, facilitating, clarifying	Facilitator, mentor, “Expert participant, preserver of practice/discourse” (p. 7)
Nature of knowing	Having, possessing	Belonging, participating, communicating

Table 1. *Comparing the Acquisition and Participation Models*
(summarised from Sfard, 1998, pp. 5-7)

In the Acquisition Model, the focus of learning activities is on the acquisition of pre-specified knowledge and the development of pre-determined concepts. In contrast, in the Participation Model, the focus of learning activities is on becoming a member of a community of practice: not only learning from the community, but also contributing to it. In the Acquisition

Model, what is to be learned is generally pre-determined. The quality control of the content selection and presentation rests with the instructor. In contrast, in the Participation Model, the interactions to which the learner contributes may serve to change the knowledge base of the community even as he or she participates in it. In this model, learning is not so much a matter of understanding and applying, but rather of achieving degrees of insight, belonging and participation (Collis & Moonen, 2001, 2005a,b).

The need for participation reflects current developments in society. Internationalisation, the world becoming a global community, the fact that individuals can expect to work in different settings and as members of multifaceted teams, and the need for social skills and the capacity to function effectively as a member of a team: all are commonly described as characteristics of living and working that are rapidly gaining in importance. But participation is not enough: the participant must also *contribute* in order to make a difference.

These principles are similar to those expressed by Jonassen, Peck and Wilson (1999), who assert that the primary goal of education at all levels should be to engage students in meaningful learning – which they define as active, constructive, intentional, authentic, and cooperative. Interaction with learning materials and with others is also important to Laurillard’s interaction-oriented approach (Laurillard, 1993). However, in both these approaches, it is possible that all the activities and interactions that take place are based on pre-determined and pre-structured learning materials. In a contributing-student approach to pedagogy (Collis & Moonen, 2001), pre-structured learning materials are not the main focus. Instead, the contribution-oriented activities themselves are central, mediated via an appropriate Web-based system. Our contributing student model is an approach in which students can: contribute to the learning material based upon their own experiences, can draw on each others’ experiences, and can use material that they obtain via the Web or from their workplaces. This approach is similar to the participation aspects of Sfard’s two metaphors for learning; Kearsley and Shneiderman’s (1998) *Engagement Theory*; and *Action Learning* (Dopper & Dijkman, 1997; Simons, 1999). Table 2 contrasts these approaches with the key ideas of the contributing-student pedagogical model.

"Participation-oriented" (Sfard, 1998)	"Action Learning" (Dopper & Dijkman, 1997; Simons, 1999)	"Engagement Theory" (Kearsley & Shneiderman, 1998)	"The Contributing Student"
<p><i>Key definition of learning:</i> Learning as participation, the process of becoming a member of a community, "the ability to communicate in the language of this community and act according to its norms" (p. 6); "the permanence of having gives way to the constant flux of doing" (p. 6)</p> <p><i>Key words:</i> Apprenticeship, situatedness, contextuality, communication, social constructivism, cooperative learning; Belonging, participating, communicating</p> <p><i>Stress on:</i> "The evolving bonds between the individual and others" (p. 6); "The whole and the parts affect and inform each other" (p. 6)</p> <p><i>Role of the instructor:</i> Facilitator, mentor, expert participant</p>	<p><i>Key characteristics:</i></p> <p>(a) Practical problems are central: Learning is based on working on problems from one's own work situation</p> <p>(b) When there are contacts among learners, these are focused on stimulating self-reflection and learning from others</p> <p>(c) Instead of "lectures" learners use contact times for activities</p> <p><i>Role of the instructor:</i> Leader, motivator, and guide of the learning processes; giving feedback on evolving phases of the problem-oriented project, and evaluator of the final submission. Must ensure that learner contact is more that the sharing of experiences but also that experiences are related to theory</p> <p><i>Stress on:</i> Learning to learn, to collaborate, to self-regulate</p>	<p><i>Key idea:</i> "students must be meaningfully engaged in learning activities through interaction with others and worthwhile tasks" (p. 20)</p> <p><i>Key characteristics:</i> Learning activities that</p> <p>(a) "occur in a group context (i.e., collaborative teams)</p> <p>(b) are project-based, and</p> <p>(c) have an outside (authentic focus)" (i.e., are meaningful to someone outside the classroom)</p> <p><i>Role of instructor:</i> Supporting and screening the initial definition of projects and formulation of teams, provide guidance in working in teams, provision of criteria to evaluate projects</p> <p><i>Role of technology:</i> "To facilitate all aspects of the engagement" (p. 23)</p>	<p><i>Key ideas:</i> Learners contribute to the learning materials via contributions made available to others in a Web-based system. The others may be others in the same group or others at other times.</p> <p><i>Key characteristics:</i></p> <p>(a) the Web site is largely empty at the start of the learning experience; the learners and the instructor will fill it via the process of many activities during the course</p> <p>(b) Learners learn from realistic materials as well as peer-created materials as much as or more than professionally developed materials</p> <p>(c) Learning materials contributed by students are re-used in other learning settings</p> <p><i>Role of instructor:</i> Designer of activities and of feedback and monitoring strategies for activities.</p> <p><i>Role of technology:</i> To facilitate all aspects of the activities</p>

Table 2. Learning characteristics relating to active students
(from Collis & Moonen, 2001, p. 88)

The Contributing Student conception integrates many of the characteristics identified in Table 2. It differs from the other approaches shown in Table 2 in that it is more flexible. It can be used in combination with acquisition-type learning (where the stress becomes activities such as contribution to a collection of model answers, of frequently asked questions or a databank of test items), and thus can relate to both of Sfard's Acquisition and Participation modes. It does not assume a particular type of activity approach, such as the group-based projects for external audiences in Engagement Theory, as one

particular approach may not be feasible in all learning contexts. Also, it does not assume that learners can base their learning on their own professional experiences, as does Action Learning; again this depends on the nature of the course and the learner. Thus, while it shares characteristics with other pedagogical approaches in the literature, the contributing-student approach is a pedagogical basis that can be applicable to students of many types and in many types of courses.

Learning activities for a contributing-student pedagogy

In the contributing-student approach, the stress is on activities –sometimes called generative activities– that involve the learner as an active contributor to the learning experiences and resources. Learners, through their learning and knowledge-building activities, generate something which they use to ‘test their ideas with each other.... becoming active investigators, seekers and problem solvers’ (Grabinger, Dunlap, & Duffield, 1997, p. 10), and to share via a common network environment and workbench. Such activities can take many forms and can be carried out in an individual fashion or by a group. A shared digital environment is used as the workplace for working on, contributing to, and subsequently accessing the contributions. In simplest form there are two categories of learning activities for a contributing-student pedagogy: finding and contributing, or creating and contributing (where creating usually involves some elements of finding). Table 3 shows some examples from school and higher education sectors.

Activity	Brief description
Searching for information and sharing what is found (Collis & Moonen, 2001, pp. 99-101)	Students are given the activity of finding an appropriate example or article on the World Wide Web that relates to a topic under discussion in the course, or illustrates a concept, or extends the references and examples given in the textbook, and then contributing it for others to build upon
Creating a report to then be used as a learning resource (Collis & Moonen, 2001, pp. 99-101)	Students work in groups and each group is assigned a topic relevant to the course. The group must prepare a report for use by other students. The intention of the activity may be to extend and complement the textbook in relation to the topic.
Testing one's insight through the development of test questions to be used by others (Collis & Moonen, 2001, pp. 99-101)	For some topic in a course, students must construct several multiple-choice test items, along with a scoring key and appropriate feedback for each of the choices in their items. After initial scanning by the instructor, all items are available via the course Web site as study materials for other students
Reusing task-directed discussions (Dineen, Mayes, & Lee, 1999)	Students use a computer-conferencing tool to participate in written discussions relating to issues being discussed in the course. Students can take turns having the role of moderator of the discussion. Their results become a new form of courseware, available for reuse via an indexed multimedia database.
Contributing to peer-assessment activities (Tsai, Lin, & Yuan, 2002)	Students participate in a networked peer-assessment system involving rounds of peer feedback on course projects during their development. Not only the different stages of the projects must be available via contribution in the course Web site, but also the peer feedback has to be contributed in the same environment, for all to make use of.
Being a peer-mentor (LaMaster & Tannehill, 1999)	Pre-service teachers provide each other with support and guidance via posting questions and sharing experiences with peers via a network.
Contributing via role-play games (Jasinki & Thiagarajan, 2000)	Students are given a role in a scenario, contribute "new stories" relating to the scenario from the perspective of the roles they are playing in the course Web environment, rate the "top five" ideas from the anonymous list, and then vote on critical issues relating to the scenario.
Co-creating: collaborative knowledge construction (Fischer, Troendle, & Mandl, 2003)	Learning groups use a shared document repository and whiteboard to discuss and support each other during each phase of a communal problem-solving activity

Table 3. Examples of activities for a contribution-oriented pedagogy
(Collis & Moonen, 2005a, p. 281)

In these examples students are active in a way which directly contributes to the course as a whole, not just to their own learning. Sets of examples illustrating these sorts of activities in the higher-education context can be found in Collis and Moonen (2001), Oliver and Herrington (2001), and in the "learning designs" generated by a multi-university project in Australia (AUTC, 2003; Oliver, Harper, Hedley, Wills, & Agnostino, 2002).

The following descriptions give examples of ways in which courses can be designed around the contributing-student approach.

- In a course on the topic “Online Learning” that ran from January-April 1994, the main activity for the students was to communally create a book on the potential of the Web for education. As the technology was new, there was no textbook available; the students and instructor needed to build on what had been learned in the past about technology and learning, and then extrapolate this to the new affordances available via the Web as a workbench. Together they identified a set of chapters for the book, which would not only be about the Web but would also be a Web-based product jointly created by all in the course for an audience beyond the course. The students worked in groups of three; each group chose one of the chapter themes, and each was paired with a colleague of the instructor’s somewhere in the world who had agreed to serve as a mentor for the chapter.
- In a course on evaluating the impact of learning in the corporate sector, students worked in groups each responsible for developing a portion of a Web resource to be used by practitioners in a specific corporate-learning centre responsible for such an evaluation in their own situation. The resource had background conceptual materials, examples from other corporate settings, and specific methodological guidance for the target practitioners.
- In a course in computer science, teams of students each had the responsibility of developing coaching and self-study and testing materials for their classmates on one of the topics of the course. They had to become “experts” in that topic in order to answer questions relating to the exercises and model answers that they developed.

In a course designed in such a way, traditional timetables no longer apply. Students need to begin specialized study of their assigned part of the contributed resources early on. The instructor needs to shift attention away from linear lecture-to-lecture presentation of material to supporting self-study, working with the groups of students to help them to help others in the course through what they produce.

In corporate and professional situations, similar ideas to these can extend the contributing-student approach to a contributing-professional approach. In these contexts, the benefits of extracting and building on the tacit knowledge within the corporation or professional group can be easily seen. Examples from a corporate-learning setting for engineers in the oil industry (Margaryan, Collis, & Cooke, 2004) include:

- A course on health-risk assessment in the workplace in which participants arrange a visit to a site of their choice in their workplaces, diagnose it in terms of potential health or safety hazards, and develop a plan for reduction of the risks. Each step of the process involves interactions with a team in the actual workplace, summarized via the course Web environment, and used by the other participants as resource materials for analyzing their own work. The activities in this course progressively build upon one another, the final product being a health-risk assessment plan for each participant's own workplace, ready to put into action.
- A course that involves challenges that occur with the application of new technologies in the oil-production plant in which the participants submit detailed descriptions of a problem situation in their own workplaces to the course Web environment before the classroom session. Once physically together, the learners form small groups based on their interactions via the Web site, and tackle each others' submitted problems by peer-assisted activities (Collis, Waring, & Nicholson, 2004).
- A course in which the activities relate to the participants' analyses of commercial opportunities in their own operating units. Once these analyses are submitted to the course Web environment, follow-up activities occur in which the participants reflect on each others' submissions and compare and contrast these with their own workplace situations. The activities also involve the participants interacting with others in their own workplaces or throughout the company, and using knowledge-sharing groupware tools for the creation of the analyses. Analyses with particularly interesting aspects are reused in subsequent versions of the course.

A comparable approach, with more scaffolding, can be carried out with younger learners, even in primary education. Strahan and Noble (1999) make available a collection of ideas for elementary schools in which children explore, create and together develop a product such as a newspaper or a

database. In The Netherlands, the Beatrixschool (Beatrix Elementary School; <http://www.beatrixschoolhaarlem.nl/enmain.html>) developed an IT policy along with parents that reflects excellent starting points for both the contributing-student approach and for using technology as a workbench in the knowledge society. Key principles of the plan (translated from Van Leeuwen, Heek, & Eisenberger, 2004) are based on the belief that:

“We live in an information and communication society and computers play a steadily increasing roll in the daily lives of the children. ICT is an outstanding tool for learning new things and to search for new information on the Internet and in software packages. The motivation to do this is present in almost all of the children.... Learning with the computer is for children new, motivating and for the most a real place of discovery (‘een echte ontdekplek’). The Internet is a major part of this discovery machine (‘de ontdekmachine’).”

Finally, the so-called ‘Studiehuis’ (study centre) approach, now applied in higher secondary education in The Netherlands, emphasizes students working in groups in increasingly self-reliant ways to carry out projects can easily evolve into a contributing-student approach (<http://www.minocw.nl/tweedefase/>).

All of the above types of activities engage the learners in ways consistent with a contributing-student orientation, and all explicitly reuse each others’ contributions as learning resources. Learners are active in a way which directly contributes to the community as a whole, not just to their own learning. The most interesting contribution-oriented activities are those that are combinations of discovering and creating, comparing and discussing, and building on other learners’ products. This approach avoids the problems of lack of fit or the “not invented here” reaction which accompanies so many computer-based learning products. The products developed as a result of the process of participating in the course or learning community are by definition a good fit to the local communication norms and culture. When the learning community includes professionals in multi-national settings, the processes help strengthen their skills in functioning socially in a global knowledge society (Collis & Moonen, 2005b).

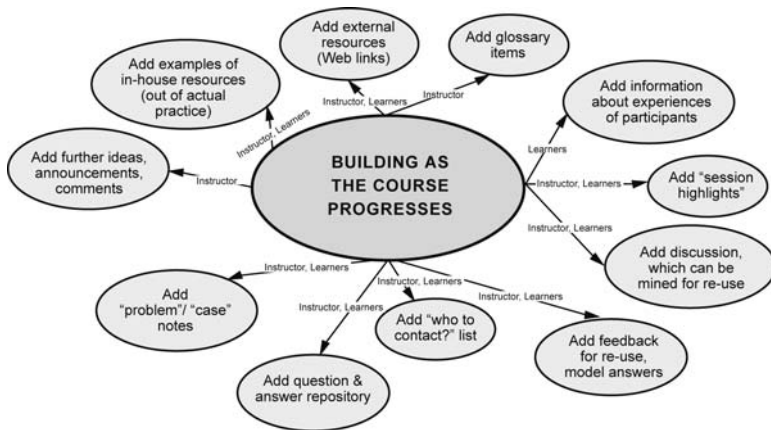
For a contribution approach in the knowledge society, the affordances of computer- and network technology are increasingly important.

Technology and Learning in the Knowledge Society

Networked technology is an important facilitator of the contributing-student approach and, more broadly, of other learning settings in the knowledge society. Digital workbenches offer particular affordances for learning in the knowledge society.

Technology and the contributing-student approach

Technology is a critical tool in contribution-oriented learning activities. A Web-based system with appropriate upload, collaborative, and communication functionalities provides the common medium into which contributions are placed for further sharing as well as for feedback and assessment. The following figure shows how a course Web environment can grow in terms of materials contributed to it during the course itself. The activities mentioned in the figure are typical of a contribution-oriented approach. These activities can be initiated by the instructors, but are essentially conducted by students individually or within student groups in the course. Users of the contributions may also be students in other cycles of the course, students in other courses, or learners who are not in a course context at all but who could refer to the materials via a database in the same way in which they now use a library or a Web search engine.



Building as the course progresses, through contributions (Collis & Moonen, 2005b)

With a contribution-oriented pedagogy, the resources contributed can become new content objects in themselves, depending on how they are used in subsequent activities and other course processes.

Technology and learning, more broadly

The above figure relates to what are called blended or hybrid courses: courses that integrate human communication and contact with the use of technology outside of face-to-face settings. These types of courses can be seen in a broader framework for the use of Internet/Web technology to support learning in a knowledge economy. This broader learning framework comprises two basic dimensions: content and communication (Collis & Moonen, 2005c). The content dimension is a continuum with three points of reference:

- *Content in a repository*: This refers to all the sorts of resources that teachers and learners find when they use a Web search engine.
- *Pre-structured content, within a course*: This refers to content that has been organized by an instructor or instructional designer into a course or a series of lessons.
- *Co-constructed content and meaning*: These are resources that are the results of teachers and learners working together to create or construct new resources –including their own collective understanding of a problem– and to make these available for others via the Web.

The communication dimension also has three points of reference:

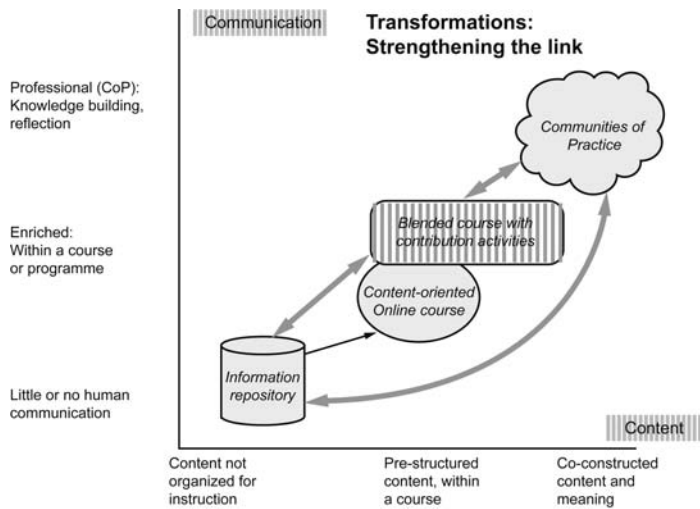
- *Little or no human communication*: Learners or teachers make little or no use of the Internet or the Web to communicate directly with other people.
- *Guided communication, within a course or programme*: With a course, learners use the Web to communicate with the instructor and with each other, as well as possibly with others outside of the course. If there are no face-to-face components of a course, it may be that using the Internet is the only way in which members of the course can communicate with each other. But even in a course where the teacher and learners are regularly in direct contact with each other, they can make good use of the Internet and Web to extend their communication.
- *Professional communication, via communities of practice*: This occurs when members of the learning community use the Internet and Web technologies to ask each other questions, share their experiences, provide information and ideas to each other, and develop collective knowledge.

As with the content dimension, these three points of reference advance from simplest to richest. The contributing-student pedagogy will include both the second and third types of content and communication.

Within these dimensions of content and communication using Web/Internet technology, we can identify four basic categories of technology-supported learning:

- a) Accessing information repositories for learning,
- b) Participating in courses via the Web while remaining at a distance from others in the course,
- c) Blending uses of the Web with regular classroom-based learning (the type of setting for contributing-student approaches such as shown in the previous figure), and
- d) Participating in communities of practice for learning and for knowledge building.

The following figure shows these four categories within the Content-Communication axes.



Four categories of technology use in learning, in terms of content and communication (Collis & Moonen, 2005c)

The location of the shapes in the above figure relate to the place of the category on the Content and Communication axes. The repository cylinder and the content-oriented online course circle indicate well-defined environments managed by a professional, while the community-of-practice cloud indicates an environment continually in transition in terms of its content, organization, participants, and even leadership. The notched rectangle represents a blended course in which explicit attention is given to the co-construction of resources. The two types of arrows in the figure have a particular meaning relating to the contributing-student approach. The thin, one-way arrow from the repository to the content-oriented online course represents the idea of using a LCMS (learning content management system) to assemble a course out of a selection of learning objects and then to offer that course via the Web. The thick, two-way arrows indicate a different dynamic. Learners in both formal learning situations (blended courses) and informal learning situations (communities of practice) not only make use of common repositories but also contribute to them, a process of contribution that can link those in courses and those in practice when activities are designed around meaningful contacts between the two groups.

Although such synergistic interactions are only beginning to emerge in practice, they have the potential to expand significantly the potential of technology-supported learning (Lamon, 2005). What is common to many of the examples is the idea of technology being used as a workbench: for access to resources, for different kinds of communication, and for the creation and contribution of resources for others. Without such workbenches the contributing-student approach to engagement is not scalable and may not be even feasible in practice.

Digital workbenches, also for learning

The idea of digital workbenches for learning is not new although the terminology and technologies used today differ from those used in the past. As early as 1980, analysts were discussing the distinction between the computer as a digital teacher and the computer as a tool for learning purposes in the educational context (Taylor, 1980). Moursund, a pioneer computer-using educator in the USA, wrote regular columns in the journal “The Computing Teacher” between 1974 and 2001 in which he focused on the use of computers as tools and workbench platforms. In an analysis of different forms of educational software in the early 1990s, software such as an electronic workbench for simulating the creation of electronic circuits was seen as the most

likely to be portable, or reusable in different cultures and school contexts in that its use would be shaped by the needs of local conditions, rather than being pre-designed within the programming (Collis, Zhang, Stanchev, & Dong, 1994). Scardamalia and her colleagues were the inventors of CSILE (Computer Supported Intentional Learning Environments), one of the first networked knowledge-building environments for education, and have also researched tools for shared knowledge construction since the 1980s (see for example Thomas, Pellegrino, Rowley, Scardamalia, Soloway, & Webb, 1992).

Given this evolution, digital workbenches for learning can be grouped into four general categories:

1. *Common application tools*: Commonly available tools in so-called “office suites”, sometimes called ‘productivity tools’. Examples include word processors, spreadsheets, database applications, presentation tools, and drawing tools, as well as specific web tools such as browsers, search engines, bookmark tools, and as a new type of software, blogging tools
2. *Specialized tools and platforms, but not created especially for learning*: Groupware tools and systems, cognitive tools such as mind-mapping and concept mapping software, EPSSs (electronic performance support systems), knowledge-management tools, conferencing and forum environments, editors for the creation of electronic resources including Web editors, video and audio editors (see for example <http://www.surweb.org/>)
3. *Workbenches created for learning purposes*: Digital portfolios, and specific products such as the Electronics Workbench (http://www.ni.com/academic/companion_products_ewb.htm), Knowledge Forum (<http://www.knowledgeforum.com/K-12/products.htm>).
4. *Educationally oriented workbenches for teachers and instructional designers*: Authoring tools, authoring environments, and authoring-oriented programming languages have been available for teachers and educational-software developers since the early 1980s (Barker, 1987). Tools to develop certain types of educational resources or environments are continually emerging. A current example is the Mappit Project tools for creating Web-based portfolios for learning (<http://www.mapping.scotcit.ac.uk/homepage.htm>). All of these examples can be interpreted as workbenches to prepare electronic learning materials. Web-based course-management environments (CMSs)

(see a comparative analysis at <http://www.edutools.info/course/compare/byfeatures/index.jsp>) can be seen as workbenches for the teachers who use them to design and prepare Web-based course environments.

For Categories 1 and 2, it is the context in which the product is used that turns a workbench into a learning workbench. Category 4 tools offer workbench functionalities to instructors and developers, but whether the products that are created will be used as workbenches by the eventual learners depends on their design. The majority of authoring tools and systems are oriented toward developing tutorial-type educational software (Barker, 2002) and the majority of course environments developed with a CMS are oriented toward information transfer (De Boer, 2004). If designed flexibly, CMS course environments have the potential to be used as workbenches by learners, but this depends very much on how the environments were set up by the instructor or course designer, what affordances are available to learners to co-create, share, and re-use each others' products, and how the learners are told to use the environment as a learning tool.

An example of a CMS digital workbench is the Web-based TeleTOP course-management system (<http://www.teletop.nl/teletop.nsf/home/en>), developed at the University of Twente (Collis, 2002). TeleTOP is in itself pedagogically neutral. It is a platform with an integrated tool set that can be used as the teacher or environment owner wishes. The tools that can be used in TeleTOP are not limited to a proprietary set. Any tool that can be uploaded as a zipfile and then launched, or launched as a Java-based tool, or accessed via a link through a TeleTOP window can be added to the toolset and made available to the user. A key feature of TeleTOP is that the user with instructor privileges can at any time add or remove the embedded tools available within TeleTOP to the navigation frame, and can also tailor the environment in many ways, such as within the shared workspaces. The LCMS tools integrated with TeleTOP allow TeleTOP databases to serve as repositories for meta-tagged collections of reusable learning objects (most of which usually turn out to have been created by the learners and contributed for others to use and reuse; Strijker, 2004). Most important, however, are the ways in which TeleTOP is being used as a workbench by learners from both within and outside of structured learning settings. TeleTOP is being used as a workbench in practice in settings of considerable diversity, in terms of level of education, language, culture, pedagogical vision, or type of content. The students in all of the courses relating to the contributing-student ideas

discussed earlier in this paper were using TeleTOP and the figure on p. 23 relating to “building as the course progresses” relates directly to TeleTOP functionalities. TeleTOP also serves as a community-of-practice environment: as an environment for users to manage and publish their own materials, as a shared workbench site for project teams, and for professional development. TeleTOP can be a learning workbench for each of the categories shown in the two dimensions of content and communication indicated in the previous figure.

Emphasizing the role of a CMS as a learning workbench does not mean that there is no place for specialized educational resources such as simulations, e-modules, and instructionally-designed learning objects. All of these can be resources in a repository for users to select as tools in their own workbenches. More interesting, however, are the tools that allow the learners to create and contribute resources themselves to the common repository, with guidance and structure from an instructor as part of course processes, or in a self-directed way as part of their interactions in a community.

Challenges

These examples illustrate some of the ways in which the social and technical developments of the knowledge society can be applied to different learning settings, both in formal courses and programs, and for informal professional development. Network technology, particularly groupware tools and tools for self-expression, provide key affordances, and the contributing-student approach provides a pedagogy. However, there are many potential barriers to realizing this kind of workbench use in educational practice.

If workbenches are used in a learning context, they are usually not enough in themselves to support the intended learning results. A good teacher, coach, or peer user is important in scaffolding the use of different tools, in providing a model as well as a critique of what is being produced, and in encouraging the persistence needed to develop into an expert user. Oliver and Herrington (2001) show this in their analysis of learning settings that support knowledge construction. They argue that such pedagogical approaches require learning designs that integrate tasks, resources/tools, and learning supports. Moursund describes this change as moving from using electronic tools for augmentation (doing the same things, but faster or better), to second-order changes which he argues are necessary to transform

education. Second-order changes require that the educational system changes to “incorporate the idea of educating students and ICT to work together” (Moursund, 2002).

For the contributing-student approach to make an impact in educational practice, new roles for the instructor and the learner are required, as well as new expectations. These processes will be new for both instructors and students, and can lead to uncertainty, excessive time demands, and disputes relating to grading decisions when the skills and insights for participating in a variety of knowledge communities over time and distance are stressed and assessed as much as (if not more) than the acquisition of knowledge.

Another aspect that can be both a strength and weakness of technology as a learning workbench is that the use of workbenches in practice is contextually determined: Many a good educationally-oriented digital workbench made as part of a cross-institutional project has never found its way into mainstream practice. There are many contextual elements that need to come together to support mainstreaming, but the ability to influence this larger contextual situation is generally beyond the scope of a research project. Also, a workbench will only be used if the user has a problem for which the workbench provides an appropriate response or if the use of the workbench is cost-effective. From the institutional perspective, issues relating to the cost of the electronic workbenches, the management and monitoring of the network systems involved, intellectual-property management, and security are issues that must also be handled.

More generally, for the instructor or trainer and the learners, these new roles and processes may lead to a culture clash among stakeholders in an organization. Boltanski and Thévenot (1991) describe six different cultures within organisational contexts. An organization that reflects a traditionally-oriented pedagogical culture, as is the case with many higher-education institutions, will likely have difficulty with the contribution and learning-workbench approaches. A mismatch of cultures can prevent the realization of technology-supported learning initiatives (Strijker, 2004). The evolution of the Dutch study-center (*studiehuis*) approach in secondary schools is a typical illustration of these challenges. After an enthusiastic start in the late 1990s, when almost everybody supported the learner-centered, activity-based philosophy behind the approach, many problems occurred in practice, mainly because of the needed changes in behavior and roles of the teachers

and students and the lack of fit of the existing time constraints versus the required and appropriate time investments needed (De Kock, 2005).

What will stimulate or prevent the further development of the workbench approach in education? Given the continual convergences of technology and tools and the rapid uptake of the tools in learners' social and work practices, technical issues are increasingly less of a problem. People are naturally making use of a variety of types of digital workbenches for tasks that matter to them. The increasing ubiquity of technology, and the rapid integration of a combination of tools of the user's own choice into one interface is leading to new levels of "logistic flexibility". But as we have seen in studies of course-management systems in universities (De Boer, 2004), logistic flexibility is a necessary but not sufficient condition for the transformation of learning. The challenges that are involved in bringing workbenches into transformed pedagogical practice are human and organizational, and relate to the shared motivation needed to bring many different actors together into a common frame of reference, a common sense of community, and to some shared key goals. Learners and instructors alike move into new roles and require a shared sense of satisfaction in shifting the focus of learning from content delivery to being co-learners together in a construction and contribution process.

The knowledge-sharing communities in large organizations, supported by knowledge-management tools and processes and effective coaching and mentoring in the workplace, are the closest current match to the requirements for productive participation in the knowledge society. In such corporate settings, the need to adapt to the changing business environment is a strong motivator for change and for new models of organizational learning (Collis & Joergensen, 2005). However, such models of learning oriented around knowledge-sharing, management, and co-creation are infrequently seen in schools and higher education. For a transformation of education to occur, national policy and accreditation processes and institutional assessment and degree requirements will need to better reflect the societal transformation that is already emerging. And network technologies must be used for "know why", "know who", "know when", and "know where" much more than "know what" in the primary processes of education. The Contributing Student, or more broadly The Contributing User, is an important role for the learner in a knowledge society using technology as a learning workbench.

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Part 2

The Journey: a Personal Perspective

The concepts of the contributing student and technology as a learning workbench have been growing in Betty and Jef's minds since the beginnings of their careers. This second part of our reflection document presents major activities that illustrate the evolution of the mindset described in Part 1. This description is more than a retrospective commemoration of some important moments of our careers; the examples illustrate the core of our research approach on the learning-workbench journey over the years. Part 2 begins with general reflections on our work as researchers, then moves to some key incidents from our Pre-Twente and Twente years.



Betty and Jef in 1989 in front of the TO (faculty) building

Preface: Research Related to Technology as a Learning Workbench

Throughout our work, we have searching for new solutions or attempting to optimize existing schemes and approaches involving technology and learning, adapting to changing circumstances in context, learning behaviour, and technology. Much of our research has followed an action research, design research, or development research methodology. In this preface we briefly discuss why we feel that these methodologies have been most appropriate for our work with technology as a learning workbench.

There are many resources describing an action research methodology. The following is a typical description of the methodology:

“Action research can be described as a family of research methodologies which pursue action (or change) and research (or understanding) at the same time. In most of its forms it does this by using a cyclic or spiral process which alternates between action and critical reflection, and in the later cycles, continuously refining methods, data and interpretation in the light of the understanding developed in the earlier cycles. It is an emergent process which takes shape as understanding increases; it is an iterative process which converges towards a better understanding of what happens. In most of its forms it is also participative and qualitative.” (Dick, 1999)

In the educational context, action research can involve an individual as a reflective practitioner with the focus on changes in his or her own setting, a team working collaboratively with the focus on changes related to a particular process or initiative, or an entire community focussing on organizational improvement (Calhoun, 1993). There is learning via iterative cycles of planning, acting, observing, and reflecting where each new innovation is put to the test of use in practice as early as possible. The reflective insights of the researcher/practitioner form the basis of the methodology (Schön, 1983). Action research by definition is context sensitive. When researchers are a different group than the practitioners in the action-research context, the importance of:

“involving practitioners as essential participants in the research, both as objects of study and as fellow-researchers sharing in all aspects of the project from design to implementation and evaluation...those with the problems contribute equally to the solution process. It is a collaborative model which places the researcher in position as a partner working alongside those affected by the problem, rather than as an objective observer who might suggest changes from the outside. In contrast to ‘basic’ research, the focus is on specific desired changes in a unique situation” (Ryder & Wilson, 1997).

When action research makes specific use of a design process for the creation of its interventions, and particularly when what is to be designed involves digital tools or systems, the processes of design research, as described by

Reeves, Herrington, and Oliver (2005), and development research as described also by Reeves (2000) and Van der Akker (1999) can guide the application of the general approaches to action research to specific software-development projects. This context has been on-going in our own work, and thus the philosophy as well as specific steps described in design and development research also appear frequently in our research and in that of our graduate students. The iterative cycles of the design and development process are realized through the approach of rapid prototyping (Moonen, 1996), a process well known in the field of software engineering. In both design and development research key aspects are:

“addressing complex problems in real contexts in collaboration with practitioners, integrating known and hypothetical design principles with technological affordances to render plausible solutions to these complex problems, and conducting rigorous and reflective inquiry to test and refine innovative learning environments as well as to define new design principles” (Reeves, 2000).

In contrast to action research, a software design and development project may be focused on a larger group than could be available for the iterative cycles of prototyping. In this type of project, only representatives of the target group can be involved at occasional times of interaction. Further, design and development research as methodologies expand the local-change orientation of action research by making a commitment to generalizable guidelines or to theory construction and explanation, even while focusing on a local problem. This is what Reeves, Herrington, and Oliver call a “socially responsible approach to instructional technology research” (2005).

With variations based on the situation, much of our research has been of the action, design, and/or development research types. The sensitivity to context that is part of these methodologies also underlies our methodological approaches to implementation and evaluation research. Salomon’s metaphor of “studying the flute AND the orchestra” brings the importance of context into focus with his call for a “systemic paradigm” for research on computers in education. In 1989 Salomon wrote a marvellous article in which he emphasized the difference between cognitive effects with computer tools and of computer tools: “The former manifesting improved performance and the latter manifesting a subsequent cognitive residue as a result....analytic research fails to capture the multivariate rich classroom environments that

the effective use of computers requires and brings about. It is suggested that another research approach – a systemic paradigm – is needed to study such rich and multivariate cases” (p. 521). A systemic approach requires studying the entire system of interacting variables as opposed to focusing on one element (“the study of the flute is not the study of the orchestra”, p. 525). Salomon contrasts an analytic approach to studying computer effects, in which one variable is studied leaving everything else unchanged, with a systemic approach, in which “everything has to be changed” if computer use is to be an effective change agent in real practice. In a systemic approach, once one thing is changed, many other things change as well. “While the analytic approach assumes that a complex and rich environment can be studied and understood by singling out for analysis its more basic elements, the systemic approach assumes that the situation cannot be so studied. ...the flute alone is not the flute in the orchestra.”(p. 529). Clark’s 1983 arguments that media are no more than the “delivery truck” delivering the “groceries” (i.e., the instructionally designed contents) and the ensuing debate with Kozma (1991) and others also capture the complexity, if not lack of validity, of using only an analytic approach to studying computers in support of learning.

Our work has been influenced very much by Salomon’s argument. It is a key reason why we have made relatively little use of controlled experimental work for hypothesis testing in our research. Ethnographic and reflective approaches are the most effective means of studying the impact of a contributing-student approach using technology as a learning workbench in the type of rich and complex ecology where variables are continually interacting and changing because of the interaction. Most of the situations where we have worked have been, as Salomon says, situations where “most everything is allowed to affect most everything else...The music we enjoy is produced by symphonic orchestras, not just single flutes” (p. 530). Each of the examples of our research that we will mention in Part 2 could be interpreted as a kind of (meta)-case study within these approaches.

Our action-research and design-research orientations do not mean that we did not think very seriously about the more-traditional research approach involving experimental design and hypothesis testing during our careers. We formulated our views in a special issue of the journal *Computers and Education*, which we published together with our colleague dr. Ivan Stanchev (Collis, Moonen, & Stanchev, 1993).



Ivan, Betty and Jef, 1989

The issue was focused on the question: What is the nature of research relating to computers in education? How can it be conceptualized? In the preface of that special issue we explained how we answered those two important questions. The following paragraphs are based on that preface, with our current comments added. We began by saying:

We see our approach to research in a spiral conceptualization where each revolution of the spiral could be broadly seen as having three phases of research activity.

The first phase of this spiral revolution was described as follows:

The Describe-Understand-Explain Phase, where the intention is to look insightfully at a particular context, to see what is happening with computer-related applications in that context, and to try to explain it in that context, at the same time relating the local context to theory and to generalizable guidelines and experiences from previous research.

In practice, much of this kind of research is often commissioned by large organisations, or on a small scale, and is often done by individuals during their involvement in project work. Depending on the results, the impact of

such large-scale research can be of major importance on the policy level. On the individual level, the scale is often too small to have impact.

The second phase was described as follows:

The Multiple-Loop Instrumentation-Implementation Phase, where the intention is to bring a particular version of instrumentation or implementation to a local setting and test its fit to the context. From this experience, the researcher revises the instrumentation or implementation strategy, and tests its implementation again.

In practice, many computer and education projects reflect this approach. Given the general attitude in the 1980s and 1990s, the focus in projects was mostly on producing a 'product' in the format of educational or instructional software and implementing it in a specific situation. Design-research methodologies, as well as methodologies from software engineering adapted to the educational situation, apply here. Many times our goal was to incorporate enough flexibility, portability, or adaptability into the product so that the end user can tailor it to his or her own situation. As examples of this approach we introduced the concept of a 'teacher toolkit' (Moonen, 1989), and researched the possibilities of increased portability of educational software (Collis & De Diana, 1990). Prototyping was used to create opportunities for iterations to optimise the projected product, adapting it to the evolving insights in the context in which it had to be used.

Finding out about the real impact of a product on characteristics of the user (learner) –in Salomon's terms on the performance of the user as well as on the subsequent "cognitive residue"– occurs in the third phase of the research spiral that we and Stanchev described in 1993. In contrast to the formative character of the evaluation in the second phase, in this third phase a summative evaluation approach is used.

This third phase is called:

The Impact Measurement Phase, in which the intention is not only the elaboration of the impact in the local setting, but from this, insights, guidelines, principles, or even theory can be articulated, to be used by ourselves and others in a new round of the Describe-Understand-Explain Phase....This sort of activity can lead to a new revolution of the spiral itself, aimed at building a global set of design guidelines for the domain. Such guidelines must transcend individual, localized experiences, be both useful as organizers and visionary as directions for subsequent [action and design] research. Occasionally such studies can stimulate the research direction in a field, so that it jumps out from one gestalt of the domain to something new, new in perceptual vantage point or new in metaphor or new in agenda.

Many of our activities and results, in particular the evaluation and trend studies we have done over more than two decades, can be recognised in the approach described. In most cases there were insights evolving from activities in which we tried to describe, understand, and explain, and then extrapolate such insights to a broader framework. When appropriate, we became involved in design and development work, relating to the second phase of our 1993 research framework, often leading to the formulation of design guidelines or/and a decision-support structure to be used by the projected target group. In addition, and often in the context of the dissertation research we supervised, we also explored the impact-measurement phase. (The appendix lists the dissertation projects that we either separately or together supervised during our Twente years).



Three of our PhDs: Elske Heeren, Dianne Aarntzen, Carla Verwijs

It may be that the insights and (design) guidelines that are generalizable to broader contexts are our most long-lasting contributions. In this respect, our work has led to the development of a number of (mostly) procedural frameworks which have formed a reference point for our further thinking and research, and which have been validated in a number of settings outside of the original local contexts. Examples include the 4-E Model (Collis, Peters, & Pals, 2001); the 3-Space Design Strategy (Moonen, 2000); the Simplified Return-on-Investment approach (Moonen, 2005); and the TeleTOP architecture as an reference model for a CMS to be used as a learning workbench (Collis, 1999). The First Principles Plus Reference Model, emerging from Betty's work with Anoush Margaryan at the Shell EP Learning Centre, has the potential to be another useful procedural framework (Collis & Margaryan, 2005). But most important, these lines of thinking have led us to the concepts of the contributing student and the learning workbench. For us, the contributing-student approach is the core of a new pedagogy relevant in the context of a rapidly evolving technology within the emerging knowledge society. The electronic learning workbench, for us, is the vehicle to make the new pedagogy practical and scalable.

In the next sections some major experiences in the professional life of Betty and Jef as researchers and practitioners will be used to illustrate the evolution of our major ideas. These experiences are organized around a number of different time periods: (a) our separate pre-Twente years, and (b) our shared Twente years divided into three sections, shaped by our working situations and the dominant technologies of the time (1987-1993; 1994-1999; and 2000 until the present). For each time period some major focuses will be mentioned. For us, the whole process has been, and remains, a fascinating journey.

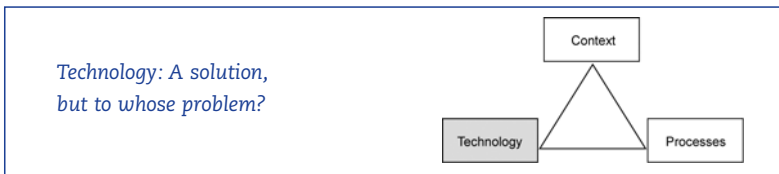
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The Pre-Twente Years

Although Jef and Betty come from different continents, their backgrounds have interesting similarities that brought them to share the general observations illustrated by the triangles in the introduction to Part I of this reflection, even before they met each other.

In terms of our context-processes-technology triangle the major focus of the first part of this period was:



Betty and Jef had professionally similar starting points in their educational technology journeys. Both were mathematics teachers, and early on both became professionally active, working with other mathematics teachers.



Jef and Betty as mathematics teachers

Both co-wrote textbooks for mathematics teachers. While Betty's textbook was only used in her school district in California, Jef's series of books were used for many years throughout Belgium.



*First of a series of books aimed at pre-service teachers,
by Jef Moonen and Frans Snoeys*

Both did graduate work at consecutive times in the late 1960s at Stanford University in the USA with the same mentors and instructors (although they did not meet each other then). In particular, both worked with Patrick Suppes, one of the first people to develop programmed instruction on the computer. Both went on to become faculty members in universities (Betty in Canada at the University of Victoria, Jef in The Netherlands at Leiden University), both teaching statistics and research methods. Both loved teaching; particularly contact with the students. Both were developing a philosophy of teaching that focused on the learner being able to, at least occasionally, take control of how he or she learned. But particularly relevant to their eventual shared story is the fact that both became involved with computers in education because of problems they faced in their own teaching.



Opening page of the Leistat program

Jef had practical problems in his teaching of statistics at the University of Leiden. He had to deal with hundreds of students. While he wanted to offer individualization and differentiation, with so many students he could not manage this on his own. Thus, in the mid 1970s, Jef began work with computer-based learning material. In this context, Jef designed and developed a software package called Leistat, which was subsequently used in different versions for more than 20 years at the University of Leiden as well as other locations.

Leistat was a digital workbench, not a program to deliver instruction. It was not meant to replace the instructor, lecture, or textbook but rather to serve as a workbench to support students in their practical assignments and in preparation for their assessments. It was not a tutorial-based system, but was problem focused. There were problems that students could download, if they chose, to practice trying to solve. Resources were available to help them, including small tutorials which they could call on if they wanted help with a specific problem. The power of the computer was used for calculations, for generating simulations to illustrate statistical concepts, for automatic feedback on practice assessment exercises, and for the logistics of individualizing and differentiating practice based on the control and choices of the students.

For Betty, the problem was of a smaller scale but was still a problem that formed a basic frustration for her in her work. Betty is left-handed and writes with her hand hooked around the pen or chalk from the top; because of this she could not write legibly on blackboards. In addition, Betty was also aware that she could not demonstrate the dynamics of many mathematical ideas on the blackboard with her poor chalk-handling skills. What Betty had seen about tutorial-type computer-based instruction at Stanford in the 1960s

The "Draw" Program

```
10 REM DRAW A PICTURE BY BETTY COLLIS OCTOBER 1982
11 HOME
12 VTAB (8): HTAB (12): PRINT "*****"
13 VTAB (10): HTAB (13): PRINT "GRAPH A PICTURE"
14 VTAB (12): HTAB (12): PRINT "*****"
17 PRINT : PRINT : PRINT
20 INPUT "PRESS 'RETURN' IF YOU ARE READY TO GRAPH YOUR PIC-
   TURE . . . "; B$
30 HGR
40 HCOLOR = 6
50 VTAB (21)
60 PRINT "TYPE THE COORDINATES OF YOUR CORNERS"
70 INPUT A,B
80 X = A * 20
90 Y = 140 - 10 * B
100 H PLOT X, Y
110 INPUT C, D
120 X = C * 20
130 Y = 140 - 10 * D
140 H PLOT TO X,Y
150 VTAB (23)
160 INPUT "DO YOU HAVE MORE POINTS ?"; Q$
170 IF Q$ = "NO" GOTO 200
180 PRINT : PRINT :
190 GOTO 110
200 PRINT : PRINT
210 VTAB (21)
```

Example of small BASIC program by Betty

was no answer to her personal problem. For Betty, the breakthrough came in 1979 when the Apple II microcomputer became available. The first moment that Betty saw the portable computer she realized that she could use it as a personal workbench for her own teaching, to demonstrate dynamic ideas, for example through probability-based games, and to display animated visual material such as the graphs of equations of various sorts changing their characteristics with changes in their coefficients. She could prepare beforehand, and could also set up the little programs so that the students themselves would do the input of data for the probability simulations and the graphing activities and thus, in a small-scale way, also use the computer as a workbench. Betty bought an Apple II the very day she saw it in the store and began to write a little BASIC program each evening that she could use the next day with her secondary-school students.

Betty's ideas always involved students using the computer themselves, in a whole-class setting, to demonstrate or try out ideas or create something to share with each other. Like Jef, Betty did not design "instructional software", she created environments in which students could try something out or express themselves, or make something that could be shared and displayed. A good teacher was still necessary.

Thus, in their pre-Twente years both Jef and Betty were triggered by problems in their own teaching; both took the initiative to make use of computer technology to respond to those problems in their own particular contexts; both used a student-in-control approach rather than an instructional approach; both were using an action-research methodology (without knowing the term); both did their dissertations around their experiences (Jef in 1978, Betty in 1984); and both found that in using computers in their own contexts many other good results occurred beyond the original problems that motivated the first step.

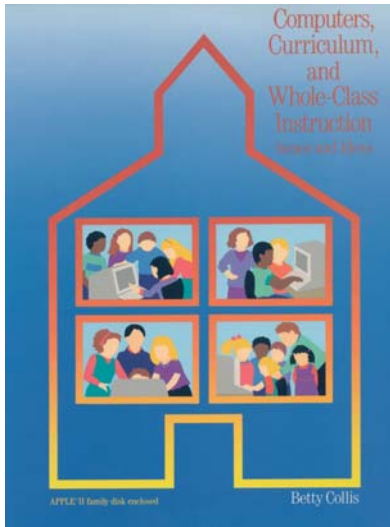


Betty at her promotion at the University of Victoria



Jef at his promotion at Leiden University

Typical, however, of their later work, there were some differences in their early approaches. Jef created a complex mainframe-based system for his Leistat workbench, requiring considerable programming skill and representing state-of-the-art technical approaches that required institutional support for the technical infrastructure. In contrast, Betty wrote her little BASIC programs overnight, with the aim of capturing an idea that came up in the classroom the day before. These differences partly reflect their different geo-social contexts: Betty is a North American who expects to go forward, fast, on the basis of personal initiative; Jef is a European who first gains organizational support for his carefully thought out ideas and for the resources needed to support them. These differences show up in the next phases of their pre-Twente years.



Textbook written by Betty

Reflecting these differences in personal styles, Jef and Betty built on their initial workbench-related uses of computers in different ways. Betty began working directly with teachers, in their own classrooms, trying to directly adapt to their own contexts and to find an approach for using the micro-computer that would fit their needs and interests and that could be set up and running in a short period of time. The textbook she later wrote was structured around these types of activities (Collis, 1988).

She subsequently did more than 250 hands-on workshops for teachers all over the Canadian province of British Columbia –always in their own schools and classrooms, always focusing on the microcomputer as a tool for learners to express themselves– to explore and extend what could occur within the ordinary learning setting. The implicit goal was to find out if her approach was generalizable over different teachers, subject areas, and infrastructural circumstances. Her central question became “Will they use it?” where the “it” was not Information Technology as a broad category, but rather some specific computer-related activity for a particular classroom moment. This bottom-up approach also created top-down perspectives, as Betty started to be asked to advise on and evaluate what others were (thinking about) doing with computers in education, at the institutional and district level both in and outside Canada (for example, Collis, 1987).



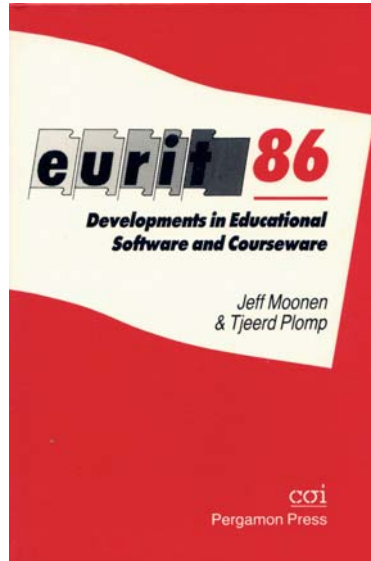
Award for Betty's work in ICCE and ISTE

She also became involved in international professional activities relating to supporting teachers in their uses of computers, becoming President of the International Society for Technology in Education (ISTE) in 1987. These different lines of experience made it clear to her that 'people in their contexts make it complicated'.

In contrast, after his Leistat experiences Jef built upon his organizational sensitivities to become involved in broader policy perspectives on computers in education (Plomp, Van Deursen, & Moonen, 1987).



Proceedings of a European conference on computers and education, co-chaired by Jef

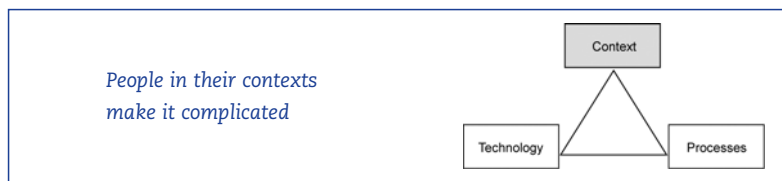


Proceedings of the first EURIT conference, co-chaired by Jef

When the Minister of Education in The Netherlands started a policy to introduce the use of micro-electronics in schools in the early 1980s and, as part of his policy measures, established a national centre for education and information technology (COI), Jef was asked to set up the centre and to become its first director in 1981. The Center was to be in Enschede, related to the University of Twente. For Jef this was the opportunity to explore if his ideas about computers and education that worked quite well in his Leisat experience could be generalised to a broader national context. For Jef, information technology (IT) in the broad sense could be a tool to improve education, but it required national commitment, professional project management, strategic alliances among many different stakeholder groups, and financial stewardship for its implementation. One of his major interests was to support the development of a general development methodology for educational software, focussing on an industrial approach for quality control and scalability (Moonen & Plomp, 1987; Moonen & Van der Mast, 1986).

But even with substantial amounts of money available and consistent positive political support, as was the case in the informatics stimulation plan (INSP) that was the project backbone of the national IT-related activities in The Netherlands in the 1980s, success was only partial and certainly not guaranteed. After the INSP a series of follow-up national IT-stimulation projects had to be created to keep the stimulation effort going. However, (and even now in 2005, 25 years after the beginning of the computers in school stimulation in the Netherlands), many problems with respect to using information and communication technology (ICT) still remained, particularly problems related to the structural organisation of the educational system and to the willingness or ability of the teachers and the others involved to change: As Betty had also learned, *People in their contexts make it complicated*.

Thus, for both Jef and Betty, the major focus for the second part of the pre-Twente years was context.



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The Twente Years



Jef at work at TO

In 1987 the COI became a private company (called ECC: Educational Computing Consortium), and Jef became its first director. At the same time a vacancy for a professor in the Department of Instrumentation Technology (ISM) opened up in the Faculty of Educational Science and Technology (in Dutch: TO, abbreviation for Toegepaste Onderwijskunde). Jef applied for this position and was appointed, thus handling both jobs until 1989 when he moved full-time to the academic setting. Jef chose to return to teaching and research instead of managing a commercial entity, particularly to be able to research why the establishment of the INSP did not work out as expected.



Betty at a conference in Bulgaria in the mid 1980s

In addition to her work with teachers, by this time Betty had established an international career as an evaluator of regional computers-in-schools projects and a member of various international committees, all relating to computers in education.



Betty and Jef at the COI, 1988

When they met in 1987, Jef needed an external evaluator for work going on at the COI. Betty became that evaluator and thus also became familiar with Jef's faculty at the University of Twente. Given her expertise and interests, she was invited to join the faculty herself in 1988.

As we worked together, we found that we had gone through the same kind of experiences with computers in education, albeit in different circumstances, and we also found that we agreed in our analyses of the problems encountered. Together we could start searching for solutions. Our on-going journey began.

Because of the length of the period, we will divide our Twente years into three sections, partly shaped by technology, partly shaped by our working situations. The first period, a time when technology convergences were a major development (multimedia and telematics), started around 1987/1988 and continued until around 1993-1994. The second period, the World Wide Web years, concludes at the end of 1999, when we finished our joint study trip and together drafted our book based on our lessons learned (Collis & Moonen, 2001). The third section concludes with our retirements, and is dominated by new rounds of experience with technology as a learning workbench.

Selected Reference:

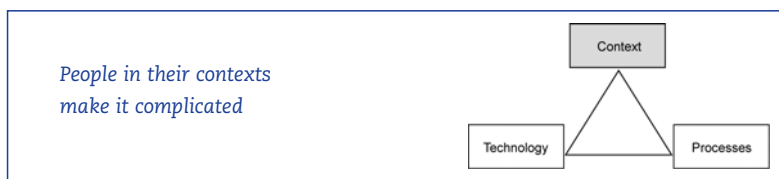
Collis, B., & Moonen, J. (2001). *Flexible learning in a digital world: Experience and expectations*. London: Routledge.

Period 1987/88-early 1990s:

From Microcomputers in the Classroom to Multimedia and Telecommunications

For Jef, this period was focussed on the convergence of technologies into multimedia; for Betty it was related primarily to the introduction of telecommunication technology in the school environment.

In terms of our context-processes-technology triangle the major focus of this period was:



*Jef appointed Advisory Professor by the President
of East China Normal University*

For Jef, the period was dominated by an institutional focus and leadership, as Department Head during the entire period, also as Dean of the faculty from 1991-1994. Despite this administrative responsibility he also remained active internationally, for example becoming an Advisory Professor at the East China Normal University in Shanghai.



Betty's focus was on national and international educational computer- and telematics-related implementation and evaluation projects.

Betty as co-chair of the TELED 1993 conference

Examining why computer-related technology gets used, or more often why it does not get used, in practice was a dominant focus for both Betty and Jef. While in the field the big issues relating to computers in education were how to get what platform of computers into the schools (and how to train teachers and students to use the computers), two different kinds of convergences were evolving on the cutting edge of technology developments. One type was the convergence of audio-visual technologies and computer software into multimedia. The other type was the convergence of information and communication technologies –called telematics and later ICT in Europe and telecommunications in North America.

A major event for Jef during this period was his inaugural speech (“oratie”, in Dutch) as a full professor in the University of Twente (Moonen, 1990).



Jef on his way to give his inaugural address



*Computers are changing the world,
but will they change education?
Inaugural address by Jef*

In this speech, Jef emphasized the potential of hyperlinked multimedia databases as learning tools, particularly in a transition from computer-based learning as something that is steered by the teacher or software developer to the discovery-oriented learning that can take place in the workbench context. He predicted a new situation in which the learner would become the final author of customized learning material. He also emphasized the importance of having access to original resources in order to strengthen the position of the user in the process of information dissemination and to reduce what he called “information pollution”. In his conclusion (translated from the Dutch) Jef said:

“...Information technology for learning should be focused on approaches where open exploration is an important component. From this perspective, multimedia databases have a strong potential. The teacher can shape the learning routes taken with the databases so that they best fit the needs and context of the learners, also in an exploratory sense. This approach calls for a new sort of collaboration between teacher and student and can have a positive impact on the development of insight and problem solving”(1990, p. 37).

Betty's technology focus remained the convergence of information and communication technology which had been a passion for her since the mid-1980s. Her emphasis was on using technology to expand communication and collaboration processes for learning (for example, Collis, Veen, & De Vries, 1993). With the educational use of telematics, the technology was purely a workbench, with tools to help people connect, communicate, and collaborate. There was no instructional design for the software involved, and generally no specialized educational software at all: how the workbench was used depended on the creativity of the teacher or user. As technology, the

tools available at the time for network connectivity were hard to access and hard to use; the workbench itself –the network platform– was a serious barrier. Although the Internet was available, this was generally only in the university setting, and it required complex infrastructure and policy commitment at the institutional and even national level. In Europe, the Internet was seen as a product of the American military, and many countries promoted their own networks and forms of datacommunication as alternatives, such as Minitel in France. Betty, with her colleagues Pieter de Vries and Wim Veen, wrote recommendations for an educational network service for schools which were ahead of their time in the early 1990s.



Recommendations for an On-line Service for Dutch Education (Collis, Veen, & De Vries, 1993)

Within their own courses in the faculty, Betty and Jef continued to be pioneering users of technology. Both redesigned courses that they inherited, from lecture dominated to “blended” models. Jef used the notes function in Windows as a tool for students to annotate each others’ work online. Betty used e-mail as a tool for communication and collaborative activities with her students, even though all were on campus (this was considered a novelty—the use of telecommunications was assumed to relate only to communication over distances). Both Betty and Jef used the computer-conferencing system “First Class” as an electronic workbench, not only for communication but also to integrate electronic study materials, student submissions, feedback, and as a platform for collaborative work.

Several research projects relating to stand-alone computers in schools were particularly important to Jef and Betty in this period. One of them was the

PRONTO Project. Instead of a general national plan, the idea of PRONTO was action research within specific school contexts. PRONTO was a longitudinal project (1987-1992) financed by the Dutch organisation for educational research (SVO). Its main goal was to implement (the school part) and identify (the research part) ways in which to fully integrate computers into all aspects of the curriculum in two specific secondary schools in the Netherlands. Both schools were in the neighbourhood of the University of Twente, in order to make sure that a close cooperation between researchers and the teaching staff of the schools could be optimal.



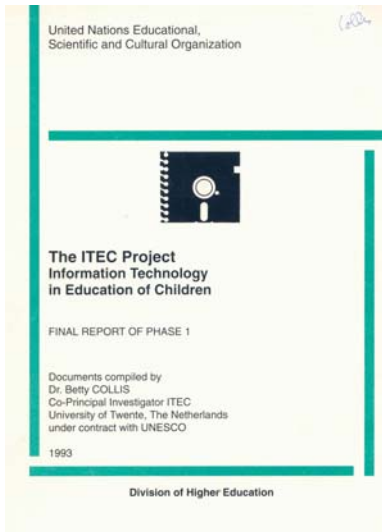
Final report of the PRONTO project

Jef remarks:

The project worked out rather well, although at the end of the project, I, as the project leader, faced a moral dilemma. Although the great majority of teachers (70-80%) were indeed using computers in their lessons, there was still a substantial group of teachers who refused to do so. More important, it was not clear how the group of resistant teachers could be convinced to change their minds. Nevertheless, in the end report of the project (Moonen, 1993), my response to the question 'Is there a future for computers in secondary education?' was 'Yes,' mainly based on the argument that the students who were more and more confronted with IT in their daily lives would not accept that the schools would stay behind. This was an important argument to convince myself that involvement of the real end user in the process of using IT in education should become more prominent. This was for me a crucial turning point in my search for an appropriate design and development methodology for electronic learning material.

Another opportunity for Jef to work further on this objective of involving the end user in the design process came during the period that he was dean. In 1992, during a regular meeting between the deans of the three social-science faculties of the University of Twente, the deans came to the conclusion that the design methodologies used in the three faculties generically showed much similarity. An idea was born to see if it was possible to describe a common social-science design methodology. The university financed a joint four-year project for the three faculties involved. Eventually it led Jef to formulate what he called the 3-Space Design Strategy, a generic framework for design-and-development processes. The basic idea of the strategy is a process which is heavily based on the importance of the context and the involvement of end users. After two phases of interactions involving the end users (during buy-in and project specification, and during rapid prototyping), a partial product emerges which the end users take over and tailor themselves to a final form that fits in their own specific, even individual, contexts.

For Betty, a major research project during this period was ITEC (Information Technology in Education and Children). The 1986-1991 project, of which she was co-chair, was sponsored by UNESCO. For this research, Betty worked with researchers from over 20 countries around the world (Jef was the Dutch representative), studying in detail the practices of teachers in each of the



Final report of the ITEC project

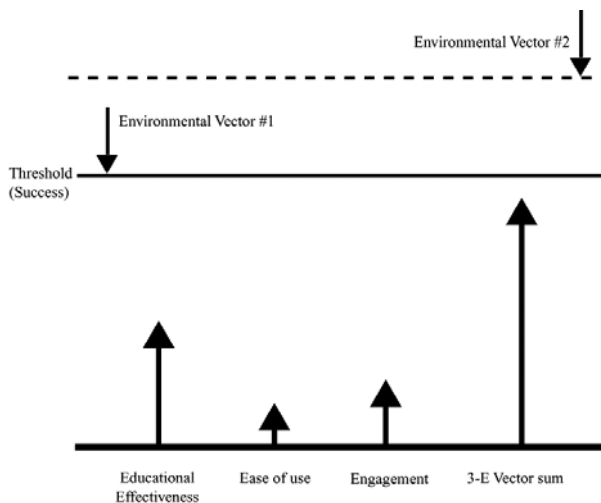
countries who were recognized by their peers as “doing great things with their (nine-to-ten year old) students using classroom computers”. Instead of studying barriers to implementation, the project studied successes. The final conclusion of the ITEC project (Collis, 1993) was that there was no recipe for these successes: the teachers were doing many different types of activities with the classroom computers, some had minimal equipment and some had well-equipped labs, the types of hardware varied, as did many other demographic features of the courses such as class size and physical environments.

Betty summarizes this long study:

The common elements were the importance of the teacher and the chemistry between the teacher and the students. The computer was not the dominate focus; it was this interpersonal interaction. In some countries it was free and informal, in others formal. These were good teachers, who used the computer as a tool in a way that fit their contexts. Also, the learning activities involved the students working actively together, using microcomputers as tools rather than as devices delivering instruction.

With regard to telematics for education, Betty was lead researcher in ten different studies involving inventories of applications of telematics for learning, evaluations of different initiatives that piloted particular applications, and strategic analyses and recommendations for how to go forward. From one of these studies (Collis & De Vries, 1991) building on Betty’s “Will they use it?” orientation, the 4-E Model was first expressed. Betty, Jef, and many of their ISM colleagues and graduate students have been using the 4-E Model as the interpretative framework to respond to the question of “Will

they use it?” ever since. The 4-E Model is a model to describe or predict the likelihood of an individual’s voluntary use of a technology-related intervention/tool/resource for support of learning. The model indicates that this likelihood can be expressed in terms of the vector sum of three clusters reflecting the point of view of the individual involved: (Perceived) Effectiveness (relating to the user’s own problem); Ease of Use; and (Personal) Engagement; weighted against a cluster representing the characteristics of the Environment or context in which the individual is a part. The interaction of these 4 Es explain or predict the likelihood of the individual’s use of the technology-related intervention/tool/resource in his or her own context and setting. Jef was investigating the same implementation problem, but from the perspective of cost-effectiveness. Are the results worth the cost? This perspective can map onto the 4-Es: effectiveness is clearly in both, and cost can be seen as a function of ease of use, personal engagement, and environment.



The 4-E Model

Throughout this period we reflected on appropriate research methodologies as well as design methodologies for the questions which dominated our work (see the Research Preface). We saw clearly that the coupling of research with the design process or with implementation processes was appropriate for our user-oriented philosophy. We came to see the generalizability of our results in terms of design guidelines and interpretative frameworks, rather than in terms of a theory to be tested in context-neutral contexts (Moonen, & Stanchev, 1993). For us, humans in their complexity are both the objects of study and the co-contributors to the design/research process.

In conclusion, Part 1 of the Twente years

Betty and Jef's interest in technology as a learning workbench remained strong in this period, as researchers and as users of technology as workbenches in their own teaching. Both were concerned with implementation issues, and with taking into account the complexity inherent in people in



Betty and Jef together

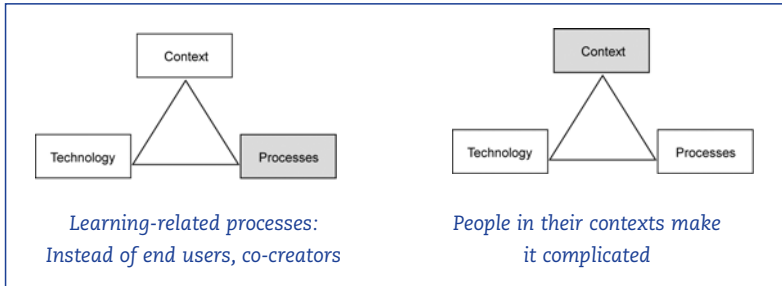
their contexts. At this time, technology continued to offer much promise in education, but the gaps between its possibilities and what actually happened in practice were high. The 4-E Model for Betty and the 3-Space Design Strategy for Jef emerged during this period, and have continued as major frames of reference for us throughout our careers. During this period, Betty and Jef became a smoothly interacting and productive partnership, professionally, in the university, nationally, and internationally. They also interacted well on a personal level: Betty and Jef married in 1990.

Selected references for the period:

- Collis, B. (Ed.), (1993). *Final report of the ITEC Project: Information Technology in Education and Children*. ED/93/ws/17. Paris: UNESCO. (406 pp).
- Collis, B., & De Vries, P. (1991). *Vooronderzoek telematica in het onderwijs*. (Telecommunications in secondary education). Report contracted to PRINT-VO, Ministry of Education and Science, Hoevelaken, NL: PRINT.
- Collis, B., Veen, W., & De Vries, P. (1993). *Final report of the CISO project*. Den Haag: PTT Telecom.
- Moonen, J. C. M. M. (1990). *Computers veranderen de wereld, doch veranderen ze ook het onderwijs?* [Computers are changing the world, but are they changing education?] Inaugural address, for assuming the professorship "Instrumentatie Technologie". Enschede: Faculty of Educational Science and Technology, University of Twente.
- Moonen, J. C. M. M. (Ed.), (1993). *Is er toekomst voor computers in het voortgezet onderwijs?* [Is there a future for computers in secondary schools?]. De Lier, NL: Academisch Boeken Centrum.
- Moonen, J., Stanchev, I. (1993). Educational interactive systems research: Instrumentation and implementation. *Computers in Education*, 21(1/2), 163-172.

Period 1994-1999: The Step Change-The World Wide Web

During this period our major focuses were:



In terms of technology, the World Wide Web became available in 1994 and changed society in many ways. It immediately created a step change in the use of technology for learning, and it created a step change in our work.

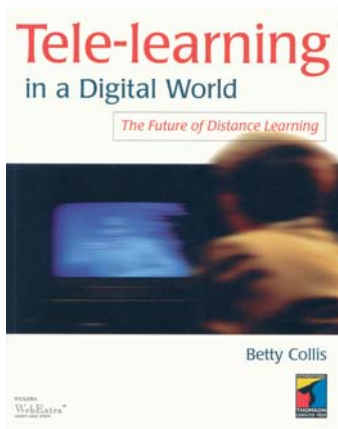
The World Wide Web is a remarkable phenomenon. As a technology, it provides a common platform accessible from any computer that can access the Internet. The substantial barriers associated with access to information and resources that had always been the case with stand-alone educational software could now be substantially reduced. The Web as a platform integrates communication and hyperlinked information in a seamless way. Web browsers and Web search engines quickly became electronic workbenches for people of all ages all around the world. Unlike pre-structured educational software, the Web is neutral in its pedagogy: the workbench offers its affordances via intuitive, simple-to-use browser interfaces. Most importantly, the Web offered a new platform for self-expression, for creation, and for sharing, for contributing one's ideas and experiences for others to find and use. Action research was the means by which Betty and Jef and their ISM colleague Gerard Gervedink Nijhuis explored this potential in their own courses during this period (Collis & Gervedink Nijhuis, 2000).

In the first year or so of the Web, it was not yet a platform for multimedia; the technology for accessing animations, video, and audio took a few years to become mainstream. However, it improved throughout the 1990s, as, for example, with streaming technologies. Web sites became more complex, and

frames came to be used to better structure the sites and simplify navigation. With the gradual addition of interactivity via cgi scripts, Javascript, and Java, Web sites could “remember” some aspects of the profiles of their users and retain and reuse users’ submissions. The power of databases came to be integrated with Web environments, so that Web page views could be generated on demand based on templates that served as interfaces to the database. Communication and collaboration tools were quickly integrated into Web systems; the emergence of Web-based course-management tools began in the mid 1990s and soon became the most-successful type of learning-support software ever, in terms of quantity of users. Betty led the team that developed the Web-based TeleTOP course-management system beginning in 1997-1998, which we will discuss later in this section.

The professional learning-technology community tended to be slower than the general public in responding to Web technology. When Web functionalities were limited, as was the case in the early and mid 1990s, the minimal access to multimedia and multimedia communication, coupled with the “cowboy” feeling of the amateurs who were calling the Web their own and publishing and communicating without benefit of professional designers, developers or gatekeepers, led many technology professionals as well as policy makers to feel sceptical about the Web. But Web technology, coupled with the Internet, created such a groundswell of attention and use in society that the Web and the Internet quickly became the focus of a new round of attention, policy, prediction, and development relating to technology in education.

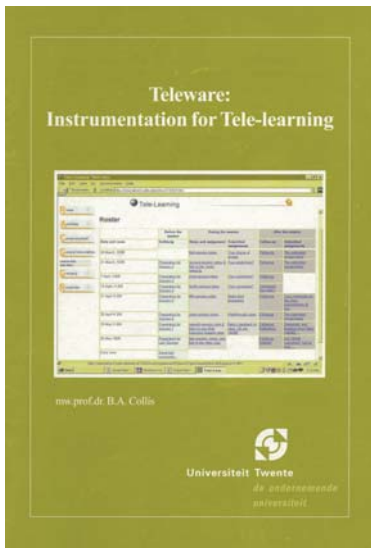
Many, unaware of the experience and research that had already accumulated with computer-related technology and learning, became new prophets, predicting the same radical changes to education as their counterparts of the 1970s had predicted at the start of the microcomputer era. The step change does make new and powerful affordances possible, but people and institutions remain barriers to radical change; teachers need to see and make use of the pedagogical potential of the affordances of the Web, or its use will fail to exploit its potential (Collis, 1996a).



Textbook by Betty, 1996

Betty made this the theme of her inaugural speech (“oratie”) when she became a full professor in 1997 (Collis, 1997). At this time she defined ‘tele-learning’ as “making connections among persons and resources via telematics for learning-related purposes” and “teleware” as products used in the context of tele-learning. In her inaugural speech she noted:

What are the requirements for success of teleware? First of all, not only teleware, but also a social dimension (perhaps we could call this humanware) is important; as these sorts of learning experiences typically involve communication and interaction with distributed co-learners or experts.....In order to optimise the quality of the learning experience, a learning community must develop among the participants, and this in turn requires commitment and regular participation. (p. 12-13).



*Teleware: Instrumentation for Tele-learning.
Inaugural address by Betty*



Two professors now

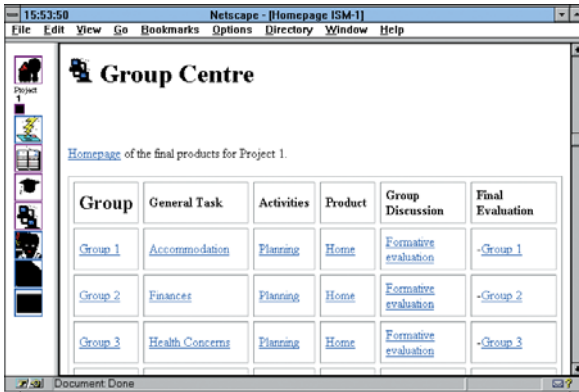


University of Twente Best Instructor Award
1997 for Betty

During this period, Betty also received the award for the best instructor (in Dutch: Onderwijsprijs) at the University of Twente. The best-instructor award from the students was important in that it showed that students valued the contributing-student approach to Web-system use that Betty emphasized in her courses.

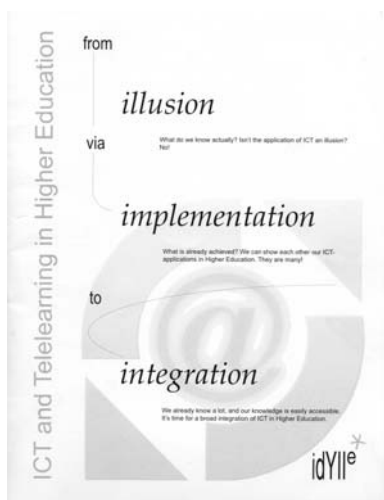
When Jef finished his deanship, he returned his full attention to the Department ISM. It was a period of change and growth in the Department that reflected the changes in technology. One major area of change was the curriculum. The first-year design-and-development course, called ISM-1, was completely redesigned with Betty now part of the instructor team. The new ISM-1 not only focused on multimedia, but also on the Web. HTML pro-

gramming (and soon, Javascript) were not only objects of study; Web technology was also the workbench for the overall course processes themselves and the medium of the students' products.



Screen dump of website for the course ISM-1 (1995)

Jef and Betty were also involved in the university-based IDYLLE project (1996-2000). The University of Twente profiled itself as a leader in ICT research, and in this context Jef became the project leader of an extensive project, IDYLLE, whose goal was to demonstrate the appropriate use of ICT to help students to move through the degree programs in the time expected. The project was structured around five subprojects, each of which was chaired by a team of two professors, one from our own faculty and the other from the Computing Science faculty. The cooperation between educationalists and computer scientists was seen as an advantageous combination of the best of two worlds: education and computer science. However, the local contexts of the two faculties involved –their disciplines, language, and views of research– were very different. Although the intention was to develop, within the five subprojects, the building blocks of a common technology workbench, each of the subprojects became too focused on its own scientific



Cover for a conference about the IDYLLE project

objectives to produce a common product. Again, people in their contexts made it very complicated. Through its various activities, for instance through the conferences it organised and the website it made to disseminate the information about the project and help instructors, the project did make an important contribution to the awareness of the potential of ICT in higher education teaching and learning at the University of Twente (Wetterling & Moonen, 1999). This helped shape the context in which TeleTOP (which was developed outside of IDYLLE) could succeed.

The experience gained from the use of Web technologies for support of our courses, as well as from other research and practical experiences that were accumulating, led to the start of the TeleTOP Project. In 1997, the leadership of our faculty decided to stimulate working people to participate in our educational programs, and Betty was asked to lead the project that would prepare the faculty for this new cohort, which would appear in nine months'

time. A first, and key, decision was to focus on providing flexibility to all students, not just the working cohort, and thus not to launch a parallel



The TeleTOP team: Betty Collis, Wim de Boer, Allard Strijker, Elka Remmers, Oscar Peters, Gert-Jan Verheij, Ger Tielemans

distance-education variant but instead to redesign our courses around flexibility and options for all students. The number of lectures was reduced, and replaced by an increase in the number and type of activities that the students would do outside of the classroom setting using technology as their workbench. This ambition required a Web-based system. From our experience in a European Union project with the course-management systems currently available (Collis & De Boer, 1997), we knew that our ideas, particularly for building courses around student contributions, could not be expressed with the systems at the time. Thus, the TeleTOP team was formed with

Betty as team leader, and the TeleTOP system was designed and developed. The way in which this design evolved reflected Jef's 3-Space Design strategy (Moonen, 1996, 1999a).

00	Dates & TOPICS	Introduction	Activities	Workplace
10	Welcome Everybody! Week 1 (21.9 - 28.9)	Make 'Yourself at Home'	Finish by September 28th Activities in Week 1	<ul style="list-style-type: none"> Talk to your supervisor Communicate your P# set-up Arrange a visit to the "shop" of the data acquisition contractor
20	Introduction & Data Acquisition Week 2 (29.9 - 3.10.)	Get to know Petrophysics	Finish by October 3rd Activities in Week 2	<ul style="list-style-type: none"> Talk to an experienced Petrophysicist from your OU about Operations
40	Working Knowledge Week 3/4 (5.10 - 17.10.)	The Tools & Quicklook	Finish by October 17th Activities in Week 3&4	<ul style="list-style-type: none"> Finish by October 17th Explore Petrophysical Concepts in your OU
50	Workshop Preparation Week 5 (20.10 - 24.10.)	Preparation for the Workshop	Finish by October 24th Activities in Week 5	<ul style="list-style-type: none"> Week by October 24th Get ready for your Workshop Presentation
60	Workshop at Shell Learning Centre Workshop@Shell, The Netherlands www.shell.nl	Practical Aspects of Petrophysics (more info on first day of workshop)	Course material & exercises available day-by-day	

Screen dump of a corporate course using TeleTOP

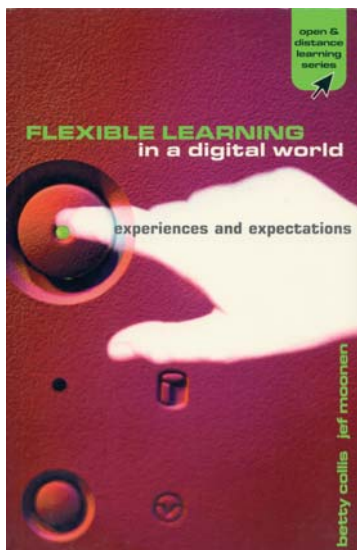
There are many publications and presentations relating to the design and development of TeleTOP in the 1997-1999 period; Jef and Betty synthesized them in their 2001 book. By the end of 1999, TeleTOP was in use in all of the courses of the faculty and was in high demand by other faculties and by other institutions outside of the University of Twente. Thus, during 1999, plans began for transferring the operational responsibility for TeleTOP out of the faculty and up to the overall university level. In 2005, the TeleTOP system is still in use in many different settings (www.teletop.nl/teletop.nsf/home/en) from elementary schools to a military college, and provides affordances (particularly through its embedded performance-support tools for instructors and its roster functionalities) that are not present in the same way in other course-managements systems (Collis & De Boer, 1999).

Also on the applied level and in accordance with our general research approach, Jef became more interested in measuring the impact of using technology for learning; he therefore became involved intensively in research on cost-effectiveness. The research followed a path from traditional cost-effectiveness studies in a number of large-scale projects (for example, Moonen, 1997) towards thinking in a more-methodological perspective. He focused on the inadequacies of traditional cost-effectiveness approaches to capture intangible aspects of technology use in education, and from this, his Simplified Return on Investment (SROI) approach took form (Moonen, 1999b). The SROI approach involves providing a tool for decision-makers for systematic thinking about return on investment (ROI).

Conclusion: Part 2 of the Twente years

For Betty and Jef, this was a period of combining the leadership of large research projects with personal, hands-on use of Web technology for their own teaching. For all of these, the results supported similar conclusions: The workbench approach for technology is more likely to be tailorable to the specifics of the local context than content-delivery approaches; the user needs to be engaged and in control, with his or her own problem as the starting point; and the contributing-student pedagogy is a powerful learning process that exploits the affordances offered by Web technology. TeleTOP was more successful than the other projects because it reflected these criteria more than the other projects. By the end of the 1994-1999 Betty and Jef, with TeleTOP, were able to be creative more easily with technology in their own teaching than had been the case in the previous period: they were able to use technology as a workbench to support expression and the peda-

gological ideas of the contributing-student approach. For us, Web technology, the World Wide Web, and TeleTOP put that potential into our hands again.



*Flexible learning in a digital world,
by Betty and Jef*

At the end of the busy period came a time of reflection and consolidation. An important decision for Betty and Jef was to take a joint study leave for the last four months of 1999. During the study trip, we made the conceptual choices for our book “Flexible learning in a digital world: Experiences and expectations” (Collis & Moonen, 2001).

The book is constructed around 18 lessons learned from our collective experiences. The concept of the ‘Contributing Student’ was also made explicit in the book and worked out in relation to different scenarios of technology evolution in education. The following table shows those lessons.

Lesson 1	Be specific	We need to define our terms and express our goals in a measurable form or else progress will be difficult to steer or success difficult to claim.
Lesson 2	Move from student to professional	Learning in higher education is not only a knowledge-acquisition process but also a process of initiation into a professional community. Pedagogy should reflect both acquisition and contribution-oriented models.
Lesson 3	You can't not do it	The idea whose time has come is irresistible, and conversely.
Lesson 4	Don't forget the road map	Change takes a long time and is an iterative process, evolving in ways that are often not anticipated.
Lesson 5	Watch the 4-Es	An individual's likelihood of voluntarily making use of a particular type of technology for a learning-related purpose is a function of four "E"s: the environmental context, the individual's perception of educational effectiveness and of ease of use, and the individual's sense of personal engagement with the technology. The environmental context and the level of personal engagement are most important

Lesson 6	Follow the leader	Key persons are critical.
Lesson 7	Be just-in-time	Staff-engagement activities to stimulate instructors to make use of technology are generally not very effective: Focus on just-in-time support for necessary tasks.
Lesson 8	Get out of the niche	Most technology products are not used in practice beyond their developers. Keep implementation and the 4-Es central in choosing any technology product.
Lesson 9	After the core, choose more	Technology selection involves a core and complementary technologies. The core is usually determined by history and circumstances; changing it usually requires pervasive contextual pressure. The individual instructor can make choices about complementary technologies and should choose them with flexibility in mind.
Lesson 10	Don't overload	More is not necessarily better.
Lesson 11	Offer something for everyone	A well-designed WWW-based system should offer users a large variety of possibilities to support flexible and contribution-oriented learning not dominated by any one background orientation. If so, it is currently the most appropriate (core or complementary) technology for flexible learning.
Lesson 12	Watch the speed limit	Don't try to change too much at the same time. Start where the instructor is at, and introduce flexibility via extending contact sessions to include before-, during- and after aspects, with each of these made more flexible. Move gradually into contribution-oriented activities.
Lesson 13	Process yields product	Through the process of contributive learning activities, learners themselves help produce the learning materials for the course.
Lesson 14	Aim for activity	The key roles of the instructor are becoming those of activity planning, monitoring, and quality control.
Lesson 15	Design for activity	Instructional design should concentrate more on activities and processes, and less on content transmission and a pre-determined product.
Lesson 16	Get a new measuring stick	What we are most interested in regarding learning as a consequence of using technology often can't be measured in the short term or without a different approach to measurement. Measure what can be measured, such as short-term gains in efficiency or increases in flexibility.
Lesson 17	Be aware of the price tag	It is not going to save time or money to use technology, at least not in the short term.
Lesson 18	Play the odds	A simplified approach to predicting return on investment (ROI) that looks at the perceived amount of relative change in the factors that matter most to different actors is a useful approach to support decision making or evaluation.

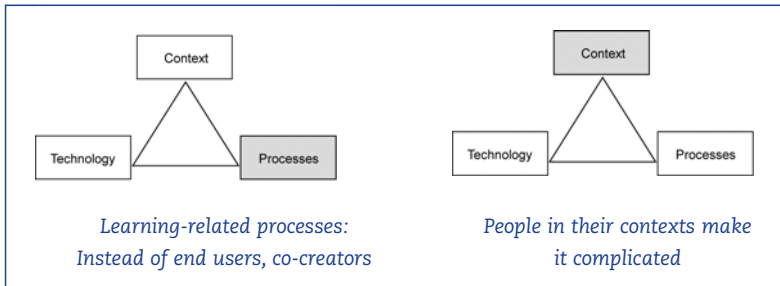
Lessons learned, (Collis & Moonen, 2001, pp.2-3)

Selected references for the period:

- Collis, B. (1996a). The Internet as an educational innovation: Lessons from experience with computer implementation. *Educational Technology*, 36(7), 21-30.
- Collis, B. (1996b). *Tele-learning in a digital world: The future of distance learning*. London: International Thomson Publications.
- Collis, B. (1997). *Teleware: Instrumentation for tele-learning*. Inaugural address, for assuming the professorship "Tele-Learning". Enschede: Faculty of Educational Science and Technology, University of Twente, Enschede, The Netherlands.
- Collis, B., & De Boer, W. (Eds.). (1997). *Evaluation of the technical platform and of the course adaptation process, the FORUM Project*. Deliverable 8.3. FORUM Project. Project Coordinator: LaSept/Arte, Paris, France. Project sponsored by the Commission of the European Communities, DG XII, Brussels.
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- Collis, B., & Gervedink Nijhuis, G. (2000). The instructor as manager: Time and task. *The Internet in Higher Education*, 3(1-2), 15-37.
- Collis, B., & Moonen, J. (2001). *Flexible learning in a digital world: Experiences and expectations*. London: Routledge.
- Moonen, J. (1996). Prototyping as a design method. In Tj. Plomp & D.P. Ely (Eds.), *International encyclopedia of educational technology* (2nd ed.) (pp. 186-190). Oxford: Pergamon.
- Moonen, J. (1997). The efficiency of telelearning. *Journal of Asynchronous Learning Networks*, 1(2). Accessed 21 May 2005 from <http://www.sloan-c.org/publications/jaln/v1n2/index.asp>.
- Moonen, J. (1999a). The design and prototyping of digital learning material: Some new perspectives. In J. van der Akker, R. Branch, K. Gustafson, N.M. Nieveen, & Tj. Plomp (Eds.), *Design approaches and tools in education and training* (pp. 235-248). Dordrecht: Kluwer Academic Publishers.
- Moonen, J. (1999b). *Who needs ROI analysis?* Presentation at FLISH (Flexible Learning on the Information Highway) 1999, Sheffield Hallett University, Sheffield, UK.
- Wetterling, J., & Moonen, J. (1999). Supporting telelearning at the University of Twente: The Idylle project. In *Studieren 2000: Alte Inhalte in neuen Medien* (pp. 163-181). Münster: Waxmann Verlag.

Period 2000-2005: Applying the Workbench

Our main focus in this current period is applying the workbench in a variety of context, but with the contributing student approach as our interest. Thus, in terms of the contexts-process-technology triangles:



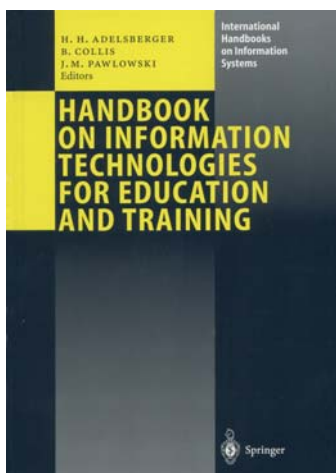
This period has found Betty away from Twente as much as she was there. Since 2000 Betty has been leading a large-scale research project in cooperation with the Shell Exploration & Production Learning & Leadership Development team which requires that she spend several days each week at the Shell EP Learning Center first in Noordwijkerhout and then in Rijswijk, in the west of the Netherlands. Jef continued his work at the university and in project-based activities, some of them in the corporate sector, but also started to explore the appointment of an eventual successor. At the same time Betty and Jef had to deal with organisational and curricular changes which became more and more visible in the Faculty.

The technology context

Technology developments have, of course, continued in the period 2000-2005. Technology is becoming more mobile, more ubiquitous, and Web-based technology is becoming more and more a part of everyone's daily life. In higher education, ICT infrastructures are good, and access to the Internet can occur in an increasingly on-demand manner. Web-based course-management systems are common; "You can't not do it".

In international comparative studies of ICT in higher education we found several major conclusions:

ICT tools particularly e-mail, electronic agendas, and the Web, are common and commonly used to support the organizational processes of education; courses are now “blended”, featuring different combinations of digital and non-digital resources, tools, modalities, and types of communication integrated by a course-management system. ICT has not replaced the book and lecture on traditional campuses but is contributing to a process of “stretching the mold” through facilitating more and more flexibility in course procedures. Instructors are spending increasing amounts of time managing all of this technology support but with no particular reward, recognition or support (Collis, & van der Wende, 1999, 2002; Collis & Moonen, 2001).



*Handbook on information technologies
for education and training
co-edited by Betty, 2002*

But the widespread use of Web-based systems does not necessarily mean new pedagogical practices; typically the basic learning scenarios remain the same, but are more efficient and handier to deal with. Web systems are used as course archives, as course notice-boards, as vehicles for submission and management of assignments, and in some cases, for delivery and management of testing. The pedagogical affordances possible with Web-based workbenches are substantial, but not yet substantially exploited (Collis, 2003; De Boer, 2004, see appendix for reference).

This period also saw several types of developments within Web-based systems that particularly relate to Betty and Jef's work. In the corporate world, and to a lesser extent in other educational sectors, the idea of small, self-contained pieces of educational software has returned from the 1970s and 1980s, now in the form of “learning objects”. Old (and largely discredited

after many attempts to develop intelligent tutoring systems) ideas of delivering learning completely through a computer are returning under the name of e-modules, the use of LMSs (learning management systems) and LCMSs (learning content management systems), and the supposition that applying the right metadata will allow the system (or maybe a human) to make the right selection of modules for the learner at hand, delivering these as “beads on a string” (Collis & Strijker, 2001-2002). In his PhD research (see the appendix for references) Allard Strijker from the Department ISM and also from the TeleTOP team studied the reuse of learning objects throughout this period, working closely with Betty.

Also in the corporate world, a major debate is classroom vs e-learning vs blended learning, where blended learning most often is taken to mean a period of using the Web to do e-modules with little or no human interaction, followed by traditional classroom sessions or seminars. Workbench ideas for technology and learning are not yet familiar in the majority of corporate training settings. However, this is different in companies in regard to the support of informal learning. Knowledge-management tools and systems, as well as key “learning partners” in the workplace, play an important role in supporting the capture of tacit knowledge in the organization and facilitating knowledge sharing, coaching, and a learning community over time and distance (Bianco & Collis, 2004). Communities of practice are often well established and supported in corporate settings, where different network tools –typically Web-based and accessible only via the corporate intranet–facilitate contacts, knowledge sharing, and knowledge construction among professionals with a common interest. When community-of-practice ideas are successful outside of a common corporate context, notably among groups of professionals sharing a common interest, the technology used to facilitate them often takes the form of Web-based portals with tools for member submissions, shared workspaces and archives for accessing the underlying community repository, and tools for communication and transactions. Companies that integrate the strengths of formal learning and learning via community-of-practice approaches are seen as best-practice examples of organizational learning. This is the approach that has evolved via our action-research collaboration at Shell EP (Collis & Joergensen, 2005).

In both the corporate world and outside, “EPSSs”(electronic performance support systems) are another form of workbench-type technology to support learning- and performance-related activities. This name refers to a loosely

defined category: electronically available support to help individuals in the performance of a task or tasks. Gery, a pioneer in the field, describes (as quoted at http://www.pcd-innovations.com/what_is_epss.htm) the category as:

An integrated electronic environment that is available to and easily accessible by each employee and is structured to provide immediate, individualized on-line access to the full range of information, software, guidance, advice and assistance, data, images, tools, and assessment and monitoring systems to permit job performance with minimal support and intervention by others.

EPSSs can vary, notably in the form that the performance support can take (mini lessons? e-modules? examples? captured stories and reflections? help organized in various ways?); the extent to which the performance support is embedded within a task or other software system; the extent to which the user can control when and how he or she makes use of the support; and the extent to which the support is in some way tailored to the user based on his or her job profile or previous use of the system. EPSSs to support professional practice and on-the-job work and training typically operate in proprietary software systems, are database driven, and now are increasingly accessible via a Web browser. EPSSs, in development since at least the early 1990s (depending on the definition used), are now frequently overlapping with Web-based portals and tool environments available on the World Wide Web, and are the focus of a new wave of interest. In the Department ISM they have been the focus of a number of design-research projects, most recently the PhD research of Gerard Gervedink Nijhuis (2005) for the time- and task management of instructors using systems such as TeleTOP (see the appendix for references).

As a tool to support personal presentation and reflection, there is particular interest in the use of digital portfolios either separate from or integrated with course-management systems (Moonen & Tulner, 2004). An electronic portfolio uses electronic technologies, allowing the portfolio developer to collect and organise portfolio artefacts of many types (audio, video, graphics, text). It is a workbench that provides a comprehensive storage and display medium for the results of individual assessments, accommodating a potential variety in the instruments themselves as well as providing assessment opportunities at different time frames and for different performance indicators, in particular indicators dealing with less-intangible

results. Digital portfolios are seen as appropriate for all levels of professional and personal development. The European Institute for E-Learning (EIFEL, <http://www.eife-l.org/>) is providing all of its members with an electronic portfolio, calling it “the most innovative and fastest growing technology in the field of education, training and human resource development”. A European conference on the digital portfolio (ePortfolio, <http://www.qwiki.info/projects/Europortfolio/ep2004/>) in La Rochelle, France in 2005 had the following as its premise:

It is our belief that in 2010, every citizen will have an ePortfolio; this belief is supported by strong evidence such as the forward looking eLearning policy of Wales, which has already decided that each Welsh citizen will have an ePortfolio, the Italian Ministry of Education that has decided to provide each pupil and school with an ePortfolio. In 2010 every citizen will have an ePortfolio.

The last segment of our Twente years takes place in this technology context.

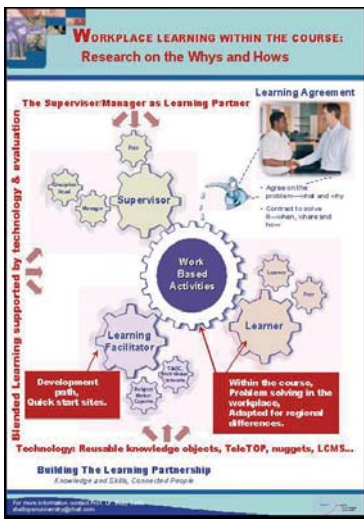
Workbenches in context

Our major focuses during 2000-2005 have been applying the TeleTOP workbench in new types of contexts, as well as designing, developing, and/or studying several new smaller-scale workbench-type tools. For Betty this has involved taking our ideas and technology into the corporate sector (with the major context being Shell International Exploration and Production). Jef’s research work went back to a situation similar to his University of Leiden period, in which technology was used to solve a particular problem in a particular situation, thus focusing on the fit of the context variables as closely as possible. Both Betty and Jef’s long-time interests in implementation continue as strongly as ever, for Betty in projects involving the 4-E Model (Collis, Peters, & Pals, 2001), and for Jef through developing criteria and tools for the Simplified ROI model and in the context-specific implementation research of three PhD researchers from Kuwait (Al-Hammar, 2005; Al-Najjar, 2002; Al-Thuwaini, 2003; see the appendix for references).

In this technology context, Betty’s work with Shell EP has been a substantial focus of her time in the period 2000-2005. In 2000, Betty was approached by representatives from Shell Exploration and Production Learning who had heard of her work with TeleTOP. Could she lead some projects at Shell EP linking learning to their competence-development framework for their

engineers and technical professionals with the support of technology, and in particular, could she see if the use of the TeleTOP system might offer possibilities for the Shell context and its unique problems? She agreed, and with Jef and others from the Department ISM she began a series of explorations at Shell EP in an action-research partnership context. Betty's comments:

The Shell EP project was another challenge for me; would our ideas and our TeleTOP system transfer to this corporate-learning environment? I believed that they would, but also knew (keeping the 4-E Model in mind) that I would be dealing with an unfamiliar and complicated context. A first critical step was to determine what their major problems really were. This was not hard; many of the senior technical staff in Shell EP will be retiring within the decade and those who will take their place will come from different cultures, regional contexts, and professional backgrounds. How can this 'big crew change' be prepared for? Trying to transfer the experience and know-how of the senior professionals within classroom-based courses was not enough. Could TeleTOP support part of an answer to this problem?



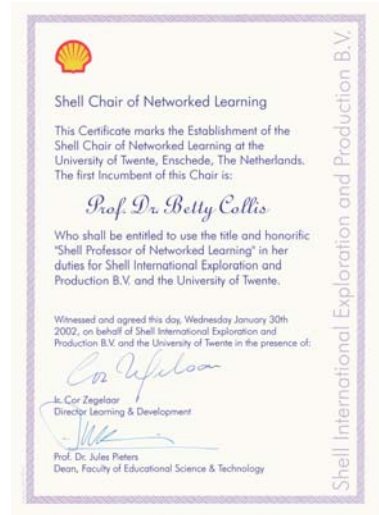
Shell EP workplace learning within a course

The answer is yes. Now in 2005, five years later, approximately 75 Shell EP courses have been redesigned in TeleTOP representing a version of the contributing-student approach tailored to the “big crew change” context (Margaryan, Collis, & Cooke, 2004). This has contributed to the eventual integration of formal course-based learning with knowledge management in an overall approach called Shell EP workplace learning.

Betty has held the Shell Chair of Networked Learning at the university since 2001, and also holds the position of Head of Research within the Shell EP Learning & Leadership Development unit.



Betty appointed as
Shell Professor of Networked Learning



Certificate to establish
the Shell Chair of Networked Learning

Betty has been personally engaged in many different aspects of the Shell EP learning evolution. She reflects:

Working with the course leaders (instructors) in the Shell EP context brings me back to where I feel most at home: starting with a context-specific problem, then helping to implement a new learning process (the contributing-professional approach) that can help solve the problem, with the help of a well-designed digital workbench.

In the context of the Shell project, three PhD projects are completed or nearly completed (Strijker, 2004; Bianco and Margaryan, both to submit in 2005, see the appendix for references) and 14 Masters projects have been successfully carried out.



*American Society for
Training and Development award*

The action-research partnership been awarded a Best-Practice designation by ASTD, the American Society for Training and Development (Collis & Joergensen, 2005).

Jef's research into design methodology and the Three Space Design Strategy (expanded into consulting design via the PhD work of Pieter de Vries, 2005; see the appendix for references), continues (Moonen, 2000; 2002). Jef also continues to pursue innovative approaches to studying the costs and effectiveness of technology-supported learning (Collis, Winnips, & Moonen, 2000). He recently completed a project to make his SROI approach available to other organizations via the Web with a team from the Digital University of The Netherlands (a consortium of higher-education institutions) (Moonen, 2005). A particular focus now is on criteria for measuring the implementation and impact of digital portfolios (Moonen, Collis, & Anderson, 2005).

During this period our work context at the University of Twente has undergone change. Because of a reorganization within the faculty (which changed from the Faculty of Educational Science and Technology to the Faculty of Behavioural Science in 2003), the Department ISM became part of a larger department called PHPT (Psychonomics and Human Performance Technology) in 2004, shortly after Jef's retirement. Betty's research group will be migrated into other research teams after her retirement.



Part of the ISM group in 2000

Thus, Betty and Jef's Twente story is coming to a close, but their on-going journey –personally and with technology as a learning workbench– continues.

Conclusion: Part 3 of the Twente years

In a way, our professional lives can be seen as a spiral. We both started our professional careers using technology to solve particular problems in particular situations. Characteristic of those beginnings was the use of technology within an existing traditional pedagogy. Given our work situations, these approaches brought us to expand our investigations into a broader context, looking for generalizable solutions. However, two main complexities frustrate this search to succeed: the complexity of the context and the complexity of the user. This made us realize that technology acting mainly as a delivery system could never produce a generalizable solution. Instead, technology should become the partner of the human, taking over his or her tasks where appropriate, but mainly supporting his or her activities by providing a superb tool and workbench (Collis & Moonen, 2005). In that perspective we are still very much convinced that action and design research are the appropriate vehicles to gain better insight into how to improve the performance of instructors and students using the flexibility offered by technology. And we feel it is important to take into account a

broad measure of return-on-investment, also incorporating intangible costs and benefits, in order to realize “socially responsible approaches” as explained by Reeves, Herrington, and Oliver (2005, see Research Preface). When acting in this way, action and design research will also lead, perhaps only partially and in a localised manner, to better insights in the “subsequent cognitive residue” described by Salomon (1989, see Research Preface). We have translated this into the contributing-student approach using technology as a learning workbench for the knowledge society. Such insights could then be the basis for more-theoretical research which incorporates hypothesis testing. However, this assumes that the personal and technology context of such investigations has found an equilibrium and will be stable for a considerable amount of time. There is evidence, visible each day, that this situation will not occur in the near future, and maybe not even in the far future. And thus we remain engaged, just as at the beginning of our careers, in applying and researching technology as a workbench in particular situations, but now within a new pedagogy of the contributing student.

Selected references for the period:

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- Bianco, M., & Collis, B. (2004, 25 November). *Technology-supported work-based learning in corporate settings: Exploring the role of the workplace learning partners*. Paper presented at the Workplace Learning from the Learners Perspective Conference, Learning Lab Denmark, Copenhagen.
- Collis, B. (2003). Stretching the mold: Web applications as tools for change. In V. Uskov (Ed.), *Computers and advanced technology in education* (pp. 2-7). Anaheim, CA: ACTA Press.
- Collis, B., & Joergensen, E. (2005, 6 June). *Partners in a learning evolution*. Paper presented at the ASTD International Conference & Exhibition, Orlando, FL.
- Collis, B., & Moonen, J. (2001, second printing 2002). *Flexible learning in a digital world: Experiences and expectations*. London: Routledge.
- Collis, B., & Moonen, J. (2005). Lessons learned about technology and learning. In G. Kearsley (Ed.), *Online Learning: Personal reflections on the transformation of education* (pp. 36-46). Englewood Cliffs, NJ: Educational Technology Publications.
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- Collis, B., & Strijker, A. (2001-2002). New pedagogies and re-usable learning objects: Toward a new economy in education. *Journal of Educational Technology Systems*, 30, 137-157.
- Collis, B., & Wende, M. van der (Eds.) (1999). *The use of information and communication technology in higher education: An international orientation on trends and issues*. Study commissioned by the Dutch Ministry of Economic Affairs and the Ministry of Education, Culture and Science. Enschede: CHEPS (Center for Higher Education Policy Studies).
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- Margaryan, A., Collis, B., & Cooke, A. (2004). Activity-based blended learning. *Human Resource Development International*, 7(2), 265-274.
- Moonen, J. (2000). A three-space design strategy for digital learning material. *Educational Technology*, 40(2), 26-32.
- Moonen, J. (2002). Design methodology. In H. H. Adelsberger, B. Collis, & J. M. Pawlowski (Eds.), *Handbook for information technologies in education and training* (pp. 153-180). Vienna: Springer.
- Moonen, J. (2005, 6 April). *A Web-based instrument to measure the value of e-learning*. Paper presented at EDUCAUSE Australasia, Auckland, New Zealand.
- Moonen, J., Collis, B., & Anderson, J. (2005). Standards and assessment for e-learning. In P. Resta (Ed.), *Teacher development and e-learning* (in press). Paris: UNESCO.
- Moonen, J., & Tulner, H. (2004). E-learning and electronic portfolios: Some new insights. In V. Mahnic & B. Vilfan (Eds.), *IT innovation in a changing world* (pp. 488-493). Ljubljana: University of Ljubljana, Faculty of Computers and Information.

Appendix

Overview of PhD dissertations and Masters theses in which Betty or Jef were part of the supervisory committee (promoter, main supervisor, chair and or member) in the Twente years.

Phd

- Amal Al-Hammar, *Electronic portfolios in Kuwait higher education* (defense planned, 31 March 2006)
- Petra Boezeroy, *ICT and models of change in higher education* (defense planned, 31 March 2006)
- Anoush Margaryan, *Work-based learning for technical professionals: A blend of pedagogy and technology*, (defense planned, 17 February 2006)
- Manuela Bianco, *Support for work-based blended learning: The supervisor and the workplace community* (defense planned, 3 February 2006)
- Gerard Gervedink Nijhuis, *Academics in control: Supporting personal performance for teaching-related managerial activities* (defense planned, 14 September 2005)
- Pieter De Vries, (awarded 10 June 2005), *An analysis framework approach for managing corporate e-learning development*
- Allard Strijker, (awarded 29 September, 2004), *Reusability of learning objects in context: Human and technical aspects*
- Wim De Boer (awarded 13 February 2004), *Flexibility support for a changing university*
- Salah Al-Thuwaini, (awarded 27 August 2003), *Navigational support for using virtual reality*
- Kholoud Al-Najjar, (awarded 19 June, 2002), *The application of blended computer-based training (CBT) in the Public Authority for Applied Education and Training (PAAET) in Kuwait*
- Gerrit Hiddink, (awarded 2001). *Educational multimedia databases*
- Lora Aroyo, (awarded 2001). *Task-oriented approach to information handling support within Web-based education*
- Slavi Stoyanov, (awarded 2001), *Mapping as a learning method in problem solving design*
- Petra Fisser, (awarded 2001), *Using information and communication technology: A process of change in education*
- Jan van der Veen, (awarded 2001), *Project-based tele-learning: Analysis, modelling, design and evaluation*
- Koos Winnips, (awarded 2001), *Scaffolding the development of skills in the design process for educational media through hyperlinked units of learning materials*
- Huai Heling, (awarded 2000), *Cognitive style: Its relations to memory capacity and concept mapping*
- Carla Verwijs, (awarded 1998), *A mix of core and complementary media: New perspectives in media-decision making*
- Chris Blom, (awarded 1997), *Usage-oriented courseware development for agricultural education*
- Joachim Wetterling, (awarded 1996), *Decision making and educational media. ESTIMA: A computer-based support tool*
- Elske Heeren, (awarded 1996), *Technology support for collaborative distance learning*

- Zhang Ji. Ping, (awarded 1996), *Investigating the portability of multimedia learning resources: Design for a "Teaching Models Toolkit"*
- Zhu Zhi Ting, (awarded 1996), *Cross-cultural portability of educational software: A communication-oriented approach*
- Sjoerd de Vries, (awarded 1996), *Aangepaste courseware: Vormgeving en betekenis. Aspecten van een methodologie van het onderzoeken van courseware-ontwerpproblemen*
- Al-Noor Ladhani, (awarded 1995) *Modelling and using performance knowledge for courseware design*
- Hilbert Kuiper, (awarded 1995), *An instructional support system for training simulators*
- Diana Aarntzen, (awarded 1994), *Audio in interactive tutorial courseware: Methodological and design guidelines*
- Plon Verhagen, (awarded 1992), *Length of segments in interactive video programmes*
- Piet Kommers, (awarded 1991), *Hypertext and the acquisition of knowledge*

Masters

In addition to supervising PhD candidates, Betty and Jef have been part of the supervisory team for approximately 250 Masters theses during the Twente years. A selection of these follows. The 'Int' after an entry indicates the International Master Programme. For a more complete list see the Web site <http://www.BettyCollisJefMoonen.nl>.

Selection from 1988-1993 (total of 52)

- Berg, David (1992). *The design of audiovisual materials for a teacher training for junior lecturers at the Indonesian universities.*
- Botter, Bob (1990). *Het ontwerpen en ontwikkelen van een simulatieomgeving in de object-georiënteerde taal Smalltalk-80* [The design and development of a simulation environment using the object-oriented language Smalltalk-80].
- De Kleine-Noorbergen, Eline (1991). *Het ontwerpen en evalueren van een prototype van een standaard instructieroute over kaasbereiden voor het lager agrarisch onderwijs.* [The design and evaluation of a prototype of an instructional approach to teaching cheese preparation in Lower Agricultural Education].
- Derks, Marieke (1989). *Needs assessment for design tools for (multimedia) courseware development.*
- Heeren, Elske. (1991). *Het in kaart brengen van concepten met behulp van de computer: Software die functioneert als een cognitief hulpmiddel.* [Bringing concepts into a map with the help of the computer: Software that functions as a cognitive helper].
- Kwant, Désirée (1989). *Een interactief beeldplaatprogramma voor het lasonderwijs.* [An interactive videodisk for vocational training for welding].
- Lanzing, Jan. (1993). *Visual aspects of the cultural portability of educational software.*
- Siteur, Ilse. (1993). *Ontwerp en ontwikkeling van een prototype simulatiespel ter motivering bij de implementatie van telematica in het voortgezet onderwijs* [Design and development of a prototype multimedia simulation game to motivate learning about telecommunications in secondary education].
- Ten Broeke, Bart (1992). *Ontwerp van de gebruikers-interface voor een multimediale gegevensbank voor het agrarisch onderwijs* [Design of the user interface for a multimedia database for agricultural education].

- Van Delft, Corné (1992). *Telecontact: een prototype telecommunicatiemiddel in videotex voor doven én horenden* [The development and evaluation of extra provisions in an on-line communication and information system for the deaf].
- Van der Hulst, Anja (1990). *Representing the domain in intelligent teaching systems: Anticipating on instruction*.
- Van Doorn, Frank (1993). *MacSimAuthor: een auteursysteem voor computersimulaties* [MacSimAuthor: An authoring system for computer simulations].
- Verwijs, Carla. (1992). *Computerjournaal: Evaluatie en implementatie van een multimedia pakket* ["Computerjournal": Integrating and implementing a multimedia learning package].
- Volman, Cees (1990). *Kwaliteitsbepaling van interactieve onderwijs leermiddelen* [Judging the quality of interactive learning materials].
- Voorburg, R.C., & Derksen, J.J.M. (1989). *Een audiovisuele gegevensbank voor basis- en speciaal onderwijs* [An audio-visual database for elementary and special education].
- Zwart, Willem Jaap (1988). *Flowsim: een computer simulatieprogramma voor het Waterloopkundig laboratorium met Gem op ATARI 1040-ST gebaseerd op het wiskundig model WAFLO*. [Flowsim: A computer simulation program for the Waterflow Laboratory with the GEM language on the ATARI 1040-ST based on the mathematical model WAFLOW].

Selection from 1994-1999 (99 in total)

- Arav, Tom. (1995). *Remote-Classroom: Hoe leerlingen praktijkinformatie kunnen verkrijgen via videoconferencing en PC-besturing op afstand tussen een klaslokaal en een bedrijf* [Remote classroom: the design of live communication sessions between the classroom and industry].
- Bolkestein, A. (1996). *Ontwikkeling van een handleiding voor het ontwikkelen van een educatieve CD-ROM* [Development of a handbook for the development of educational CD-ROMs].
- Breman, Jeroen (1995). *Het effect van instructieformat op segmentering bij instructie met interactieve video* [The effect of instructional format on the segmenting of instruction with interactive video].
- De Boer, Wim, & Hamel, Quirijn (1998). *Supporting the design of courses in the World Wide Web*.
- De Vries, Linda (1994). *Design considerations and the application of a qualitative content evaluation to a tele-seminar at the Distance Education Centre, Toowoomba*.
- De Wit, Guido (1999). *Implementatie van gedigitaliseerd videomateriaal in verschillende onderwijssituaties* [Implementation of digitized video material in different instructional situations].
- Eekma, Anke (1996). *Defining guidelines for an individual distance learning environment*.
- Fisser, Petra (1996). *Interactive personalized course generation. Design and prototyping of an electronic management course on the World Wide Web*.
- Hamers, Coen (1995). *Ontwerp van een netwerk voor de regionale overheid Twente* [Design for a community network for Twente] (Int).
- Hoogendoorn, Paul (1998). *Design of a group memory system based on computer conferencing in a distance training*.
- Jager, Karen (1999). *Wereldwijd toetsen: Toetsen via een WWW-omgeving in het basisonderwijs van de Wereldschool: implicaties en nieuwe mogelijkheden voor leerlingen, ouders, en docenten* [Worldwide testing: Testing via a WWW environment in primary education in the 'Wereldschool: Implications and new possibilities for students, parents and teachers].

- Kraan, Andriani, & Moorelisse, Natasja (1997). *From Enschede to Shanghai: The portability of an Internet course.*
- Lohuis, Ronnie (1996). *Distance education through the WWW: Making a HCI course available throughout the world.*
- Margaryan, Anoush (1998). *Design and development of a www-based course on integrated performance support systems. (Int).*
- Mijwaart, Maarten (1996). *De ontwikkeling van een standaard didactische interface voor projectonderwijs op het world wide web [The development of a standard didactic interface for project-based learning on the World Wide Web].*
- Moonen, Bert (1995). *Een onderzoek naar de factoren die het gebruik van informatietechnologie in de klas veroorzaken [Research on factors that influence the use of information technology in the secondary school classroom].*
- Nieuweboer, Jan (1995). *Adapting groupware for distributed learning groups.*
- Nikolova, Iliana (1996). *Design of a method for flexible instructional modules development. (Int).*
- Remmers, Elka (1998). *Design of a support environment for mentors, managers, counsellors, tutors and learners active in the EUROPRO Programme.*
- Sijsling, Marinka (1996). *Multimedia-ontwerp: Multimediale ondersteuning bij de voorbereiding op en uitvoering van multimedia-projecten [Multimedia design: A multimedia electronic support system for the design and execution of multi-media products].*
- Strijker, Allard (1997). *De instrumenteel technische ondersteuning van teleleren door toepassing van Internet hulpmiddelen [Instrumentation for the technical support of tele-learning through the application of Internet tools].*
- Van der Linde, Myra (1995). *Didactische werkvormen en interactieve video: theorie en praktijk [Didactic approaches and interactive video: Theory and practice].*
- Van Rennes, Linda (1998). *WWW-based support environment for part-time students studying at a distance: Social and technical issues and guidelines.*
- Van Werkhoven, Sander (1998). *On-line support for handling off-nominal situations with the European Robotic Arm.*
- Verheij, Gert-Jan (1997). *Het Digitale Schoolplein Groningen, schakel tussen de Rijksuniversiteit Groningen en de Tweede Fase van de Voortgezet Onderwijsscholen [The Digital Schoolyard Groningen: Bridge between the University of Groningen and the senior secondary Schools in Groningen].*
- Verleur, Ria (1994). *Audiovisuele ondersteuning van schriftelijk instructiemateriaal: een toepassing van een streepjescode-gestuurde beeldplaat [Audio-visual support of text-based instructional material: An application of the barcode-accessible videodisk].*
- Veugelers, Erwin (1994). *Design of a computer communication and information system for distance education.*
- Vingerhoets, Jolanda (1994). *A 'cafeteria approach' to enhance flexibility in pan-European multimedia tele-training.*
- Vogelzang, Ina (1996). *Onderwijs en videoconferencing. Kennisoverdracht en probleemoplossen van experts in de medische sector [Education and videoconferencing: Supporting knowledge transfer and problem solving for experts in the medical sector].*

Selection from 2000-2005 (96 in total)

- Agelink, Edwin (2004). *Docentondersteuning bij ICT-gebruik: Docenten leren in een 'Community of Learners' [Instructor support for ICT use: Instructors as learners in a Community of Learners].*
- Alekseeva, Maya. (2002). *Design of WWW-environment for collaborative learning at the Heineken University. (Int).*

- Al-Jarah, Wijdan (2003). *Implementation of e-learning in an Arab Open University*. (Int).
- Cetywayo, Monica (2003). *Instructor support using TeleTOP at the initiation stage (University of Transkei)*. (Int).
- De Rijke, Rob (2002). *Guidelines to design and develop blended learning at Shell*.
- Ellafi, Ali Mosbah (2003). *Designing an electronic portfolio for measure preservice teachers' achievement*. (Int).
- Fekadesalassie, Fitsum (2002). *Redesigning the M148 Course for Blended Learning at the Shell EP Learning Centre*. (Int).
- Graeb-Konneker, Sebastian (2003). "Let's make things better": *The design and formative evaluation of a one-day workshop at Philips Centre for Technical Training*. (Int).
- Hafidz, Abdul (2003). *Learning effectiveness and perception of TeleTOP of onsite and distance master students in the Faculty of Behavioral Sciences of the University of Twente*. (Int).
- Hanevelt, Tessa (2004). *Het ontwikkelen van een digitaal portfolio voor het voortgezet onderwijs [The development of a digital portfolio for secondary education]*.
- Hendriks, Aniek (2003). *Quick Start Sites: The development of support tools for TeleTOP blended-learning courses*.
- Iswara, Rayi Pradono (2003). *Evaluating cost effectiveness in e-UMB environment. A case study in comparing traditional and digital activity of administrative processes*. (Int).
- Jacobs, Friedie (2002). *Corporate learning: The E-factor*. (Int).
- Jacobs, Lesley (2005). *How to use the IMAT tools in the RNLAf?*
- Kalinov, Vassil (2003). *Simplified return-on-investment instrument*. (Int).
- Li, Ziyuan (2003). *E-learning tool selection strategy in small to medium-sized enterprises*. (Int).
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