Information Technology and Interaction in Learning
Studies of Applications in Academic Oral Health Education

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Cover Photo: An archaeological discovery of questionable value. Hercules while attending an Internet-based course, under the affectionate eyes of Goddess of Wisdom, Athena. Observe the Greek ice-coffee (…Φραπέ!;) at Hercules hand, symbol of convenience, and easy life. Photo by S. Koutsoukos, Washington DC.

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...νόι δὲ μένει πίστις ελπίς αγάπη τὰ τρία ταῦτα. Μεῖζον δὲ τούτων ἡ αγάπη.
Παῦλος πρὸς Κορινθίους.

...and now all that is left is these three: faith, hope and love.
And the greatest of all is love.
Paul to Corinthians
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Studies I - VI
Preface:

This thesis is based on the following publications:


Abbreviations
The following abbreviations are used in this thesis:

CBL Computer-Based Learning
CMI Computer-Mediated Interaction
DL Distance Learning
HCI Human-Computer Interaction
HTML Hypertext Markup Language
ICT Information and Communication Technology
LeO Learning On-Line (software application developed by A. Nattestad - R. Attström)
PBL Problem-Based Learning
VAS Visual Analogue Scale
Abstract

Learning is an interactive process between the learner and the surrounding structures, the so-called learning environment. Several types of instructional interaction—such as the learner-tutor, the learner-learner, the learner-content, and recently, the learner-interface interactions—have been identified in higher education. The design execution of these interactions may significantly influence the learning impact of an academic educational session. Information and communication technology (ICT), and especially the Internet, has affected learning in many ways, but most significantly through introducing new possibilities for instructional interaction. The overriding aim of this thesis has been to elucidate the relative role of certain types of interaction between the learner and his or her environment in academic oral health education. In this thesis, ICT is studied in two distinct roles: as a mediator of communication—that is, as the mediator in learner-instructor and learner-learner interaction—and as a partner in interaction through the educational interface—the so-called learner-interface interaction (human–computer interaction).

ICT as a mediator of communication was studied during two Internet-based problem-based learning (PBL) courses and one Internet-based examination of undergraduate students. The potential of ICT as a partner in interaction through the educational interface was investigated through an interactive software application, which aimed to improve the self-assessment ability of students.

The results of these studies suggest that computer-mediated interaction (CMI) has an important role to play in higher education, can facilitate complex instructional methodologies such as PBL, and can effectively supplement and enhance face-to-face instruction. However, CMI presented several methodological differences when compared with face-to-face interaction, in terms of both quality as well as quantity of interaction. CMI was received less positively than face-to-face interaction by the students, when used in examination settings. In addition, it remains unclear if computer applications are able to constitute an effective, short-term, remedial support for the improvement of complex cognitive skills in students—such as self-assessment skills—without human feedback. At the basis of these findings and currently available technology, the most beneficial scenario from an educational point of view would include both computer-mediated and face-to-face interaction, with a considerable degree of user-determined flexibility. Future studies should focus on the roles of the various factors that affect learning through the process of interaction.
Introduction

Learning is the consequence of a series of interactions between the learner and his or her environment. The important aspects of these interactions can be systematically divided into different categories. The text that follows will summarise some classical views and modern reflections on these various types of interaction.

Interaction - Interactivity

Interaction is, in principle, a series of events or actions that take place between at least two objects. Interactions occur when these objects mutually influence each other (Sutton 1999) in a way that each action of one object comes in response or relation to a previous action of the other and can provoke an adequate reaction. Interaction is a process and is therefore not to be confused with interactivity. Interactivity is an inherent feature of a specific medium, which allows the user to experience a series of exchanges by means of technology. Interactivity has also been defined as the degree of control a learner has over the sequencing of the content (Schwier 1991).

Interaction in learning-
Instructional interaction

Learning is not simply the act of acquiring more information or of building knowledge banks. It is, rather, the complicated process of using facts and information to built understanding, to develop abilities to perform new tasks and skills and in general to change attitudes towards the particular field. Acquisition of information is a static storing; learning is the process of using the acquired information to develop or change.

It is apparent in this definition that learning is an interactive process between the learner and the surrounding structures, the so-called learning environment. The learner acquires information from the environment and in turn affects his environment at the basis of his understanding, generating new circles of interaction. Learning is therefore a result of interaction, but of course not all interactions lead to learning. The type of interaction that results or is intended to result in learning is called “Instructional Interaction”. According to Wagner (1994) the purpose of instructional interaction is to respond to the learner in a way which could change his or her behaviour towards an educational goal. Instructional interaction is in essence the foundation of all kinds of education.

Several types of instructional interaction have been identified (Moore 1989; Hillman et al. 1994) as parts of various educational approaches. These typically include:

- The learner-tutor interaction
- The learner-learner interaction
- The learner-content interaction
- The learner-interface interaction

The learner-tutor interaction

This type of interaction takes place between the student, the apprentice or the trainee and the instructor, tutor, or supervisor. The tutor acts as a source of knowledge and experience and also provides motivation, guidance, and feedback. In some educational approaches this type of interaction is considered both
necessary and sufficient for a complete education.

The learner-learner interaction
This is the interaction between peers or associates. The fellow student or the peer serves as a source of knowledge, motivation, guidance and assessment. This type of interaction exists to various degrees in all educational systems, formally or informally, within or outside the classroom. Learner–learner interaction is especially emphasised in systems favouring teamwork and active learning such as Problem-Based Learning (PBL).

The learner-content interaction
This critical type of interaction characterises the way learners interact not with other persons, but with information itself, the so-called learning content.

In the usual educational settings, the raw information is available as sensory stimuli in various forms (fig.1). Text, image, mind maps, sound, video, hands-on training and so on, all represent different carriers of raw information with specific potential and limitations within educational settings. Social and cultural factors as well as individual learning styles (Walker 1999) appear to be of critical importance in determining the way we interact with the content. Learner-content interaction is a very interesting and multidisciplinary field of research, which has received increasing attention in light of recent findings in cognitive science (Regehr et al. 2002). This type of interaction is beyond the scope of the present thesis.

Figure 1. Learner-content interaction: the raw information is available as various sensory stimuli. The same information can be communicated through a series of images, a video, a text, a narration or more.
The learner-interface interaction

T
technological developments and their applications in education have necessitated the further study of this type of interaction, the interaction with the interface (Hillman et al. 1994). The information or raw content is not only available in different forms of sensory stimuli, but it can also be delivered in a variety of ways. Only a few decades ago, the “standard delivery format” might have been a script on paper with hand-made illustrations. Today the same content might be available as a book, a set of slides, a videotape, a multimedia CD-ROM, a lecture, an on-line course through the Internet and many more. All these various alternatives of delivery represent different types of interfaces. In distance education settings, learner-learner and learner-instructor interactions are made possible through the interaction with the interface.

The Vicarious Interaction

A fifth type of interaction was proposed by Fulford (Fulford et al. 1993) and Sutton (Sutton 2001), who claim that psychological interaction is predominantly vicarious in nature. This type of interaction was named “vicarious interaction” and it involves all four previously mentioned types. Individual student characteristics – some of them social, cultural or
psychological- might inhibit some students from participating in forms of direct interaction. However, it was observed that many students can demonstrate enhanced achievements even if they are not directly and actively participating in the various interactions during a course (Sutton 2001). Those who actively observe and cognitively process the interactions of other participants should benefit substantially from vicarious interaction.

A vicarious learner can learn through other students’ interactions with the content, the instructor, other learners or the interface (fig.3). Interaction in this case is not direct, hence the term “vicarious”.

Vicarious interaction adds an interesting dimension to instructional interactions and might account for several “overlooked” phenomena in learning. Under the scope of this theory, we should consider re-examining our traditional approaches of assessing and evaluating students’ activity in distance learning (DL) courses and how it relates to learning outcome. Unfortunately, our knowledge and understanding in this field is still very limited.

Figure 3. A schematic representation of the direct and vicarious interaction during an educational process. (Sutton 2001, modified).
The learner-self interaction

Another type of interaction that has been described as critical for the learning process is the learner-self interaction. This includes the cognitive operations that constitute learning as well as the meta-cognitive processes that help individuals regulate and structure their learning (Hirumi 2002). The specific cognitive operations that occur within an individual and constitute this type of interaction are widely unknown and several epistemological schools have attempted to approach them in different ways. For example, according to information processing theories of learning, learner-self interaction would include sensory memory, selective attention, pattern recognition, short- and long-term memory, encoding, rehearsal and chunking and more (Atkinson 1968). Learners are self-regulated to the degree that they actively participate meta-cognitively in their learning, which can only be an outcome of learner-self interaction.

Several researchers have identified learner-self interactions as the primary level of interaction especially in e-learning environments (Hirumi 2002, Zimmerman 1986). The relative limitations in learner-tutor and learner-learner interaction, as well as the “anytime-anyplace” character of e-learning environments emphasises even more the importance of self-regulation and learner-self interactions. Self-regulated learners may have a substantially greater potential in DL environments than learners who mostly rely on instructors or other learners to monitor, regulate and facilitate their learning (Hirumi 2002). These facts lead Hirumi (2002) in a recently published classification of e-learning interactions to place learner-self interaction at the base of the learning experience (fig 4). According to Hirumi, all previously mentioned kinds of instructional interaction aim to generate learner-self interactions.

The learner-self interaction and its role in the learning process -both in traditional as well as e-learning settings- is a wide field of research, and currently draws attention from many scientific disciplines. As such it is well beyond the scope of this thesis.

![Figure 4. Levels of planned e-learning interactions (Hirumi 2002, modified)](image-url)
Information and Communication Technology and Instructional Interaction

Information and Communication Technology (ICT), and especially the Internet, has affected learning in many ways, but most significantly through by introducing new possibilities for instructional interaction. Two distinct developments will be studied in this thesis:

- Information Communication Technology as mediator of communication, therefore as mediator of learner-instructor and learner-learner interaction. (human-human computer mediated interaction, Virtual Classrooms)
- Information Communication Technology as partner in interaction through the interface, learner-interface Interaction. (human-computer interaction)

A tentative conclusion from the above overview indicates that the design of these interactions may significantly influence the learning impact of an academic educational session. The overriding aim of this thesis has been to elucidate the relative role of certain types of interaction between the learner and her or his environment when learning a given subject in oral health.

Aims

In particular this thesis aims to:

- Summarise the past reported experience in the field of Internet-based DL in health education.
- Study the impact of interactive examination methodology and evaluate students’ attitude towards this type of assessment.

and investigate the following:

- How feasible is a fully Internet-based PBL course for undergraduate students in periodontology, and what is the students’ acceptance of such a course?
- What are the main differences (both objectively observed as well as subjectively experienced by participants) between face-to-face interaction and interaction over the Internet during a PBL course?
- What is the feasibility and acceptance of interaction over the Internet in the interactive examination settings?
- Can interaction solely with an Internet-based application (interface) promote the development of self-assessment skills of undergraduate students?
Materials and methods

Study I: literature review

The aim of this review was to summarise the reported experience in the field of DL in health education and identify future trends and tendencies in the field. The review was focused in undergraduate and postgraduate education of medical and dental professionals. In this review, factors that relate only to the learning methodology, acceptance and overall effectiveness of DL were investigated, leaving aside the purely technological aspects, which were reviewed in a separate article (Mattheos et al. 2000a).

DL has been the main field where technology has been applied as a mediator of human-human interaction. Existing literature in the PubMed and Ebsco databases was examined, with a focus on publications in the 1990s, as technology has dramatically changed the potential of DL during this period.

Eighty-five publications from 1985 to 1999 were reviewed. Thirty of them, which clearly described a methodology or a specific course design, were selected for further categorisation. These studies were classified according to year of publication, media employed, target audience, type of evaluation (if existing), and reported results. In addition, an effort was made to categorise DL applications according to the kind of interaction they could facilitate. Finally, an analysis of the factors of importance was attempted, identifying factors related to learning methodology, student and staff acceptance, assessment methods, and reported effectiveness of DL.

Study II: The Interactive Examination

The aim of this study was to describe and evaluate a model of examination based on different forms and levels of interaction between the learners and the tutor. Results from one cohort of students (2001) were used for the analysis.

The Interactive examination is a structured assessment methodology for small groups of students. The aim of the interactive examination is to assess not only students’ skills and competence but also their ability to self-assess themselves in the context of clinical periodontology. A schematic presentation of the examination can be seen in Figure 4.

The Interactive examination is based on reflection and interaction, not only with the assessor but also with peers within a group (Fig. 5). The various phases of the examination evolve around students’ own self-assessment and also include a written essay, a discussion, and a comparison document where the students must compare their own essays with one from an “expert”. This particular phase serves the purpose of demonstrating student’s ability to use accepted standards as a starting point for reflection and self-development in the context of periodontology. After completing the examination, students receive individual feedback on their performance and learning needs.

The Interactive Examination model was tested on one cohort of students (2001, n=54). The students’ self-assessment scores were matched to those of their clinical instructors. Relations between students’ performance in the various phases of the exams and variables such as gender and self-assessment pattern were investigated. The differences in the students’ comparison documents, as well as the accompanying arguments, were analysed and categorised with the assistance of an educational consultant from the Centre of Teaching and Learning at Lund University. Students evaluated the methodology using ordinal scales and open text comments.
### Self Assessment of Clinical skills

- Written essay with compulsory keywords
- Discussion of students' Self Assessment
- Students' comparison of own essay with expert's

### Examination phases and modules

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>Clinical Instructors’ Assessment of students’ clinical skills</td>
</tr>
<tr>
<td>2</td>
<td>Self Assessment of Clinical skills</td>
</tr>
<tr>
<td>3</td>
<td>Written essay with compulsory keywords</td>
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<tr>
<td>4</td>
<td>Students' Self Assessment</td>
</tr>
<tr>
<td>5</td>
<td>Students' comparison of own essay with expert's</td>
</tr>
</tbody>
</table>

### Teachers evaluate:

- Students' self-assessment of clinical skills, in relation to Clinical Instructor.
- Knowledge, understanding and attitude towards the content.
- Oral and written communication skills.
- Students' ability to self-assess his/her competence in relation to the expert.

### Individual feedback to the student regarding:

- Clinical competence
- Knowledge and understanding of the content
- Critical thinking and ability to self-assess his/her competence
- Recommendation of resources for further learning

**Figure 4.** A schematic representation of the phases and processes of the Interactive Examination.

**Figure 5.** A group of students during the essay question phase of the Interactive Examination.
Study III: Fully Internet-Based Human-Human Interaction

The aim of this study was to investigate the learning potential of a virtual classroom for undergraduate students using a highly structured learning method such as PBL. In addition, the study intended to evaluate the participants’ attitudes and acceptance of the learning environment as well as its possible strengths and limitations, when functioning in an international environment.

A virtual classroom in basic periodontology was designed, which was attended by 28 students from 13 European countries. The course was fully Internet based and structured using PBL methodology (Rohlin et al. 1998). Students were voluntarily organised in four groups of seven. Four tutors from the academic staff of the Department of Periodontology were allocated to the different groups. Each group was provided with three means of interaction: asynchronous web boards, synchronous on-line communication, and e-mail lists. Each group was instructed to employ all interaction methods, but they could decide independently on when and how often each of them should be used. The duration of each thematic session and the pace of discussion were decided individually by each group.

A web site was built to serve as a communication centre and gateway to the virtual classroom (Fig. 6).

The learning material of the course consisted of a large number of videos with sound, as well as series of large images. The problem of transmitting the learning material, in particular the video clips, through slow modem connections, was dealt with by means of simple HTML technology and a specially designed CD-ROM (Mattheos et al. 2000b). The CD-ROM with the learning material was not a "digital textbook", but rather an extension of the network (fig. 7 ), a supplement to the student-tutor interaction, able to assist the learning process in any direction at any stage.

Formative evaluation of different learning aspects was carried out at different stages throughout the course, and a summative evaluation took place during in June 1999, with an on-line questionnaires and a final synchronous meeting. The questionnaires included multiple choice and free text questions, as well as topics for personal commentary. One on-line assessment meeting was carried out in each group, and the final on-line meeting was an open agenda discussion among the tutors, the technical team and the group chairpersons.
Figure 7. The tutor replies to the student’s request with a html document placed on the server. The document contains a link to the relevant images and films on the student’s local CD drive. The student just has to click on these links to rapidly retrieve the illustration material and long downloading times over the Internet are avoided.

Study IV: The blended learning approach

The purpose of this study was to describe the educational experience deriving from a PBL virtual classroom for health care professionals. The study was focused on evaluating the quality and quantity of the various forms of interaction that took place during the course and their individual contribution to the learning experience.

This study was designed around a continuous education course for health professionals, which dealt with oral health care for the elderly. A web page served as a “gateway” to the tools and learning resources (fig.8).

Figure 8. The course home page

The course was modelled after the PBL methodology. However, in this pilot study in-classroom interaction was combined with and not replaced by interaction over the Internet. This allowed testing and evaluation of the various kinds of
interaction involved. Therefore, each module was introduced during an in-classroom meeting, the work was continued using asynchronous interaction and was concluded by synchronous interaction on the Internet. Eight people registered for the course, and they were organised into two groups of four. All eight participants were professionals in the field of health care and had no previous experience with either distance learning or PBL.

The participants’ mean age was 39 years. Each group was assigned one tutor from the academic staff of the faculty. Both tutors were professionals in oral health care and were experienced in guiding in-classroom sessions. Although the tutors had attended seminars on computer-assisted learning and distance learning, they had no previous experience with Internet-based teaching. Three kinds of interaction were employed during the course: Virtual synchronous (chat), Virtual asynchronous (WebBoard) (Fig 9), and In-classroom interaction.

- **Virtual Synchronous and Asynchronous interaction**
  The virtual environment was facilitated by means of the WebBoard’s software package, which includes tools for synchronous and asynchronous text-based interaction. All synchronous discussions were recorded by the server. Each unit of communication by a person was considered as one “input.” These inputs varied from simple responses, such as “yes” or “no,” to complicated sentences contributed by a person. Measurements such as the total number of inputs, inputs per minute, and inputs per person were made.

- **In-Classroom Interaction**
  The in-classroom sessions were assessed by an independent observer. In-classroom interaction measurements were performed during five randomly selected periods of 5 minutes, in one 3-hour PBL session. Only verbal interaction was recorded, with each input being one meaningful verbal sequence. Facial expressions, body movements, emotional signs, and other non-verbal communications were not registered. The purpose of this registration was to measure the quantity of in-classroom verbal interaction compared to the data collected by the synchronous online discussions.
• **Attitude and Competence**

The overall attitude of the participants towards DL and virtual environments was assessed in a final open discussion and with two questionnaires. An open discussion with an independent observer took place after completion of the course, whereby participants were invited to comment on various aspects of the learning experience. The participants’ competence with computers was measured on a percentage scale, based on replies to 26 questions representing tasks of increasing complexity.

**Study V: Internet-based Interaction in Examination Settings**

This experimental study focused on synchronous interaction through Internet-based teleconference involving the transmission of image and sound, rather than text-based communication. The study aimed in particular to investigate students’ attitudes towards teleconference when used under the sensitive examination settings.

Thirty-nine second-year dental students were examined using interactive examination methodology in December 2000. The students were organised in five groups, of which two (n=15) were assessed by standard in-classroom procedures and three (n=24) were assessed in an Internet-based teleconference. The same person acted as the main assessor for all groups, but in the teleconference settings, interaction between the students and the assessor took place with web cameras, a set of loudspeakers (2x120 W), and two microphones. The web camera could switch views between views of an individual and of the group, while a set of headphones was used for individual discussions and a microphone for group discussions. Microsoft NetMeeting 3.1 was used on a laptop placed in the room and projected through a beamer. The examiner had control of the laptop through the remote access facility of the software, which allowed him to use illustrations, PowerPoint slides, or videos stored in the laptop according to the needs of the discussions. Resource persons and a local exam facilitator were in the room with the students. Students evaluated the whole experience using ordinal scales (1–9) and free text comments.

**study VI: Learner interaction with the interface.**

This study aimed to test the learning potential of learner’s interaction with the interface. The study was carried out by testing an interactive software application against a static web page for the delivery of identical learning content. In particular the focus was in investigating the potential of an interactive database-driven Internet application (fig. 10) (Learning On-Line, “LeO”, A. Nattestad, R. Attstrom, http://tmk.odont.ku.dk/LeO) as a means of stand-alone, remedial support for the development of self-assessment skills among undergraduate dental students. The complete LeO methodology includes tutor generated feedback in certain parts, but for the purpose of this study it was used as stand-alone software, deprived of any human-human interaction. This way the potential of the actual learner-interface interaction would be more easily studied.

Fifty-two students were randomised into an experimental (n = 26) and a control group (n = 26). Students’ competence with the use of computers as well as certain attitudes towards computer-based learning (CBL) were registered through a specially designed, task-oriented questionnaire. Demographical were also recorded for each student. Both experimental and control groups went through four identical
learning cases in clinical periodontology during a period of 1 month. The experimental group received the cases through the interactive software and the control group through a static web page. Weekly questionnaires were administered to all students after completion of each case; the questionnaires investigated students’ attitudes towards the software and the content as well as the way students used the software.

The total time students spent on the task was also recorded. After the completion of all four learning cases, both groups were assessed blindly by two assessors (Senior-Junior) through the Interactive Examination methodology (see study II). For the purpose of this study students’ performance was graded in all phases of the examination, including the oral part, the written essay and their demonstration of self-assessment ability. The assessment was based on predetermined, explicit criteria.
Results

Study I: Literature Review

Results from 30 of the studies reviewed since 1985 were classified according to certain methodological features. It was concluded that human-human interaction plays a key role in DL and in computer-based courses in particular. Accreditation, team-work, and personal contact were stressed by most authors as important factors for increasing motivation and minimising drop-out rates. It was also indicated that interactive applications and especially virtual learning environments tend to employ more complicated learning methodology, with encouraging results. However, it was apparent that applications in DL lacked the support of a solid theoretical framework and original research work in this field was inconclusive. Of the 30 selected studies, only 5 were based on a clear research protocol that included control groups. The majority of studies in this field used a selected sample and based their results on post-course questionnaires, with limited control over novelty effects and other confounding factors. The positive results on interactive computer-based applications that are often presented in the research of the 1990s should therefore be interpreted with caution.

Study II: The Interactive Examination

Students’ acceptance of the methodology was very positive, and the discussion element of the examination was highly appreciated. Three elements were repeatedly commended as strengths:

- The opportunity to reflect on one’s own self-assessment
- The effectiveness in helping identify one’s learning needs
- The contact with the educators

The relaxed atmosphere of the examination also received favourable comment.

A total of 214 (42%) student scores were higher than the judgement of the clinical instructors, while 95 (19%) were lower and 197 (39%) were in agreement. On an individual basis, the judgement of 18 students (39%) was significantly higher than the judgement of their instructor ($p < 0.05$), and lower in 5 cases (11%). Multiple linear regression analyses revealed no relation between the students’ gender, group, or clinical instructor and their self-assessment pattern. Significant differences were identified between students’ self-assessment and instructors’ judgements in 4 of the 11 different fields.

The differences identified by the students in their comparison document could be classified in three major categories:

1. Differences in the form, such as differences in the language, length, style, essay format (plain text, mind map, flow chart, and so on)
2. Differences in content, such as omission or inclusion of certain points, clarifications, misunderstandings, and so on.
3. Differences in attitude towards the content, such as prioritising, elaborating, depth of detail, and so on.

In the majority of the comparison documents, a clear prioritising of the differences was observed. Matching the differences marked by students with the...
assessor’s comments on their original written essay, the assessors were able to gain deeper insight into students’ ability to identify potential weaknesses and consequently learning needs. In the majority of cases the students proved to be very skilful in locating the weak points and gaps in their knowledge. However, nine students (three females - six males) were in general unable to identify the actual problems with their essays. These students were provided with extra learning resources and asked to take part in a supplementary discussion.

Study III: Fully Internet-Based Human-Human Interaction

Twenty-three students completed the course in May 1999 (82.1% completion rate) and 15 (53.5%) fully participated in the course assessment process that followed. All drop-outs occurred during the first 6 weeks of the course. The majority of students (53%) considered the ability to handle information technology effectively for educational purposes to be the most important benefit of the course. A smaller percentage (21%) considered the encounter with PBL as the major benefit from their participation (Fig. 10).

Figure 11. Student’s response to the question “What was the most important thing you learned during the Virtual Classroom?”

Students rated their competence with computers prior to the course on a scale from 1 (almost unfamiliar) to 5 (almost expert). The majority of students rated themselves between 2 and 3, with a mean of 2.78. This self-assessment was later found to be inconsistent with the students’ actual ability to handle the technology used. Students were less competent than it was initially thought based on their self-assessment. The PBL method as practised in the network environment was accepted positively by most students. All students reported feeling confident with PBL before
the course began. However, during the first patient case, tutors realised that many students had an incorrect comprehension of the learning method. In particular, students originating from strongly didactic environments tended to view PBL as a quiz or a competition rather than as a slow, stepwise learning process. This fact necessitated a temporary pause in the course where the tutors focused on comprehension of the learning method before moving on to the actual case discussions. An on-line meeting was arranged where the tutor and some experienced PBL students carried out a “demonstration” session.

Team spirit was included by most students among the strengths of the course. The elements facilitating team spirit were reported to be team decision-making and team problem-solving as well as independence and private Internet areas for the teams.

Study IV: The Blended Learning Approach

All eight participants completed the course. From the questionnaires and the open discussion during the second study, it was evident that participants appreciated the PBL approach, considering this to be one of the main strengths of the course. PBL was reported to be “dynamic” and “engaging.” However, they all agreed that PBL is more demanding in terms of time and effort than traditional teaching methods.

The participants appeared reserved towards online synchronous communication. Five of the eight participants replied that they were unsatisfied with the online meetings, mentioning that it was difficult to lead a proper discussion. In particular, they felt the online discussions were more “superficial” than the in-classroom ones. However, six of the eight participants considered the online discussions to be valuable for maintaining contact among the group members and facilitating teamwork in the intervals between in-classroom meetings. Only two students thought the online discussions could be effectively replaced by e-mails. Six of the eight also believed that there was no need for more face-to-face contact. The asynchronous interactions were judged “valuable,” but participants still reported they would rather submit their comments during the in-classroom or online meetings.

The questionnaires revealed a slight increase in the attitude that Internet-based DL is more effective and stimulating after completion of the course. Also, the mean score in the computer competence test increased from 34% to 45% after completion of the course.

The postings on the asynchronous web board were categorised in four groups according to their content. The major finding was that students were not using the asynchronous board for communication relevant to the actual course content as much as was anticipated. Of the 165 postings made throughout the course, 36 (22%) were related to course content, 32 (20%) were related to technology, 48 (29%) were miscellaneous, and 49 (29%) were uploads of the students essays. During the evaluation, it was apparent that students would rather keep their questions or comments for the in-classroom meetings or chats, rather than post them on the web board.
In comparisons of the virtual synchronous with the in-classroom verbal interaction, two differences were apparent:

- The speed of discussion in the classroom session was much higher, with an average of 13.4 inputs per minute, compared to the 2.1 inputs, the highest rate observed during the online discussions.

- The involvement of the tutor in the discussion was much less in the classroom, with a mean of 4.8 inputs per session (SD 2.1), amounting to 7% of the total interaction. During the virtual interaction, tutor involvement was around 40%, as the tutors had to continually steer the discussion.

**Study V: Internet-Based Interaction in Examination Settings**

All 39 students completed the interactive examination and the evaluation that followed. No significant differences were found between students’ scores on the exams or pass/fail rates between the control and experimental groups.

There were no direct complaints regarding technology on the part of the students or the staff. Students’ acceptance of the overall methodology was positive, however, students who were examined over the Internet expressed significantly lower acceptance of the methodology than their colleagues who were examined face to face.

In their free text comments, students of the face-to-face group appeared to appreciate the discussion element of the examination highly, which most of them would like to see increased. The same was not as apparent in the Internet-based group, where students’ preferences appeared to be divided between the self-assessment and the discussion elements. The written essay part was received less favourably in both groups. The contact with the educators was repeatedly reported as a strength of the methodology, however, once again students in the face-to-face group appeared more enthusiastic regarding the contact element. The relaxed atmosphere of the examination also received favourable comments.

**Study VI: Learner Interaction With the Interface**

Forty-eight students (LeO, n = 24; Non-LeO, n=24) finally concluded the study. Average computer competence of the students at baseline was 18.1 (SD 8.6) on a scale of 1–50. Male students (score 22.3, SD 10.2) were significantly ($p = 0.006$) more competent than their female colleagues (score 14.1, SD 4.7). There was no significant gender difference in the attitude towards computers.

Four sets of questionnaires (one after each case) were collected, amounting in total to 82 questionnaires in the LeO group (85.4% response rate) and 84 for the non-LeO group (87.5% response rate). Significant changes were observed in some of the attitudes towards the software during the 4-week period, as measured by the VAS. A student in the LeO group spent an average of 215 minutes (SD 131) for all four cases, while the same average for a student in the non-LeO group was 122 min (SD 66).

Grades for the written essays and the comparison documents from both the Junior and the Senior assessor revealed no significant difference between LeO and non-LeO students. The same was true for students’ performance in the oral part of the examination. There was moderate (Landis et al. 1977) agreement between two assessors’ grades on the written essays and the comparison documents. No significant correlation was found between gender or self-assessment pattern and performance in the various parts of the interactive examination.
On the contrary, the total time spent on the cases was strongly correlated to many performance parameters of the interactive examination for both the LeO and the non-LeO groups.
In addition, a positive correlation was found between baseline score in computer competence and several of the performance features of the students. Judging from their free text comments, students perceived Internet support very favourably, however, especially during the last 2 weeks, there was an increasing number of comments within the LeO group complaining about increased workload and lack of time. Students judged the first three cases as “relatively easy” and “good repetition of already known facts”. The last case was repeatedly characterised as “challenging”. 
Discussion

a. Computer-Mediated Human-Human Interaction

DL can be defined as the technologically assisted learning process, where the students and the instructor are physically and temporally separated from one another. Therefore, it comes as no surprise that DL was the educational field where ICT was applied as a mediator of communication. DL is not a new phenomenon and was certainly not a product of the Internet era. However, it was the introduction of the Internet that gave birth to a whole new generation of DL applications and introduced a series of methodological implications. Various forms of synchronous and asynchronous communication at a distance were available for educational purposes long before the Internet. Technologies such as audio conference (Marshall et al. 1985), audio graphics teleconference (Kuramoto et al. 1997), microwave television (Dirksen et al. 1993), and satellite videoconference (Hinman 1996) demonstrated promising results but remained largely unexploited. A number of practical implications, mostly cost related, prevented these technologies from spreading to a larger audience (Mattheos et al. 2000a).

The revolutionary contribution of the Internet was that for the first time, all communication tools were unified under one simple environment and accessible by the individual user through a standard desktop workstation. This fact quickly boosted the development of DL courses, and very soon we witnessed the first “Virtual Classrooms” (Hiltz 1995), “Virtual Learning Communities”, or “Integrated Distance Learning Environments” (Cravener 1998). The first courses designed were not based on any sound methodological principle, but were rather created as metaphors of the traditional classrooms (Schwan et al. 1996). In this sense, CMI was initially perceived as a substitute for in-classroom discussions.

Research in the 1990s presented an optimistic picture of the Virtual Classrooms, which was reported to better motivate and activate students, enjoy a higher acceptance among them, and even achieve higher levels of interaction than traditional classrooms (Cravener 1999). However, the research of this era was repeatedly criticised for the lack of control groups and randomisation and the limited control over reactive effects such as the notorious “novelty effect” (Phipps et al. 1999).

The review included in this thesis (study I) was conducted at a turning point in relation to the educational community’s approach to CMI and CBL in general. As the initial novelty issues slowly resided, several methodological aspects were slowly uncovered by advancing research, especially in relation to the role of CMI within educational environments. The review identified the importance of factors such as personal motivation and face-to-face interaction in the learning process, and much of the research in the years that followed was consistent with these findings. Results from several studies after the year 2000, pointed out significant differences between computer-mediated and face-to-face interaction, in terms of both the quantity as well as various qualitative aspects of communication (Vrasidas et al. 1999, Arbaugh 2000, Bageherian et al. 2000). In addition, research appears to have shaped a more realistic framework for the effectiveness of CBL in general. Schittek Janda (2003), systematically reviewed several parameters in a large number of randomised controlled trials published between 2000 and 2003 in the wider area of computer assisted learning. He concluded that in the great majority of selected experiments, computer-assisted learning did not demonstrate clearly improved results (learning
effectiveness, motivation, attitudes, time) over the existing traditional teaching methods. Although it becomes increasingly apparent that face-to-face and computer-mediated communications have different strengths and weaknesses on a theoretical level, the practical implications of these differences remain largely unclear.

The findings of the experimental studies in this thesis seem to be essentially in line with the observations stated above. CMI was the only interaction method available in the periodontology virtual classroom (study III). Although the synchronous part in particular appeared to have a motivating effect on the students, it came with several practical problems, which were only overcome thanks to the enthusiasm and self-motivation of the students. The team spirit developed during this course was favourably commented, however, this fact cannot be attributed solely to CMI, as the face-to-face meeting which preceded the course probably played a significant yet unclear role.

Computer-mediated interaction was still valued when used in a blended learning structure combined with regular face-to-face meetings. It was found that computer-based “chats” were an important and possibly irreplaceable element of the course. However, computer-based discussions seemed to be “dominated” by the presence of the tutors, while the participation of the tutors was much lower in the face-to-face PBL groups. This might be attributed to the fact that the tutors felt they had to act as moderators as well, thus propelling discussion, or even to the lack of experience with the medium on the part of the participants. Also, important qualitative differences were apparent, which indicated that current text-based technology could not fully replace face-to-face meetings within a PBL group work without compromising the quality of the communication.

It must be noted that most of the participants in both of the above-mentioned studies were unfamiliar with computer-based courses and PBL. This fact introduces a “double novelty”, where students must familiarise themselves not only with a new environment (computer-based learning) but also with a whole new methodology (PBL), and the exact influence that each of these factors had over the final results cannot be estimated.

In study V, text-based interaction was replaced with audio-visual, thus reducing the “cognitive communication cost” as Reid would describe it (Reid et al. 1996). However, even in that case, the interference of the media seemed to significantly affect the interaction process. The literature indicates that students seem to accept teleconferencing easily for everyday teaching purposes (Gul et al. 1999, Gschwendtner et al. 1997), but in this particular case the study took place under the fragile settings of examinations, where students are probably more tense and sensitive and where the application of teleconference has been little studied. Although there were no significant technical problems and no particular complaint was registered, students demonstrated a markedly lower acceptance of the CMI option. It is still unknown to what extent these attitudes can influence the performance on the examination.

Basically, these findings indicate that CMI has an important role to play in education. However, due to inherent structural differences, CMI seems to have different strengths, potential, and limitations. With this in mind, the most beneficial educational scenario would currently include both computer-mediated and face-to-face interaction, with a considerable degree of user-determined flexibility.

In everyday educational reality, however, this optimal educational scenario is not always possible. Budget restrictions as well as various students’ needs often impose priorities which limit a course designer’s flexibility, and in such cases it is
important to understand that a trade-off between optimal structures and realistic needs or convenience always takes place. The real challenge in such scenarios is to define the minimum quality requirements and to balance the resources and needs with the realistic options available.

b. Learner’s Interaction With The Interface

The general introduction of computers in all aspects of our everyday life gave birth to a whole new scientific area, the so-called Human-Computer Interaction (HCI). This field of science is concerned with the design, evaluation, and implementation of interactive computing systems for human use and with the study of major surrounding phenomena (Hewett et al. 1992). HCI is a multidisciplinary field with broad applications. Besides computer science, HCI directly involves psychology (cognitive process theories, empirical analysis of user’s behaviour), sociology and anthropology (interactions between technology, work, and organisation), industrial design, and more.

This thesis focuses on the aspects of HCI relevant to interactive educational applications accessible through Personal Computer Workstations. A large amount of educational computer applications has been reported and evaluated in the last few years. Among such applications we can find case-based scenarios, virtual patients (Bearman et al. 2001), and more. Many of these applications have demonstrated very positive results (Lyon et al. 1992), indicating a high learning potential for software of this kind. The advanced potential for learner-interface interaction is supposed to be the stronghold of such applications, as opposed to more static applications such as digital textbooks and HTML pages. Some evidence indicates the importance of the learner-interface interaction in determining the final educational outcome when dealing with simple skills and memory retention (Brooks et al. 1999). These findings are further supported by recent cognitive theories, especially with regard to learning styles (Pask 1988) and different types of memory activation. However, the actual role of the learner-interface interaction in the learning process, the factors of importance for choosing the optimal interface, and its relation to individual learning styles remain largely unclear.

Stand-alone interactive computer applications have been reported successful in improving students’ competence in areas such as knowledge comprehension, clinical skills (Kaufmann et al. 2001), communication skills (Konkle-Parker et al. 2002) and so on. The development of complex cognitive skills such as self-assessment appears to be a far more complicated process than that of the acquisition of knowledge or psychomotor skills. This might be the reason why Kay et al. found no difference with the control group when testing a computer learning package for the development of clinical decision-making skills (Kay et al. 2001).

In applications dealing with the acquisition of simple skills or knowledge, the software was able to provide constructive feedback, pointing out the actual mistakes made. However, when it comes to complicated cognitive procedures (critical thinking, problem solving, self-assessment) computer-generated feedback cannot indicate actual weaknesses but, rather, provides a flexible example or standard. Subsequent reflection by the student is expected to result in improvement of the skill in question. Such an assumption is encouraged by recent theories in cognitive science on reflection and metacognition (Antonietti et al. 2000; Kuiper 2002; Landauer 2002), but research in this area is still in a very early stage.
The fact is, the most important part of life-long learning is undertaken without the direct involvement of a supervisor. It should be therefore reasonable to assume that improvement is possible without the feedback of a supervisor or peer, simply through reflection, once a satisfactory level of self-assessment skill has been acquired.

In the case of novice learners, however, such as undergraduate students, the danger is that wrong perceptions will be retained much longer or until they are corrected by constructive human feedback. If this assumption is valid, then stand-alone applications could be effective for those who already possess sufficient self-assessment skills. Such applications would not help novice learners or those who are generally weaker and actually in real need of remedial support.

In the sixth study, both assessors found no significant difference between the two groups in self-assessment skills. However, several limitations in the study design might have hindered the interactive methodology from reaching its full potential. The knowledge level of both the Internet cases and the examination was elementary and directed mainly towards comprehension of basic facts and skills. The benefits of reflective studying might be far greater and consequently measurable in deeper, more demanding, and more complex knowledge levels. In addition, the period of time allocated to the experiment might have not have been sufficient for measurable differences to appear.

Current research has pointed out that time is a significant factor in the development of expertise (Budke 1995). It is interesting that in this study, time on task appeared to be also connected with self-assessment skills. It’s unclear whether such findings indicate cause-effect relations or are due to confounding factors. The correlation between computer competence and performance might be well attributed to a similar dependence on confounding factors.

The attitude of the students towards the Internet cases was in general positive, as were their perceived benefits from their use. It was evident that the expected benefits, especially in relation to examinations, kept the student’s motivation high throughout the study. The present observations on attitude indicate that for such applications to be successfully accepted by the students, two factors are critical: first, students must have a clear perception of the benefits to be derived from the use of the software, and second, the applications should be integrated in the curriculum and replace part of the existing workload and not be added on top of the students’ sometimes already overloaded schedule.

Based on the present findings, it remains unclear if computer applications without human feedback can constitute an effective, short-term, remedial support for the improvement of self-assessment skills in students. Further studies are needed on this model. In such studies, the content of the cases and the subsequent assessment should be focused on deeper and more complex levels of knowledge where reflective and critical thinking is expected to play a greater role. It would also be of interest to investigate possible differences in the effects of such software on students with sufficient, mediocre, and questionable self-assessment skills.
Where to from here?

The sudden and at times explosive introduction of the Internet turned computer-mediated communication into a field of legend, spreading far beyond the walls of the educational community. For years, facts were inseparably blended with myth, expectations rose as suddenly as they would drop, and huge investments were jeopardised overnight in the hope of the new IT El Dorado. Today, as the “gold rush” slowly calms down and with the benefit of the first series of strictly controlled research results (Schitteck Janda, 2003), we already witness a more mature approach by the educational community.

The Virtual Medical and Dental Schools which in the early 1990s were envisioned to be just an extension of our desktop, have today matured into “a student-centred blend of e-learning with face-to-face learning experiences, an important component of which will be a bank of reusable learning objects” (Ivimeds Consortium 2003) (Fig. 12). The approach of the DentEd Consortium for the Virtual Dental School is almost identical (Nattestad et al. 2002).

Technology will definitely continue to be a driving force for educational design and applications in the future as well. Visible technological trends (Hewett et al. 1992) indicate that, in the near future, computers will communicate locally through high-speed, wireless networks and wide area networks on a national level. Infrared, ultrasonic, cellular, and other wireless technologies will make data and computational services portably available at most locations to which a user might travel.

New display technologies will enable very large and very small displays which will be thin and lightweight and have low cost and low power consumption. In this way, computation will pass beyond the realm of desktop or laptop computers into objects of everyday use, creating mixed media. The separate worlds of consumer electronics (e.g. stereos, mobile phones, palm pilots, DVD players, television) and networked computers will partially merge (Hewett et al. 1992) (Alan 2002).

In the field of education, such technological developments will offer new, improved environments for CMI with an emphasis on portability and convenience. However, as current experience shows, faster, more portable and easier CMI does not necessarily imply improvement in instructional quality per se. Therefore, at the basis of our current experience, it might be reasonable to assume that face-to-face instructional interaction will remain a critical and at times irreplaceable part of the educational process. If our progress in the areas of cognitive science and educational methodology is to be similar to that of Information Technology, we would soon be able to better understand some of the relevant factors. Future educational research could focus on the individual, widening our understanding of the roles of learning styles and cultural issues relevant to learning. This will allow the design of
complicated yet customisable and flexible learning strategies, which will go beyond CBL or DL into the so-called “blended learning” approach (Osguthorpe et al. 2003).

One of the breakthrough contributions technology could have in instructional interaction is related not directly to technical features but to the quality of the interaction itself. The greatest drawback at present regarding learner-interface interaction lies within the computer-generated feedback. Computers have been unable to provide learners with constructive, individualised feedback other than test scores or bits and pieces retrieved from a database. This might be sufficient feedback when the aim is the acquisition of knowledge or the training of simple skills, but when it comes to the development of more complex cognitive skills, computer-generated feedback appears to be weak.

Recent developments in the fields of cognitive science, artificial intelligence, and neuronal and semantic networks, however, might soon provide us with “intelligent” computer-based tools, which will eventually manage to simulate supervisor’s feedback in cognitive areas such as self-assessment skills, problem-solving ability, and critical thinking. Computer-based tools are being developed which can perform a semantic analysis of a student’s free text. Semantic analysis is a theory and methodology for extracting the contextual-usage meaning of words by statistical computations applied to a large corpus of text. The underlying idea is that the aggregate of all the word contexts in which a given word does and does not appear provides a set of mutual constraints, which largely determines the similarity of words and sets of words to each other (Landauer et al. 1997). Computer tools built on these principles use complicated semantic network algorithms; a database of text, terms, and relations called “thematic environment” or “space”; and a sample of free text from a relevant resource (University of Colorado, 2004). The analysis can therefore compare a student’s free text with the one provided as a standard through a complicated process of semantic calculations and come back with unique feedback in various forms. Such technologies are still in their infancy, and we are definitely far from their safe introduction to our everyday educational needs. However, if this field develops as intended, we might soon have a breakthrough in the field of learner-interface interaction where technology will not only be faster and easier—but also smarter, at least smart enough to undertake some of the tutors’ heavy workload.
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…and a final reflection..!

Saturday afternoon of February, sitting in a cozy café in Malmö, pretty much the same place where four years ago I started putting on paper the first words of what has now become my thesis. I’ve been reading all these one last time before they take the way to the printing house and couldn’t help looking back on these few years in Malmö.

I’m amazed by how fast everything changes. Our fast and shiny computers become soon obsolete and get replaced by faster and shinier machines. Our methods grow old with us and get replaced by other, modern ones. Even our words on paper often loose their meaning with time and they get replaced by other words, stronger and more meaningful.

It feels as a closing point. We walk on and advance without being always able to see what lies ahead. Following the natural path, the eleven thousand words of this thesis might sooner or later also become obsolete and remain a collection of text stored in some electronic database. And then all that will be left untouched is the love. The love I felt for what I did during these few years and the love I feel for this beautiful corner of earth and all its wonderful people.
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