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LONG PAPER

# Computer supported collaborative learning and vocational training: adapting the technology to the learners' needs

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**Abstract** The aim of the ECODESIGN project was the development of a course in sustainable product design. The target group are employees in the areas of product design, marketing or similar areas. Some learners from this target group have a low computer literacy and are, therefore, reluctant to use advanced forms of electronic communication. Collaborative learning has to be designed according to the learners' needs, taking into account that many participants of the ECODESIGN course have to get used to electronic communication. Despite this problem, a community of practice seems to result from the ECODESIGN course. Active tutoring was especially important to motivate learners and to constitute the community of practice.

**Keywords** Blended learning · Vocational training · Learning communities · Community of practice · Active learner support · Collaborative learning · Trans-disciplinarity

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## 1 Introduction

In the year 2000, Encarnacao et al. [11] predicted that in the year 2005, university studies would primarily be offered online. This prediction apparently did not come true. Nevertheless, there is a gradual and steady process of dissemination of online learning in all forms of education. Especially in vocational training, this can lead to problems because of the lack of computer literacy among older employees. In the year 2002, 26.2% of Austrian citizens in the age group between 45 and 54 years and 53.3% in the age group between 55 and 64 years had never used a computer before. About half of the people who do use computers do not use it on a daily basis. This indicates that there are a considerable number of persons, especially among older people, who are not highly computer literate [43]. This lack of computer literacy might make the use of more sophisticated forms of e-learning in vocational training and lifelong learning rather difficult. There are two possibilities to tackle this dilemma. Either advanced features of e-learning systems (e.g., complex hypertext systems or chat) are used, and then, relevant target groups (e.g., minorities, people with a low level of education, women) will have difficulties to access these systems, or, advanced forms of e-learning are excluded, and then the potential of computers and the Internet are not exploited fully, and e-learning is presented in the form of textbooks on screens. The following paper discusses this problem, and tries to formulate a tentative solution. The focus of the paper is on the usage of electronic communication, as it presents the most salient problems, although hypertext structure and navigation can also engender difficulties.

Accessible information systems are sometimes described as systems enabling the users to understand and use their functions and get useful results independently of the

users' abilities/disabilities [7]. It has been argued that designers tend to develop systems for themselves unless told otherwise [17]. This implies that people with disabilities, older people, and some minorities are excluded from consideration when computer systems are designed. This paper argues that this also includes older people who are still members of the workforce but with little or no computer literacy. There is some indication that these people have serious problems when they are forced to use computers. These problems are similar to those described for persons already retired. Aula [3] argues that training for older adults needs more time, that they are more afraid of using computers, and that older users have difficulties in understanding the structure of the Web. This seems to be similar to the results of a study by Tampir [46], who developed a course module for middle-aged employees of a kindergarten with no computer literacy who were obliged to use computers by their employer. She found out that these users had serious difficulties to use a mouse and that they did not understand the basic Windows metaphor (the desktop metaphor). Learning took much longer than she had anticipated. Therefore, computer systems should also be adapted to this user group. Given that there are still considerable numbers of people with little or no computer literacy in developed countries also, this seems to be a relevant minority. The requirements of such users are probably similar to the requirements of elderly persons, with the only difference that the loss of physical capabilities will be not as pronounced as in the age group of 75+ [18]. It seems plausible that overcrowded interfaces and small size of letters [3] will not only affect elderly persons but also middle-aged people.

Savidis et al. [36] argue that there is still too little research concerning "design for all" in the context of e-learning systems. This is particularly problematic, as lifelong learning is becoming more and more important. In this context, e-learning systems play an increasing role. Therefore, it seems to be necessary to gather systematic knowledge about the design of inclusive e-learning systems. Ardito et al. [2] have made a first effort to develop systematic guidelines considering accessibility as well. More research in this area is necessary.

The Vienna University of Technology offers a variety of continuing education courses. In one of these courses—a course on sustainable product design (ECODESIGN)—the problem of lack of computer literacy of participants was encountered. Small and medium enterprises often find it inconvenient to send employees holding vital positions to longer courses. This is especially relevant for companies located in remote geographical areas. Therefore, it seems to be a sensible solution to offer training in sustainable product design as an e-learning course. In a project that started in September 2003, such a system was developed. The course is based on the experience of face-to-face classes. The instructional material used so far was a book with a CD-ROM [49].

It is necessary to adapt such a course not only to the needs of the target group that consists mainly of employees in production companies in various sectors, especially product designers, but also people who work in marketing or similar occupations. Precondition for the participation in the course is an academic degree in a technical subject or work experience plus adequate technical knowledge. Most of the potential participants already have a considerable amount of practical experience, and their goal is to combine this practical experience with relevant and systematic theoretical knowledge. Conventional approaches in university education often fail to attract members of this target group. It has often been argued that adult learners need more autonomy in their learning processes, and that their practical experience should be integrated into the curriculum [16, 33]. Constructivist approaches as described, for example, in Duffy and Jonassen [9] or Schulmeister [40] seem to be appropriate in this context. The ECODESIGN e-learning course is based on practical examples that have to be solved by the participants of the course. These examples do not have one correct answer, but several possible solutions. The teaching of factual knowledge only plays a minor role. The learners' experience plays a major role for the solution of all the examples, and especially for the last example that is not given by the trainers but formulated by the participants themselves. This last example enables the learners to relate their own experiences with what they learn in the course (situated learning), which helps them to transfer the information they gain in the course to their own practice [20].

## 2 Collaborative learning and learning communities

As mentioned above, adult learners have specific needs compared to school or university students. They often have more experience in some well-defined areas than the trainers or tutors in vocational training courses. Therefore, the traditional models of instruction based on the idea of an expert teacher and naive students do not apply well to adult learning. Collaborative forms of learning, in which the learners can profit from each other's professional experience and exchange ideas and views, seem to be more appropriate. In online learning courses, such forms of collaboration are usually based on more advanced forms of communication technology (such as electronic forums, chats, video-conferencing, shared whiteboards etc.), but many learners in adult education only have little experience with computers. This issue is also mentioned in the literature. Woodrow [50] points out that there seems to be a

relationship between participation in vocational training and previous education and qualification. Contrary to expectation, lifelong learning does not especially address learners with a low level of education or minorities. In addition, there is some indication that much of the learners' computer literacy comes from informal education, and not from formal training [47]. The authors also found evidence that persons with more computer literacy evaluated e-learning more positively. More informal and formal education and training in information and communication technology (ICT) skills is, therefore, necessary. Koper and Tattersall [19] discuss another important feature of lifelong learning—the fact that the target group is often heterogeneous. In one course, there may be students with quite diverse backgrounds and educational levels. There are several possibilities to overcome this problem, one of them being setting up learning communities in which participants can learn from each other.

The concept of communities of practice and learning communities is based on the ideas of Lave and Wenger [20]. They assume that learning is social and largely influenced by daily experiences. Communities of practice and learning communities involve more than simply technical knowledge; they also require interpersonal relationships and commonly developed rules and regulations. In this way, a shared knowledge basis is developed. Communities of practice and learning communities can help to develop new ideas and new methods. Schlager et al. [37] posit that communities of practice can also come from a wider network of colleagues spanning several institutions. Sometimes they are better catalysts for innovation and learning when they function outside an institution. The community that emerged from the ECODESIGN course and is still meeting regularly is an example for such a group. In sustainable product design, there are still so few experts that a community of practice can only come into being as a network of experts from several institutions. The idea of communities of practice and learning communities has also been combined with computer-mediated communication [44, 12], but Sheard [41] comments that there are still no fully developed pedagogical models which help to explain and design such systems. She also emphasizes the social nature of learning in learning communities, but points out that creating and maintaining a learning community can be a problem. Sometimes, students are reluctant to post messages in online discussions. She also mentions the problem of the role of the teacher and whether she/he should actively participate in the discussion or not. Sometimes, it seems to be preferable that peers give feedback rather than teachers. In addition, she describes guidelines and best practices for the management of online groups.

An important aspect in the organization of electronic learning communities is to convey a feeling of social presence to the participants [27]. In computer-mediated communication, this can be difficult at times because of the lack of physical stimuli (facial expression, gestures, tone of voice, etc.), which can convey much of the meaning of a conversation. Collaboration based on face-to-face communication often seems straightforward and easy to achieve. One of the reasons for this is probably the fact that people learn how to communicate with each other from an early age onwards. In addition, there are fairly clear-cut rules that govern face-to-face communication even if they are not always consciously used or reflected by the participants of a communication process [34]. In contrast to that, computer-mediated communication (CMC) has to be designed explicitly to support the communication process. Clear-cut rules are often lacking [6]. In the literature, examples of problems with CMC in the context of e-learning systems and possible solutions for these problems are thoroughly discussed [1, 15]. Isckia and Delalonde [15], for example, report that the discussion groups they investigated contained many redundant postings, which caused feelings of frustration with many students. They also point out that in face-to-face communication, this problem would not have occurred. Wheeler [48] states that distance learning students tend to feel isolated and are, as a consequence, less motivated to finish their courses. He argues that e-learning courses are more successful when there is collaboration and interaction. When social presence is low, students feel less engaged and their commitment is low. On the contrary, when social presence is high, students' commitment is also high.

All this indicates that the problems occurring in computer-supported collaborative learning cannot only be solved by technological means. Pedagogical and organizational measures also play an important role. Especially, older or untrained learners need special forms of assistance and specifically designed systems. The organization of learning communities can be very valuable in making vocational training profitable for all learners in heterogeneous groups. In such groups, all learners have some form of professional experience and can, therefore, learn from each other. In the ECODESIGN course, for example, a small learning group was set up consisting of a product designer, a marketing manager, and a chemist. They worked together to solve a specific problem (the design of an ecologically sound product), and despite their different education and experience, they were quite successful at that. The learners in the ECODESIGN course also had a specific form of assistance (active tutoring, see below) which helped set up a learning community but also lent assistance to learners with little computer literacy.

Another important aspect in the implementation of collaborative learning systems (apart from setting up learning communities and active assistance for learners) is

the concrete design of the e-learning system. There is quite an extensive body of research about computer-supported collaborative learning. From this research, some more general conclusions can be drawn concerning the design of collaborative systems. These design guidelines, however, must be used carefully. As Dillenbourg [8] points out, there is no consensus as far as the definition of collaborative learning is concerned. Additionally, research is often context dependent. Dillenbourg mentions that research usually takes place on a small scale (few subjects, short time). This cannot, in most cases, be generalized to a larger scale. Nevertheless, there seem to be some results, which are fairly well supported by empirical research in different contexts.

Clark and Mayer [5] state that a vast amount of empirical research indicates that collaborative learning in general is advantageous. They point out, nevertheless, that it is very important to define beforehand the context of learning. In addition, in most cases it is not enough to simply tell people to cooperate. There must be a good reason for collaboration. Collaborative work must be integrated into the course in a sensible manner, and it must correspond to the pedagogical goals of the course. Otherwise, people will go on working individually. Beasley and Smyth [4], for example, describe an e-learning system where exactly this happened. An electronic forum was offered in an e-learning course, but it was not integrated into the course work and the students saw no advantages in using it. This happened despite the fact that, before the design of the system, most students had argued for the addition of electronic communication and said that they would like to use such a system. Another important experience is that students' electronic communication should always be moderated [1]. It is an open question how this moderation should look like, and to what extent the tutors or teachers should participate (see above). However, electronic communication in e-learning courses without any form of moderation tends to fail. In addition to that, principles of user interface design have to be employed. CMC should be easy to use. A forum, for example, should be structured in a clear and understandable manner and a chat program should be simple and stable.

Research indicates that collaboration in e-learning can be very advantageous if it is used properly and designed according to the learners' needs.

## 3 Promoting active learner support

The concept of active tutoring has been very important for overcoming the high dropout ratios typical for e-learning courses. Experiences with e-learning in University Continuing Education showed that learners need to be guided actively through courses. As a consequence, a didactical and pedagogical concept to provide effective online facilitation was developed. The (tele)presence of a single facilitator turned out to be a substantial factor in providing stability and continuity in a networked e-learning environment. The facilitator not only coordinates the learners' activities, but also becomes a mediator between the learners and the different authors and experts in the field. Independent from the course contents, learner activities are designed and monitored centrally and over the whole duration of the course. This active facilitation has turned out to be the key to success [29, 30].

In addition, active tutoring helps to support meaningful collaboration in learning communities, especially in cases when participants from different backgrounds have to come to a common understanding. This is important for vocational training. In such courses, the participants are usually more heterogeneous than in normal university lectures. People who attend vocational training often differ in age, educational background, and work experience. The facilitator in active tutoring has to help the participants in such courses to communicate with each other and to overcome conceptual differences [27, p. 151].

The concept of active tutoring was developed at the Vienna University of Technology and is used in several different continuing education courses. There are similar approaches at other universities. A well-known example for this is e-moderating developed by Salmon [35]. Salmon points out that an important aspect of the Internet is electronic communication. This feature should be used extensively in e-learning. To achieve this, teachers have to become e-moderators, that is, people who are able to organize and structure successful communication online. In this way, specific forms of active learning can be supported.

In continuing education, self-directed learning is most effective. Significant learning is much improved if learners are given the opportunity to discover laws, concepts, and theories—they should not be taught but can be coached [42, p. 9, 38, p. 17]. A facilitator should be willing and interested in helping the learners; facilitators should not repeat the contents or immediately answer the learners' questions; they shall help the group of learners to discover the answers by themselves [13, pp. 18–19, 32, pp. 79–80].

In the proposed approach for learner support through active facilitation, it is important to clearly distinguish between the different roles of actors involved, the most important being learners, content providers or authors of learning material, experts in the subject area, and facilitators. These different roles do not have to be "played" by different persons—for example, expert and content provider can be one and the same person, and as in peer tutoring, even one of the learners could take over the

facilitator's role—but for the success of this specific approach to e-learning, it is important to have these different roles represented.

The most important task of a facilitator is to take a "motivating" action—not in the sense of reinforcing extrinsic motivation (e.g., by sanctions)—but by supporting the formation of learning groups that develop their own social dynamics and commitment. The roles of facilitation and consequences for the facilitator profile have been defined as follows:

- The facilitator is the primary contact person for all the participants and contacts authors and experts;
- The facilitator has to take the initiative, for example, in soliciting questions, contributions or personal information from participants; (s)he elicits questions from participants and acts as moderator between the learning group and the authors/experts;
- The facilitator monitors each participant's activities, for example, by reminding them of their tasks;
- The facilitator creates a social learning environment—a virtual learning group, using the available technology; (s)he thus has to be technically and socially competent in communication technologies [22].

In short, the facilitator has to react timely to every input by a participant, should trigger self help and group support instead of providing direct answers by the expert, and keeps the team learning process going by setting tasks and deadlines, by ensuring information flow among participants, and by being supportive and communicative.

## 4 Trans-disciplinarity and collaboration

Trans-disciplinarity is the cooperation among different scientific areas. The different disciplines are involved in cooperation as equal partners. Trans-disciplinarity is process oriented and targeted. Mutual professional exchange among disciplines aims at gaining scientific findings from discursive practice.

When applied properly, e-learning is able to support such a dialogue between different actors. In this context, it is not sufficient to provide learners with online material for self-study; only active learner support can create a social setting that maintains interaction and increases the efficiency of the learning process. Thus, it enables to explore, cross borders between disciplines, and to produce trans-disciplinarity.

In the context of the ECODESIGN course, one of the basic insights is that sustainable solutions accepted by all stakeholders can only be reached by cooperation among all disciplines involved, considering all the different viewpoints, and integrating them into one solution. Only with the cooperation of experts from multiple fields of science and economy, innovative and successful solutions can be found. To apply the ECODESIGN method for solving real world problems, it is necessary to cross the borders between disciplines. Thus, ideally, the participating students should work together in trans-disciplinary teams, complementing each other's knowledge, and by this means increasing the amount of potential new insights to be gained by collaboration.

An additional goal of the ECODESIGN course is to create a trans-disciplinary community of experts to be maintained beyond the course itself. This goal can be reached most effectively based on the trans-disciplinary groups composed during the second part of the course.

## 5 Organization and design of the ECODESIGN course

The aim of the ECODESIGN course is to teach sustainable product design. Important topics in this context are not only the choice of environmentally friendly materials, but also logistics. It makes, for example, sometimes more sense to use a less environment-friendly product with short transport routes than a more environment-friendly product with long transport routes. Reusability of components or materials of products is also a relevant issue. The ECODESIGN course conveys a systemic view of this problem, taking all these aspects into consideration.

As mentioned above, the ECODESIGN e-learning course is based on a constructivist approach. In addition, teaching and learning in this course is integrated into the work practice of the participants. From interviews conducted during the course it emerged that all the participants of the first ECODESIGN e-learning course, which took place between October 2004 and January 2005, were motivated by the possibility to improve their job-related skills and by the potential to enrich their work. Many of them shared their practical experience in product design and ecology with the other participants and the trainers during the course. Whereas the knowledge of the trainers was systematic, comprehensive and more general, the knowledge of the participants was more detailed and related to the complex reality of product design. Some participants had, for example, more experience with the properties of specific materials than the trainers.

The ECODESIGN course for sustainable product design does contain a large amount of factual information, but the aim of the course is not to learn this information but to learn how to apply this information in a practical context. That is, the aim is the acquisition of procedural knowledge. The didactical concept on which the system is based has to take this into account. In addition, many members of the target group have not been involved in any formal

educational process for many years. Therefore, it is plausible to assume that these persons have difficulties with traditional teaching processes in which teachers simply present information to the students. Courses in vocational training also have to take into account that most participants work at least part-time and only have restricted time available. Therefore, the course organization has to be highly flexible to adapt to the participants' needs.

### 5.1 Pedagogical design

Sustainable product design is a trans-disciplinary process and can only be achieved as the result of the effort of work groups.

In a first phase, the participants of the course have to solve the first three introductory examples. These are very short. In this way, participants can get acquainted with the basic ideas of ecological product design. In the second phase, the participants have to solve three additional examples (which are also formulated by the trainers). These refer to concrete products (e.g., an electric water kettle or a garden chair), which have to be (re-)designed in a sustainable manner. In these examples, the participants are supposed to apply the knowledge gained so far about ECODESIGN. At the end of the course, the participants have to choose a product on their own for which they have to develop a sustainable design (phase three).

The solutions of the assignments have to be presented in text form formulated by the learners. This allows the learners to introduce their own experience in the learning process. The learners get feedback from the trainers for every example to help them understand the complexity of ecological product design.

The system is based on the metaphor of an office. The different tasks are located in different "rooms". The environment includes a room for communication: chat, discussion forum, and information about the participants of the course (Figs. 1 and 3). The examples and assignments, which the participants have to work on, are contained in files stored in an actual office. A library is also available with additional material necessary for the solution of the examples and for the everyday work of the participants (Fig. 2).

The relationship between tasks and rooms seems intuitively clear. It is obvious, for example, how to distinguish between materials in the office and in the library because the functionality of these materials is different. The material in the library consists of PDF files, which can be downloaded and printed out, whereas the material in the office is structured as a hypertext, and the participants work with it online. Because of this intuitive difference, this metaphor helps the learners to solve their task effectively and quickly.

The metaphor makes it easier for the learners to understand the structure of the system and to remember this structure [21, 40]. It is often argued that some metaphors do not work because of elements that do not conform to the domain that they are supposed to represent [28]. The interviews conducted with the participants of the first course showed that this is not the case here. The organization as an office with single rooms is a fairly consistent metaphor, which is easy to use. All participants stated that they understood the structure of the systems and had no problems navigating in it. For an analysis of the navigational behavior of 39 participants of two beta courses held in 2004, see Rester and Pohl [31].

### 5.2 Organization of the course

The maximum number of participants in the ECODESIGN course is 20. The course is organized in the form of Blended Learning. Face-to-face lessons are generally more attractive for the participants and seem to be quite an effective form of teaching. Participants, therefore, did not mind in coming to the university three times during the course. The three face-to-face lessons took place right at the beginning of the course, in the middle, and in the end. They made up about 30% of the course. In between, there were two online phases, in which the students had to work with the practical examples.

At the beginning, there was a one-day workshop with an introduction to the topic of sustainable product design and an explanation of the e-learning system. In the first online phase, the participants had to solve several examples. The second face-to-face lesson was a half-day workshop. In this workshop, the examples were discussed and the teams for the last example were set up. The teams also developed the idea for their final example. In the second online-learning phase, the groups had to work on their own project. In the last face-to-face meeting, the participants presented the results of their teamwork. This was again a one-day workshop.

### 5.3 Implementation

Some of the participants of the ECODESIGN e-learning course only had little computer literacy. Therefore, usability was a major issue in the development of the system. Accompanying the system development, several usability studies were conducted [24, 25, 31]. These studies helped to improve the system considerably. For advantages and disadvantages of different usability engineering methods, see Holzinger [14]. The interviews conducted concerning the two beta versions of the ECODESIGN course showed that the usability of the system in general was fairly good.

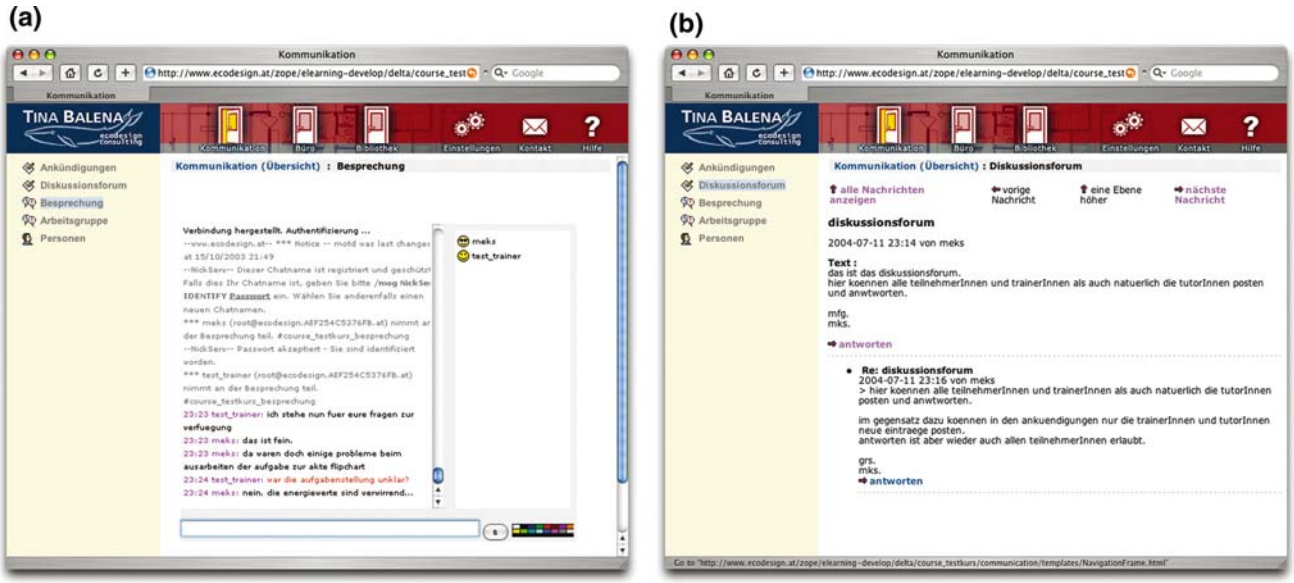


**Fig. 1** The ECODESIGN e-learning system: synchronous and asynchronous communication. **a** Chat, **b** discussion forum

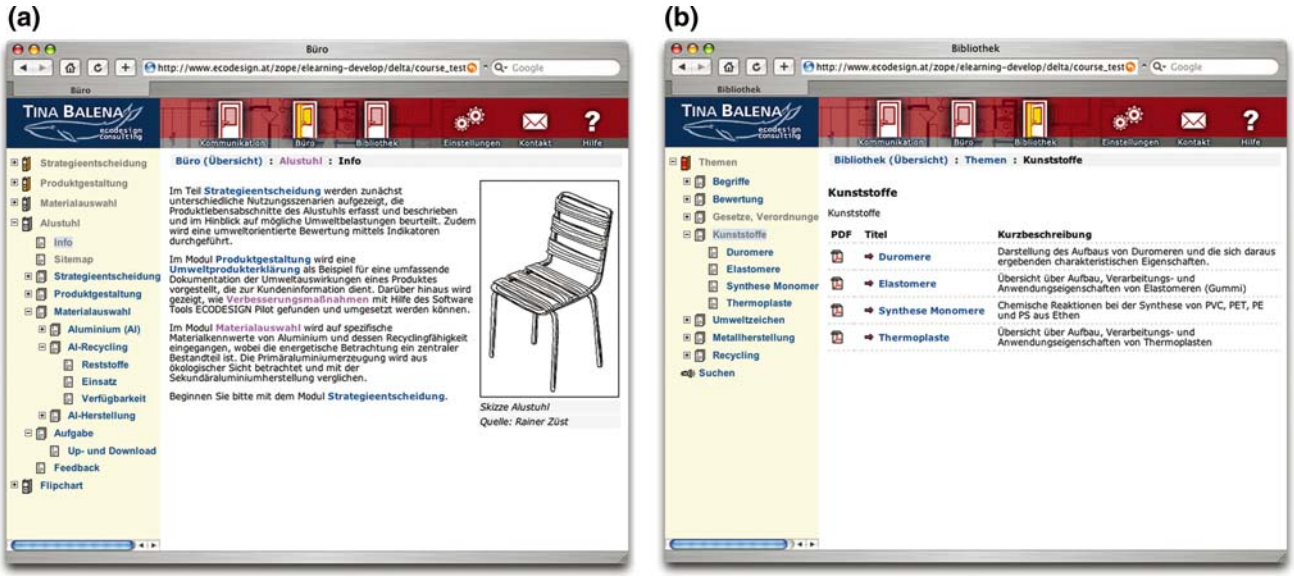


**Fig. 2** The ECODESIGN e-learning system: typical node of a dossier and documents ordered by topics. **a** Office room, **b** library

It was decided to implement the system from scratch using the open source web application server Zope. The requirement was set to keep the platform as simple as possible to ensure a high usability level, and also to make the system flexible and adaptable to the needs of the learners. Therefore, it was decided not to use an existing e-learning platform (for an overview, see Schulmeister [39]). In general, such systems are rather costly and contain many unnecessary features. Zope has an active user community (http://www.zope.org) providing constant new developments and extensions of the existing system. For the discussion forum, an extension called Squishdot was used (http://www.squishdot.org). Zope makes it possible to integrate navigational features like navigation trees or breadcrumbs into the system. The potential for the design of an attractive and consistent interface is very high. Despite some difficulties, Zope has proven to be a realistic and effective possibility for the development of e-learning platforms.

The system offers three levels of interaction with the participants, namely a help system, asynchronous communication (discussion forum and email), and synchronous communication (chats). The chat helps trainers to answers questions quickly and to avoid misunderstandings more easily than in the discussion forum. Email communication is encouraged but not conducted within the system.

Participants as well as trainers and tutors use their own email clients.

### 5.4 Course attainment

The first regular ECODESIGN course was carried out between October 2004 and January 2005. There were 11 participants with various backgrounds. Some of the participants were experienced product designers from large multinational companies, some were from small innovative companies, and some were unemployed. A total of 36% of the participants were female. This percentage is very high for a course in engineering. The organization and the technical implementation ran fairly smoothly. The only technical problems occurred with the chat software because the companies where some of the participants worked used very restrictive firewall systems. This made it impossible for some participants to take part in chat groups from their workplace.

The second ECODESIGN course took place from October 2005 to January 2006. It had six participants. All of them were male. There was no opportunity to analyze the second course in detail, but a focus group after the course ended was conducted. The main topic of the focus group was communication and collaboration processes.

## 6 Analysis of the processes of communication and collaboration

The learning environment of the course offers two ways of interactive communication, namely chat and discussion forum. Additionally, email and telephone contacts of participants, trainers, and tutor were announced in the course. Every participant could enter some short personal information about him/herself, and photos enriched the social presence [27, p. 150f] of their online "persona". This was supposed to help to overcome initial barriers (Fig. 3). In addition, the online tutor initiated communication processes between participants.

Emails to the tutor were only used for organizational questions. The tutor used email to motivate and check the status of the work by personal emails to the participants. Occasionally, the participants directly contacted the trainers with content questions about the product cases. The telephone was used a lot in the last phase of the course among the members of each group. The tutor also used the telephone when there were no answers via email and deadlines were approaching.

The methods used to analyze the processes of communication and cooperation were, on the one hand, participant observation by the tutor, and, on the other hand, a content analysis of the protocols of the chats and the discussion forum. Before the last face-to-face meeting, all participants were interviewed. The interviews lasted about an hour per person, were recorded, and then fully transcribed for analysis.

### 6.1 Planned communication

The course consists of three short introductory dossiers, three examples (product cases) defined by the trainers, and one more open example where the participants introduce their own products to improve them with the ECODESIGN tools. Chats with the trainers were provided for the three short dossiers combined and for each example. The chats were moderated by the tutor (facilitator), and were intended to offer the possibility to discuss questions and problems of each case and to give feedback. They were planned as mandatory meetings. Due to technical and scheduling reasons, the chats became voluntary. The tutor summarized each chat and posted the minutes of the chats in the discussion forum on the course platform. The course platform also offered private chatrooms for the participants to meet independently and in a self-organized way once the group formation was completed. If wanted by the participants, the tutor and/or a trainer could join the chat. The discussion forum was a pinboard for questions and answers between participants and trainers. The guaranteed response time was 24 h. The direct and fastest contact by email or telephone was open as well.

### 6.2 Chat

During the ECODESIGN course, nine planned chats implemented by three trainers and the online tutor took place. Each chat lasted 30 min. On average, seven of the 11 participants were present. Maximum presence per participant was eight visited chats, and minimum was only three chats.

The communication was mainly in the form of questions and answers. It was quite an effort to keep the communication going. The tutor had to address each participant regularly otherwise the time would pass without any topic-related discussions in the chat. The discussion became more effective only when three to four participants were present in the chat. The last three chats were held for the three workgroups. This resulted in a smaller number of participants. Due to the lack of experience in this medium, cooperative learning processes could only be induced with difficulties. Encountered problems included, for example, the typing speed needed for contributing, and participants with mother tongues other than German. Only three out of 11 participants could actively join the topic-oriented communication.

Two contradictory opinions were formed. One group really liked and used the chat for their problems and

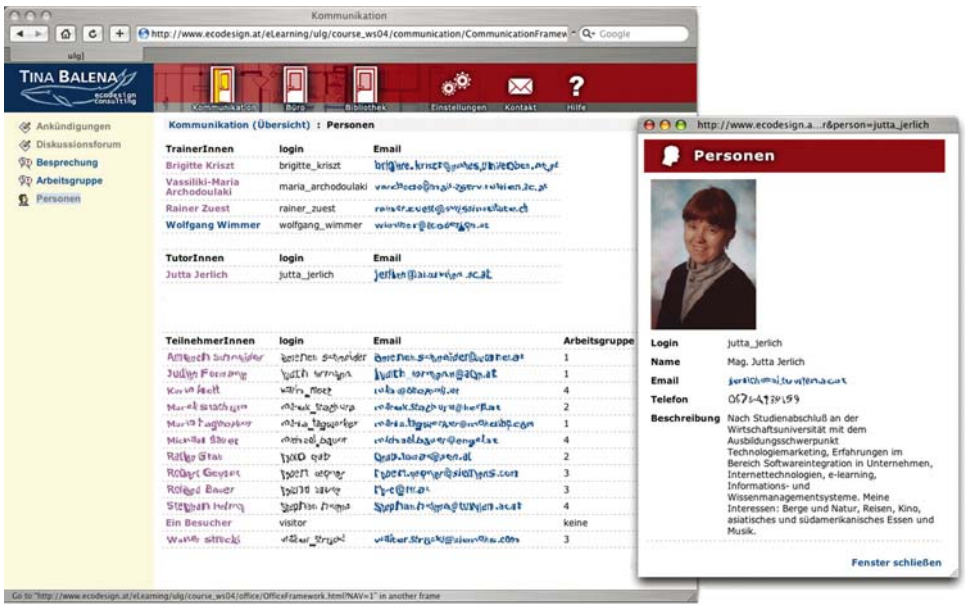


**Fig. 3** Information about the participants, tutors, and trainers in the communication "room" (photo, login name, title, full name, email, telephone number, self-description)

questions. They found it to be very effective and useful for their learning process. The other group did not find chats useful at all. However, the minutes of the chat were generally regarded as very useful.

Concerning the contents of the chats, the one for the open and self-formulated example at the end of the course was the best and most productive. Its complexity resulted from the fact that the groups had already communicated by telephone and in real-life meetings.

The ECODESIGN e-learning system offered chatrooms for every single group to support them in the solution of the last example, and the assistance of the trainers. No group used these chatrooms or invited a trainer to their meetings. One group set up their own discussion forum outside the system. The most attractive methods of interaction were face-to-face meetings and telephone conversations. This phenomenon was considered as rather surprising. At least two reasons might be given for this. On the one hand, participants probably feel supervised when they use the chat facility provided by the system. On the other hand, the participants had almost no previous experience with chats and little experience with discussion forums. They were apparently more comfortable with more traditional forms of communication, which are also part of their day-to-day work. New forms of communication might also seem time-consuming and difficult to use.

A bigger geographical distance did not lead to increased acceptance of chatting. One of the trainers was located in Switzerland. His chats were visited by more participants and somehow more accepted. This might be due to the fact that telephone contact to a different country is not as simple as with local trainers (companies might block out of state numbers). In this case, the chats were perceived as useful.

Although the participants sometimes criticized the chat discussions, they were in some cases quite valuable. One group that did not participate in the last chat and only posted their questions in the discussion forum had a basic error in the solution of their self-selected product case. The group stated that they found their chosen solution strange, but they did not question it or asked the trainers or other participants for help. If the group had used the chat, this problem probably would have been detected because the tutor always asked everybody personally for their questions and difficulties.

### 6.3 Discussion forum

Throughout the course, the forum had 132 postings whereof 15 were about technical problems or organizational questions during the first phase of the course. After that, the postings discussed the course content and the examples.

The structure of the discussion threads was mainly one or two levels deep. Similar to the chats, question/answer postings were the majority. Some questions that emerged during the chats were answered in the forum afterwards, but this did not lead to discussions in the forum either. The only suggestion for a follow-up was for the trainers to provide more detailed answers, but surprisingly there were no further questions after the first answer. Nonetheless, the discussion forum was seen as useful.

### 6.4 Communication and cooperation processes during the groupwork

Preliminary groups were formed in the first face-to-face course meeting at the start. The participants were asked to

present their own choice of a product for the final example. Then all the participants could opt for one of the products. At the time of the second face-to-face meeting, four product examples were chosen by the trainers. By then, all the participants knew each other fairly well. All of the groups were formed of people with rather diverse backgrounds, which enabled most of the groups to conduct very interesting discussions.

The last product case really encouraged collaborative and cooperative learning. Due to the free selection of the group and the example, the participants could contribute according to their interests and best capabilities. The number of questions in the forum increased, and despite the fact that the number of participants in the chat was lower, the chats developed into expert discussions. These chats only needed little moderation, and ideas were freely exchanged. Open questions that needed more space were discussed and solved in the forum.

There are visible differences in the work of the different groups. Two groups had a very fruitful cooperation and a marked improvement in the sustainability of the product. This could also be inferred from the final presentation at the end of the course. All the members of these groups had a fairly equal share in the presentation. All members could apply their specific expertise from their work environment in the formulation of the solution for their example.

The one group that made a fatal error in the formulation of their solution apparently had problems with the constructivist approach of the ECODESIGN course. They often wanted more specific and binding guidelines for the solution of the examples, something that is not possible because of the ill-structured nature of the domain. The structure of the group was also problematic. There was one leader in the group who had a considerable amount of experience and dominated the final presentation. This is an indication of a source of difficulties in collaborative learning. Because of the autonomy in the learning process, it is often difficult to detect such problems early on.

### 6.5 Follow-up meetings

Despite all the problems, the general attitude of the participants and the trainers was positive. Some of the participants of the course suggested establishing a kind of an "alumni" meeting of all the participants of the course. This meeting should enable the participants to exchange information and to help each other to introduce ECODESIGN in their respective companies. The tutor organized such a meeting. At this meeting, a third of the original participants turned up. These people came from three of the four workgroups of the course. The meetings are still going on. They have also attracted experts who did not participate in the ECODESIGN course. The pursuance of ecological aims tends to foster strong ties and the development of similar values among those committed to this cause. In this sense, it can be said that the ECODESIGN e-learning course has formed a community of practice.

### 6.6 Results from interviews

Extensive interviews were conducted with the participants of the first ECODESIGN course. The interviews were based on design guidelines developed for the ECODESIGN system (for a more detailed description of the guidelines, see Pohl [23]). The guidelines are based on an extensive literature research, especially in Clark and Mayer [5]. They basically covered four areas: navigation and structure, interactivity, multimedia, and collaborative learning. Basically, these guidelines are pedagogical in nature although it is often difficult to distinguish them from usability guidelines. A system with a good navigation is, on the one hand, a usable system, but, on the other hand, a good navigation also helps learners to form a valid mental model of the material at hand. The area "navigation and structure" describes advantages and disadvantages of various forms of navigation (tree navigation, sitemap, breadcrumbs, links, etc.). Multimedia in the context of the ECODESIGN system addresses the question of how pictures, diagrams, videos, and animations should be designed and integrated into the text. Interactivity covers the question of whether interactive examples are used. Collaborative learning addresses the usage of chat and forum, and problems that might arise in this context.

In the course of the project, 11 semi-structured interviews were conducted with the participants of the first ECODESIGN course. These interviews lasted approximately 1 h each. The interviews were then transcribed and interpreted according to the framework of the guidelines. A more comprehensive description of the results of this empirical study can be found in Stöckelmayr [45]. She describes the results for all four areas quite extensively.

The involvement of real users in evaluating the didactic effect of an e-learning system is extremely important. However, especially in the case of vocational training, this is difficult because of the time constraints the learners have. It is understandable that they do not want to spend more than approximately 1 h for testing the system. It is, therefore, not possible to use more sophisticated forms of tests (observation methods, thinking aloud, etc.). To obtain a comprehensive picture of the whole system, such methods of investigation would take much more time than 1 h. Therefore, it was decided not to use them. In previous studies, software logs [26, 31] were used. The data from software logs is interesting, in that it is possible to monitor what learners actually do in a natural setting and without influence by the investigator. It must be mentioned,

however, that the data is difficult to interpret without additional information from the subjects.

The remaining of this section concentrates on the results concerning collaborative learning and their significance for the access of learners with little computer literacy. It should be mentioned that navigation also could be a problem for inexperienced learners. Most of the learners used the tree-navigation on the left side of the screen because this was a concept well known to them. Other interesting forms of navigation like the clickable sitemap were almost never used at all. There was only one very experienced learner who used the sitemap extensively, because this was a concept well known to him from previous experience.

The results of the interviews are basically qualitative, but there are a few quantitative statements one can make. All participants except one used the electronic forum and the chat (although the persons who did not use the chat or the electronic forum were not the same). The users were, in principle, satisfied with the design of the forum, but not with the chat (Table 1).

Almost all the participants found the communication with the other students and with the trainers useful (one participant did not comment on that issue). Concerning the question whether the communication was interesting and motivating, more diverse results were obtained (Tables 2 and 3).

These results seem to be quite contradictory. There was apparently a considerable group in the course who found the communication useful from a task-oriented point of view, but did not feel motivated on an emotional level. Maybe, this is related to the problems people had with the chats.

A very significant result is that seven out of 11 participants were against using chats. They mentioned quite well-known arguments such as, for example, that communication in chats is confusing, that users often do not know whether an answer replies to their own questions, that the time-lags are annoying, and that chats with many participants can be frustrating. One participant said that either nobody said anything or all participants wrote questions at the same time. When many people participated, it was difficult to decide which comment was the answer to which question. One participant also reported that her speed in typing was too slow for the chat. She also stated that a chat should only be used for small groups (two or three people). Additionally, some participants mentioned that, because of their time constraints, it was difficult to prepare questions for the chat. Some of the participants could only learn during the weekends (because of their workload during the week) and so could not really participate in the chat. This led to the phenomenon described above that the tutor sometimes had to ask the participants to pose questions. Otherwise, there would have been silence during some of the chats. On the other hand, one participant mentioned that the chats had a beneficial effect because learners had a deadline for which they had to be prepared. Some participants reported that they only listened to the chat [10] but found the summary (which was prepared by the tutor for all chats) very useful. This is of course somehow contradictory (as one participant realized), as the summary can only be prepared on the basis of the chat. Other participants mentioned that it was not possible to give detailed answers during the chat, and that they asked their questions again in the forum.

One of the participants was very positive about the chat. She appreciated the fact that personal contact with trainers and other participants was possible during the chat. Online learning without communication would have been frustrating for her. Two participants were rather negative about the chat, but conceded that the chat was funny and gave people more motivation to learn. It was more personal than

**Table 1** Answers of interview partners (IP) to the question: "Are the tools for communication (discussion forum/chat) well designed?"

| Are communication tools well designed? | IP1 | IP2 | IP3 | IP4 | IP5 | IP6 | IP7 | IP8 | IP9 | IP10 | IP11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Forum Yes | × | × | × | × | × | × | × | × | × | × | × |
| Forum No | | | | | | | | | | | |
| Chat Yes | | | | | | | | × | × | | × |
| Chat No | × | × | × | × | × | × | × | | | × | |

**Table 2** Answers of interview partners (IP) to the question: "Was the interaction with trainers/learners interesting?"

| Was the interaction interesting? | IP1 | IP2 | IP3 | IP4 | IP5 | IP6 | IP7 | IP8 | IP9 | IP10 | IP11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Yes | | × | | × | | | | × | × | | × |
| No | × | | × | | × | × | | | | × | |
| Not specified | | | | | | | × | | | | |

**Table 3** Answers of interview partners (IP) to the question: "Was the interaction with trainers/learners motivating?"

| Was the interaction motivating? | IP1 | IP2 | IP3 | IP4 | IP5 | IP6 | IP7 | IP8 | IP9 | IP10 | IP11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Yes | | | | | | | × | × | | | × |
| No | × | | × | | | | | | | × | |
| Not specified | | × | | × | × | × | | | | | |

the forum. On the other hand, they found that the result they got out of the chat was not worth the time they spent for it. A few participants reported that they would rather have an additional face-to-face meeting instead of the chats. Participants also discussed the relationship between the anonymity of distance education and the possibility to meet people in person or via the chat. One participant found communication very important and could not imagine learning without it.

Participants did not appreciate chats during their work hours and preferred chats in the evening. This was a problem with one trainer who had a little child and could not attend the chat in the evening.

The discussion forum was appreciated by all participants of the course. One participant mentioned that she appreciated the forum because it was possible to post a question immediately when one came across a problem. The answers in the forum were more detailed and informative. All questions were answered fairly quickly. Another participant used the chat more intensively and used the forum only for reading. She found the forum interesting, but posted no questions herself. Another participant reported that he found the forum good because he could learn from the questions of others. Another participant found forum and chat slightly redundant. He found that the answers in the forum should come more quickly. The schedule for the semester was very tight; therefore, participants needed answers very fast.

Some of the participants made suggestions for a better and clearer design of the forum. They argued that the clarity of the forum could be improved (e.g., better visibility of organizational information).

As a rule, questions in the chat and the discussion forum were answered by the trainers. There was almost no discussion among the participants. This is probably related with people's expectations. The traditional school system does not foster learners' autonomy and activity. Therefore, participants have to get used to the idea that they can learn from each other by discussion among themselves. In the interviews, many of the participants found it acceptable that questions were answered by the trainers and not by other participants. Only a minority argued that discussions between participants were valuable and answered the questions of other participants.

It is an open question whether it is sensible to abandon the idea of using the chat for the ECODESIGN course. One of the advantages of synchronous communication is that it offers a strict timeframe to the learners. For some learners, this is very valuable because it makes it easier for them to schedule their tasks. In future ECODESIGN courses, improvements of the present course organization will be experimented with.

## 7 Conclusion

In general, the ECODESIGN e-learning course was a success. Participants had a positive attitude and found the examples interesting. It should be mentioned that all the participants finished the course successfully. Nevertheless, there are still some problems, which have to be overcome.

The analysis of the communication and collaboration process during the course indicates that the support for these processes in the context of an e-learning system is a difficult problem. Some of the communication and collaboration features of the system were attractive for the participants, whereas others were not used at all. The chat was criticized by many participants, partly because of the lack of experience with this form of communication. Yet, some of the chat groups were quite successful, especially the groups which discussed the final examples. This is probably due to the small size of these groups and the common ground [27] existing among the participants at that stage of the course. The discussion forum was appreciated by all participants, although the design could still be improved. On the whole, the discussion forum was used quite extensively (approximately four messages per person). The most serious problem was the support of the group work on the final example. Although chat facilities for the work groups were offered by the system, they were not used at all. For collaborative work, people apparently use the communication means they are acquainted with (face-to-face meetings, telephone) because they are (or seem) least time consuming and they also conform to day-to-day work practice. As soon as the cost in terms of time and money for these communications means become prohibitive, participants do accept electronic media (see the chats with Rainer Züst from Zürich).

Active tutoring was an important feature of the ECODESIGN e-learning course. It increases the participants' motivation considerably under the conditions of an online

course. Dropout ratios are dramatically reduced. In the ECODESIGN course, all the participants got a positive certificate in the end. In addition, active tutoring can help the learning communities by overcoming communication problems between participants arising from their varying backgrounds. The investigation of the ECODESIGN course has shown that active learner support can also effectively support the transfer of process-oriented knowledge and skills into application of the learners' own practice by means of solving "real world" problems from the learners' professional background.

In the ECODESIGN course, it was found that, especially, learners with little computer literacy had difficulties with the more advanced features of the system (such as the chat). They had no previous experience with this form of communication and apparently felt uncomfortable. E-learning systems have to be adapted to the needs of such learners. One possibility would be using Voice-over-IP instead of chat, because communication via the telephone is much more natural for such learners. Another possibility would be to structure chats very rigidly (e.g., to compel participants to prepare contributions or questions for the chat). It was decided against using only the forum for communication purposes because of the necessity to introduce a strict time schedule to give more structure to the learning process. In the ECODESIGN course, active tutoring was also used as a means to assist learners, which was fairly successful. It might be argued that the problems of learners with little computer literacy will disappear in a few years when most members of the workforce would have learned how to use a computer at school. However, this does not solve the problems of people with a low level of education or other minorities (in Austria, for example, immigrants) who still have little experience with computers. Further research should address the problems of learners with little computer literacy in more detail. Otherwise, it will be difficult to achieve access for all to modern computer technology. It seems to be necessary to add guidelines concerning "access for all" to existing guidelines for e-learning systems to overcome the digital divide.

It is, of course, difficult to generalize results gained from studying a small group. The results can only be interpreted considering previous research by other scientists. The results gained from the study presented in this paper conform to this research. Therefore, they provide a sound basis for further work in the area of e-learning at the University of Vienna.

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