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A case study of successful e-learning: A web-based distance course in medical physics held for school teachers of the upper secondary level

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Abstract

Learning activities and course design in the new context of e-learning, such as in web-based courses involves a change both for teachers and students. The paper discusses factors important for e-learning to be successful. The development of an online course in medical physics and technology for high school teachers of physics, details of the course, and experience gained in connection with it are described. The course syllabus includes basics of radiation physics, imaging techniques using ionizing or non-ionizing radiation, and external and internal radiation therapy. The course has a highly didactic approach. The final task is for participants to design a course of their own centered on some topic of medical physics on the basis of the knowledge they have acquired. The aim of the course is to help the teachers integrate medical physics into their own teaching. This is seen as enhancing the interest of high school students in later studying physics, medical physics or some other branch of science at the university level, and as increasing the knowledge that they and people generally have of science. It is suggested that the basic approach taken can also have applicability to the training of medical, nursing or engineering students, and be used for continuing professional development in various areas.

Keywords: E-learning; Distance education; Online learning; Adult learning; Continuing professional development (CPD); Medical physics; Contemporary physics; Physics teaching

1. Introduction

This article concerns an online course in medical physics that upper secondary school teachers in Sweden can take and the ideas behind it. The major aim of the course is to provide teachers the knowledge and skills required for teaching physics in what for most of them is a new context, that of medical radiation physics and its applications. Since even many students of higher education do not remember much of the science they had in school, there is a common lack of concern for science and of understanding of it on the part of many adults. This is a genuine problem at a time when science is having an increasing impact on our daily lives, and when society is more in need of scientists than ever before. Physics is often considered a difficult and highly abstract subject and interest in it appears to have been on decline for some time [1,2]. There is also a clear gender difference in the degree of interest students show in physics and how well acquainted they are with questions concerning it [3]. It is important that teachers endeavor to find means of counteracting this [4]. Many initiatives have been taken to enhance interest in physics and in science generally. An example is that of *Physics on Stage*,[1] a programme for European science teachers initiated by CERN, ESA and ESO in 1999 in response to the Call for Proposals for the European Science and Technology Week in the year 2000, which the European Commission sponsored. A current project announced by *The International Union of Pure and Applied Physics* is the *World Year of Physics 2005*,[2] a global celebration of physics and its importance in our everyday lives. Alongside these international ventures, there are a variety of domestic and local initiatives aimed at encouraging the study of physics.

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[1] http://www.physicsonstage.net.
[2] http://www.physics2005.org/.

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An approach often employed has been to show how applicable physics is to real-life problems and problem solving [1,4–6]. A physical phenomenon that can be used to elucidate this is that of *radiation*, with the practical applications it has in the areas of medicine and healthcare, e.g. diagnostic imaging and cancer therapy [7]. Medical imaging involving the use of ionizing or non-ionizing radiation can serve as a point of departure, for example, in providing students access to large segments of contemporary physics [6].

For the interest of young persons in physics and engineering to be enhanced, it is important that there be high school teachers with the motivation and knowledge for teaching contemporary physics in a manner that is exciting and stimulating. The National Agency for Education in Sweden has made efforts to encourage interest in science in the schools by letting pupils study themes and topics not offered in the normal school curriculum. To give students the encouragement and support they need in this respect, it is important to provide teachers appropriate training, not only in teaching methods but also in specific school subjects not covered in the ordinary education and training of teachers, an approach termed continuing professional development, CPD.

2. The Net University

In view of the rapid advances in e-learning during the last few years, the Swedish government established a Swedish Net University[3] recently, a multimodal university offering some 2500 e-learning courses held by different universities and university colleges in Sweden. Many of these courses are given by Lund University,[4] one of Sweden's oldest, largest and most comprehensive universities, with eight faculties and a variety of research centres and specialized departments. Students can choose between some 50 programmes of studies and over 800 separate courses on campus. In 1996, Lund University initiated an intensive, target-oriented project involving both distance education and continuing education, establishing The Office for Continuing and Distance Education (OCDE), which has played a central role in the development of the online distance courses the University has provided. In the last few years, Lund University has gone from holding only a few traditional distance courses to offering more than 150 online courses. These are a mixture of pure online courses in which students meet only virtually, and of courses given in a blended mode [8] in which online learning is supplemented by a number of face-to-face meetings and various other activities. Expansion in this area was spurred by extra resources being made available to encourage separate departments and individual teachers to develop or improve online distance courses. The university has also established The Learning and Teaching Development Centre[5] (UCLU), thorugh integration of the two former units for IT and education and pedagogiacal development, providing consultation and support for the university teachers involved.

One of the first online learning courses that was held at Lund University was "*Radiation in Medicine and Healthcare*", developed and given by the author and his colleagues. The course was intended primarily for science students, engineers, medical students, nurses and those with a technological profession who wanted to obtain more thorough knowledge of radiation and a certain orientation to the medical use of it. The fact that medical radiation imaging is such an excellent source of applications within the area of modern physics led to the idea of a new course, "*Medical Physics for teachers*", held in collaboration with The National Centre for Education in Physics,[6] located at the Department of Physics of Lund University.

Although the major target group for this course was that of physics teachers at the upper secondary school level (also referred to here as "high school teachers"), the course is also one that could serve as an introductory course for healthcare professionals. There are some 100 persons, most of them teachers and some of them engineers, who have completed and passed the course thus far. The results have been very gratifying, particularly since many of the participants teach and supervise the work of high school students on special study themes within this area.

As teachers they work either alone or in teams often composed of physics and biology teachers. One direct result of the course that has already been observed has been an increase in the number of high school students who show an interest in the Medical Physics Programme in their university studies. The number of students applying to that programme in Lund as their first choice has increased by a factor of 7 (6–42) within the past 4 years and this fall (September 2004) a majority was females (60%). The remainder of the paper concerns in large part how the *Medical physics for teachers* course is given. It is one of the many e-learning courses which Lund University provides, one that can be seen as highly successful.

3. Learning and teaching online

Online learning is so effective and well provided for today that it is difficult to argue against its being successful, as was done at the very start. It is obviously moving more and more from representing an instruction paradigm to becoming a learning paradigm, a distinction made in pedagogical theory [9]. In an instructional paradigm, a specific methodology and a specific body of knowledge determine in large measure what the teacher does, including planning, choice of content, the lessons given and the tasks assigned. On the contrary, the teacher with a learning perspective provides students support, the students themselves actively discovering knowledge and

[3] www.netuniversity.se.
[4] www.lu.se.
[5] www.uclu.lu.se.
[6] www.fysik.org.

constructing it. Thus, in the learning paradigm it is a student's own learning and success which set the boundaries and define the task. This really comes to the fore in online learning situations, since traditional lectures and classroom activities are lacking. For online learning to be successful, a complex system needs to be developed, one that provides sufficient planning but also involves a high degree of flexibility, allowing the student to manage much of what is done [10,11].

During the past decade, teachers and researchers have gained important insight into online learning and it appears that they can soon judge its overall effectiveness [11,12]. A book Stephenson [11] has edited provides a comprehensive account of what has been discovered about e-learning during the last 10 years and guidelines based of this for how it can be successful. Coomey and Stephenson [13] summarize different learning strategies taken up recently in the literature and suggest a *paradigm grid for online learning*. The paradigms involved, presented briefly in Fig. 1, suggest there to be four basic perspectives or approaches one can take in regard to online learning, the figure placing them within in a metaphoric system of coordinates: (i) specified and teacher-controlled learning activities, (ii) teacher-controlled but open-ended or strategic learning, (iii) learning activities managed and specified by the learner, and (iv) learner-managed and open-ended or strategic learning. Each of these four approaches can be described in terms of a particular characteristic, *dialogue*, *involvement*, *support*, *control* and *teachers role*, respectively. Experience during the last decade has shown the importance of structuring students' learning activities, of a course design that promotes dialogue, of helping learners become involved and of providing feedback and support. Although it is not a simple matter to decide what strategy to adopt in planning an online course and how to develop it, the paradigm system described above may make this task easier.

4. Course design

The aim of the present course is to provide the teachers with ideas for how they could design a course in medical

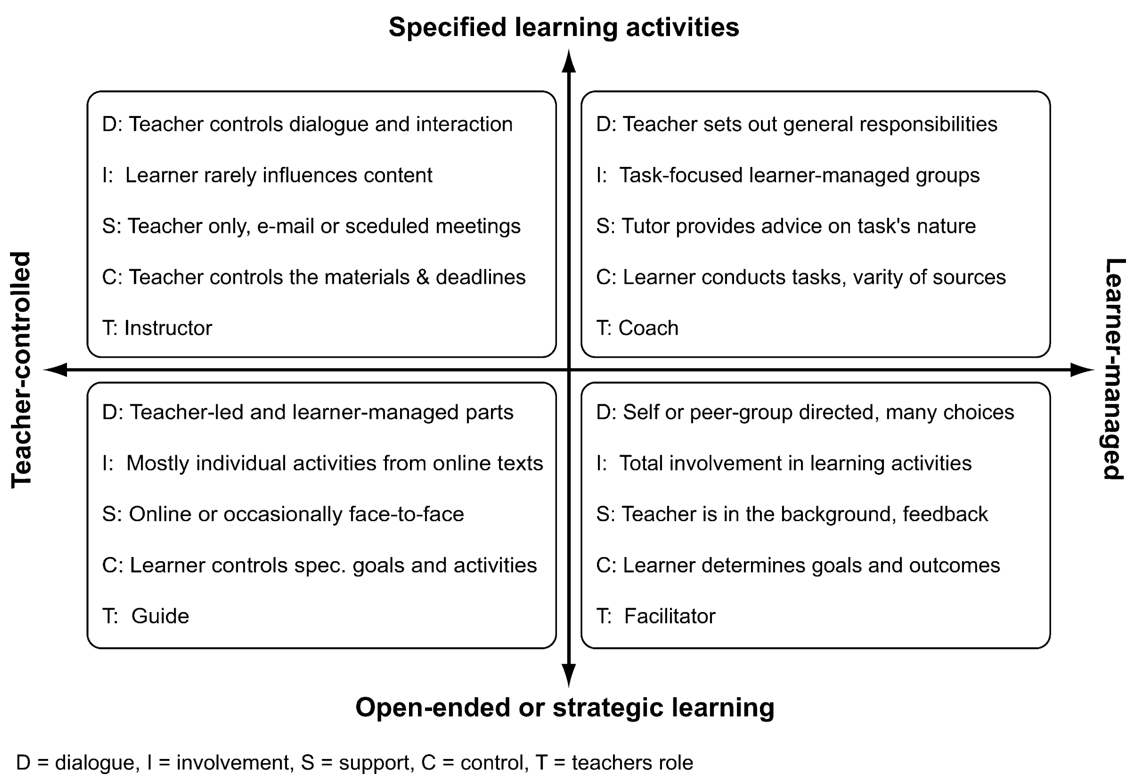

Fig. 1. A summary of the "online paradigm grid" for online courses suggested by Coomey and Stephenson [13] based on one hundred research reports and articles, here redrawn as a system of co-ordinates. (D = dialogue, I = involvement, S = support, C = control, T = teachers role)., In the first quadrant (upper-right) the learning tasks (e.g. case studies) and the principle learning goals are specified by the teacher, but the learners control how they work, in e.g. peer-group collaboration. In the second quadrant (upper-left) the teacher tightly specifies the activities and outcomes including the online (text) content, time schedule, deadlines, exchanges, with little possibilities for own initiative of the learner except for carefully controlled situations. The third quadrant (lower-left) characterizes of that the overall direction, outcomes, purpose, field and level are set by the teacher or start with task-defined activities. The learners explore access and use any specific material in line with the direction set by the teacher. After completion of the "set-learning" the students continue to explore the subject area in a more unstructured manner. Finally, in the fourth quadrant (lower-right) the learner is in control over the generally direction of the learning including learning outcomes as well as longer terms goals. Personal goals, i.e. reasons for the studies, are as important specific learning outcomes. Courses characterized in this quadrant are those which give the learner the most freedom of choice concerning goals, outcome and his/her progress.

Table 1
The content at the introductory 2-day meeting at the Deparments of Medical Radiation Physics and Oncology at Lund University Hospital

Introductory lectures (in radiobiology and radiotherapy, MRI, SPECT/PET, laser spectroscopy and photo dynamic therapy)
Demonstrations of equipment (SPECT-camera, PET-scanner, CT-scanner, MRI-camera, laser therapy in oncology (photodynamic therapy), after-load equipment, linear accelerator and dose planning systems)
Lecture concerned with "How we learn"
Introduction to information competency, i.e. search strategies for effective information retrieval on the Internet and in databases
Hands-on training on the learning management system (platform)

physics for high school students and support them in their efforts to do so. Presenting physics to high school students in a manner focused on the human being is important for gaining their interest. In the long run, it can also contribute to female students in particular deciding to major in a natural scientific subject, especially physics, in going on to university studies. The formal prerequisite for those taking the course is in most cases that of being a high school physics teacher, although the course is also open to persons with other professions, such as engineering. The course focus on the use of radiation in medicine and in health care, as based on medical radiation physics and medical imaging. Since in a distance course involving e-learning there are no lessons in the conventional sense, the subject matter of the course needs to be presented or be made available to participants in some other way. To this end, use is made of five modules and nine submodules, which contain e-book texts, tasks, other resources which the students can use. Since a certain degree of personal, face-to-face contact is seen as important, along-side web-based activities, two opportunities are also provided for the teacher and the participants to meet, there also being smaller peer-groups in which the members meet with each other. This is a course type termed "blended learning" [8].

It is important that participants become inspired very early in the course. The course starts with a compulsory, 2-day face-to-face introductory meeting, held on the campus in Lund, primarily at the University Hospital, in the middle of August, which is about 2 weeks before schools open in the fall. What is taken up at the this meeting is summarized in Table 1. At the meeting the participants (referred to in the following as learners or students, although it should be recalled that they as a rule are teachers) attend readily comprehensible lectures on radiation physics and its medical applications held by a number of medical physicists and professors of medical physics. There are also a number of demonstrations of radiological equipment, demonstrations that are combined with a general social gathering. The demonstrations, as illustrated in Fig. 2, are conducted by medical physicists,. At this face-to-face meeting there is also a lecture on the topic "How we learn". Ideas of how a medical physics demonstration could be designed for a high school course are also discussed, since that is the final goal of the course. Finally, the learning environment and the learning management system[7] (LMS), see Fig. 4, are introduced, the learners becoming familiar with the resources available in the course. After this meeting, the learners go home and continue the course online, starting with the first module (A), see Table 3.

Table 2
The content of the 2-day "half-time" meeting at the Tycho Brahe School (an upper secondary school in Helsingborg) and at the Departments of Radiology and Nuclear Medicine (of Helsingborg Regional Hospital)

Further lectures (medical ultrasound, radiopharmacy and internal dosimetry, X-ray fundamentals and the CT-scanner)
Demonstrations and examples of "radiation experiments" for use in schools (mini X-ray apparatus, NaI(Tl)-scintillation detector for spectroscopy, measurement of radon)
Evening social event (dinner) together with informal discussions, follow-up and feedback
Simple laboratory work by the learners (teachers) at the Departments of Radiology and Nuclear Medicine of the Regional Hospital in Helsingborg on an ultrasound scanner, a double-headed scintillation camera, and an X-ray machine, computer tomography and a 1.5 T magnetic resonance camera

The learners are also divided into small peer groups of 3–6 members each, normally consisting of a team of teachers (here learners) from the same school, city or region. The learners work together in these small groups, which can also make study-visits at some neighbouring hospital, is seen as advantageous. An effective course length of 5 weeks, spread over two semesters, is aimed at, involving a total of about 200 study hours. Communication between the learners and the course-instructors take place in the form of netbased online discussions in an asynchronous discussion forum within the LMS, as well as of group or individual e-mail contacts. There is also the possibility of synchronous communication in the form of chats, although there are no organized chats that are scheduled. Rather, whatever chats take place are managed entirely by the learners. A second face-to-face meeting of all course participants – this time at the Tycho Brahe School[8] in Helsingborg, an upper secondary school in which considerable emphasis is placed on contemporary physics, and at the Regional Hospital of Helsingborg – is held after about half of the course has been completed. What is taken up in that meeting is summarized in Table 2. Again, a number of lectures by medical physicists are held, primarily with the aim of inspiring the learners. There is also the course option available of attending a presentation of how schools can take up problems of medical physics. At the hospital a number of demonstrations of medical equipment are also provided, the learners being allowed to use it to make measurements in connection with this. In addition, each learner is provided an evaluation of the progress made thus far, as well as feedback in the form of peer-group review. This meeting differs from the introductory meeting in that sense that the online

[7] Since for this typical course an in-house ASP-coded and database-based LMS-system (kASPer developed by Dr. Peter Ekström, Department of Physics) is employed, the system is not further presented. A screen shot of the LMS can be seen in Fig. 4.

[8] http://www.tycho.helsingborg.se.

Fig. 2. Medical physicists demonstrating different types of radiation equipment for the learners during the introductory meeting on campus (Lund University Hospital) prior to the online studies. This provides the learners a certain inspiration for the work to be done as well as a better factual basis for starting their online studies in medical physics: (a) demonstration of the Laser equipment used for photodynamic therapy of skin cancer; (b) after-load machine for brachy therapy; (c) demonstration of a modern SPECT-CT scanner for nuclear imaging; (d) linear accelerator and the treatment procedure of cancer therapy is demonstrated.

activities are by this time running and that the learners know each other much better. After several months of collaboration online, they are very anxious to share their experiences face-to-face and discuss what they have learned and experienced.

5. Modules

The aim of the e-learning course described here is to provide the teachers knowledge of how radiation is applied in medicine, both for diagnostic and for therapeutic purposes. The objectives are (i) to gain more thorough knowledge of the basics of radiation physics, (ii) to obtain knowledge of the use of radiation in medical applications, (iii) to learn about various medical radiation imaging equipment through demonstrations of them, (iv) to take an active part in laboratory work using a medical imaging device (ultrasound, X-rays, CT, SPECT/PET, and MRI), (v) to learn of research concerned with the teaching of physics, and (vi) to develop one's ability to use ICT[9] for educational purposes, including competence in information retrieval (WWW and database searching). The possibility is also provided of obtaining a better understanding of the connections between the diseases or conditions involved and the use to which the equipment is put in diagnostic imaging and radiation treatment. A medical briefing is provided as well (concerning the anatomy, physiology and oncology of relevance), together with guidance in use of the medical information portals on the Internet.

The following syllabus and modules (see Table 3) are used in the course: (A) basics of radiation physics and biology, including matters of radiation sources, interactions, detectors, dosimetry, radiation biology and radiation protection; (B) diagnostic imaging based on ionizing radiation, i.e. PET-, SPECT- and CT-scanners; (**C**) diagnostic imaging based on "non-ionizing radiation", i.e. magnetic resonance imaging and spectroscopy, ultrasound and lasers; (D) radiation therapy; i.e. external and internal (brachy) therapy as well as radionuclide therapy. In addition, a fifth module (E), methodology and didactics, deals with how topics of medical radiation can be made use of in the teacher's own courses.

The first module (A) has no submodules and the learners all work at the same tasks. This module deals with the fundamentals of radiation physics, emphasizing matters of health physics, biology and medicine. Although physics teachers as a rule are quite familiar with atomic and nuclear physics, applied radiation physics is a topic they tend to

[9] Information and Communication Technology.

Table 3
Course modules and its sub-modules (topics)

Modules	Sub-modules
A. Basics of radiation physics and biology	
B. Diagnostic imaging using ionizing radiation	B1. Positron Emission Tomography
	B2. Single Photon Emission Tomography
	B3. Computed Tomography (X-ray)
C. Diagnostic imaging using non-ionizing radiation	C1. Magnetic Resonance Imaging
	C2. Ultrasound
	C3. Laser (spectroscopy and therapy)
D. Radiation therapy	D1. Radionuclide therapy
	D2. External Radiation Therapy
	D3. Brachytherapy (internal)
E. Methodology and didactics	Design of the teacher's (learner's) own course in medical physics and technology

know less about, probably because of its not tending to be taught in secondary schools. In this module the learner becomes acquainted with the types of radiation types used for medical diagnostics and therapy. Briefly, the module deals with the interaction of radiation with living matter, radiation dosimetry, the biological effects (both deterministic and stochastic) of radiation, and problems of risk, such as dealt with by use of the LNT-model (*linear no threshold*) for risk assessment. The tasks this module presents involve real-life situations, a radiation accident being an example. The learners are to explain the whole chain of events and the physical (and to some the extent biological) phenomena involved, beginning with the situation at the start. In writing reports on such questions the learners are to endeavour to take up matters that can be used in their teaching. Some of the peer-groups have also developed excellent PowerPoint presentations as well. The second module (B) is divided into three sub-modules that deal with imaging equipment that makes use of ionizing radiation, as shown in Table 3. Here, both the functioning of the equipment and the underlying physics are to be explained in a written report. The manner of presentation and the terms employed should be such that high school students could readily understand the report. The third module (C) is dealt with in the same way as (B), but concerns magnetic resonance imaging, ultrasound and laser techniques. Radiotherapy is the topic for the fourth module (D), which deals with interstitial and intracavitary brachytherapy (solid sources), external therapy (linear accelerators), and radionuclide therapy (liquid radiopharmaceuticals). This

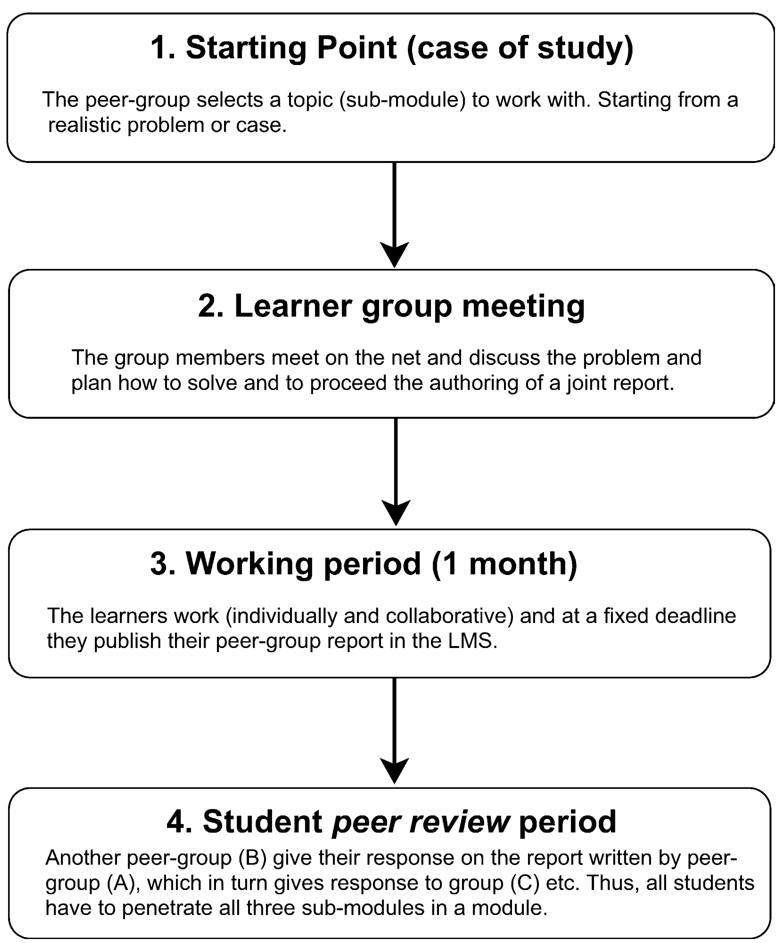

Fig. 3. Flowchart for the course Medical Physics for Teachers showing the pedagogical model used for the learning activities online.

module takes up both the technology of the equipment and the planning of the radiation dosage prior to tumour therapy. The E-module, finally, concerns how a series of lessons could be designed for illuminating some topic taken up in the course. The topic should include practical aspects, such as involving a laboratory task or studies visit to a radiological or medical physics department of a hospital in the region where the teacher work. The learner (teacher) should have in mind a clear learning situation, one encouraging use of *problem-based learning*. The learner (teacher) should also reflect on his/her role in providing pupils a realistic impression of a scientist and on the extent to which medical physics is an area of physics providing women an equal chance. A written report the working group submits in connection with this final module is included in the LMS, which is peer-reviewed by another group. For the B–D modules, the peer-groups select one submodule to work with for the period of a month. "First come, first serve" applies here. Each submodule should be dealt with by at least 3–4 groups. The tasks involved are distributed between the groups in such a way that, for example, a group that has worked with SPECT gives what it has done to a group that has worked with CT, and so on, see Fig. 3.

6. Text and Internet resources

Two textbooks [14,15] recommended (but not required) for the course provide an introduction to most of the topics covered, but much more detailed references [16,17] are also available, their use being optional and depending upon the interests of the learners, e.g. on whether they intend to design their own course in high school physics. In addition, there is a hypertext e-book (a non-commercial compendium in Swedish) the author and his colleagues have written that is made available. For every course module and submodule, a comprehensive list is also provided of links to the many web resources (e.g. texts on medicine or physics, facts of relevance, photographs and drawings), these tending within the areas of medical engineering and physics to be of very high quality. In addition, material from the EMERALD & EMIT Consortium [18,19], of which the author is a member, is used wherever suitable. The Consortium has developed a comprehensive database of pictures and PowerPoint slides for training purposes in different areas of medical physics (diagnostic radiology, nuclear medicine, radiotherapy, MRI and ultrasound). These e-learning packages, which are presented elsewhere in this Journal, have been found to be valuable both in developing the course curriculum and in conducting the course, such as in providing supporting slides for online teaching. In addition, the PowerPoint presentations used in the face-to-face meetings are published in the LMS for later viewing by the students. These lectures have been video-recorded as well, for use in on-demand video, although financial limitations have prevented production thus far. Finally, anyone registered as a student at Lund University has full access to the University Library and to the *Electronic Library Information Navigator*[10] *(ELIN@Lund)*, making information retrieval of a huge number of full-text journal articles possible.

7. Pedagogical model and student activities

The curriculum of the course is based on the student's own activities, as well as on collaborative learning supported by a variety of resources. Thus, the course can be largely characterized as being a *learner-managed* and *task-specific learning*-defined online course [13], i.e. the upper-right quadrant of Fig. 1. The basic learning goals and the major tasks involved are specified by the teacher (*dialouge*). The text and the instructions are online, hints being given of other web-based resources that are available (s*upport*). There is a mixture of case studies from daily life and of specific issues inherent to the physics behind the different "miracle" medical machines the learners deal with and how they function in a technical sense. The learners determine themselves the precise manner in which they carry out the course work, both individually and in their collaboration within the peer-group, and regarding specific tasks and goals (*involvement, control*). They collaborate by way of the net in preparing written reports or in working on problems. The one peer-group exchanges information with another and provides it feedback. There is no necessity of each learner reading the same books and using the same materials. The individual learner can search for and evaluate material on his/her own and then integrate this with what the others arrive at in the preparation of the report of the groups as a whole. Each contribution a given learner makes can reflect his or her special interests, although the report a group submits should conform will the learning goals set for the submodule in question. Thus, this approach can be characterized as being an active and collaborative one. The course teachers, acting as *coaches,* stay in the background, providing feedback by e-mail (mainly in group-mails) and also in the discussion forum if appropriate (*teachers role*). The grades of the course examination are based on the written reports submitted, on the feedback given to others, and on the discussions in which the participants took part (Fig. 4).

8. Discussion

The course described concerns primarily radiation physics and medical imaging, and how the participants can use contemporary medical imaging techniques in an appropriate way in their own teaching. The learners in the course, most of them school teachers, all appear highly motivated in their learning and represent a group which it is a joy to work with. Teachers

[10] Provided by the Lund University Libraries (http://www.lub.lu.se/index.html.en).

are a good example of a group of adult learners who have a clear need of CPD in their careers, the computer and the Internet providing them a very useful teaching and learning environment.

Evaluation of the course has been very positive, the participants appearing to be very much satisfied with the design and content of the course, Table 4. Although they express frequent satisfaction at the high degree of control they have over their study time, there clearly are specific tasks to be carried out and all are agreed that certain deadlines are necessary. The two extended face-to-face meetings are considered by the participants to be highly valuable for the inspiration and understanding they provide, as well as for the social element involved, which contributes to learning. Evaluation

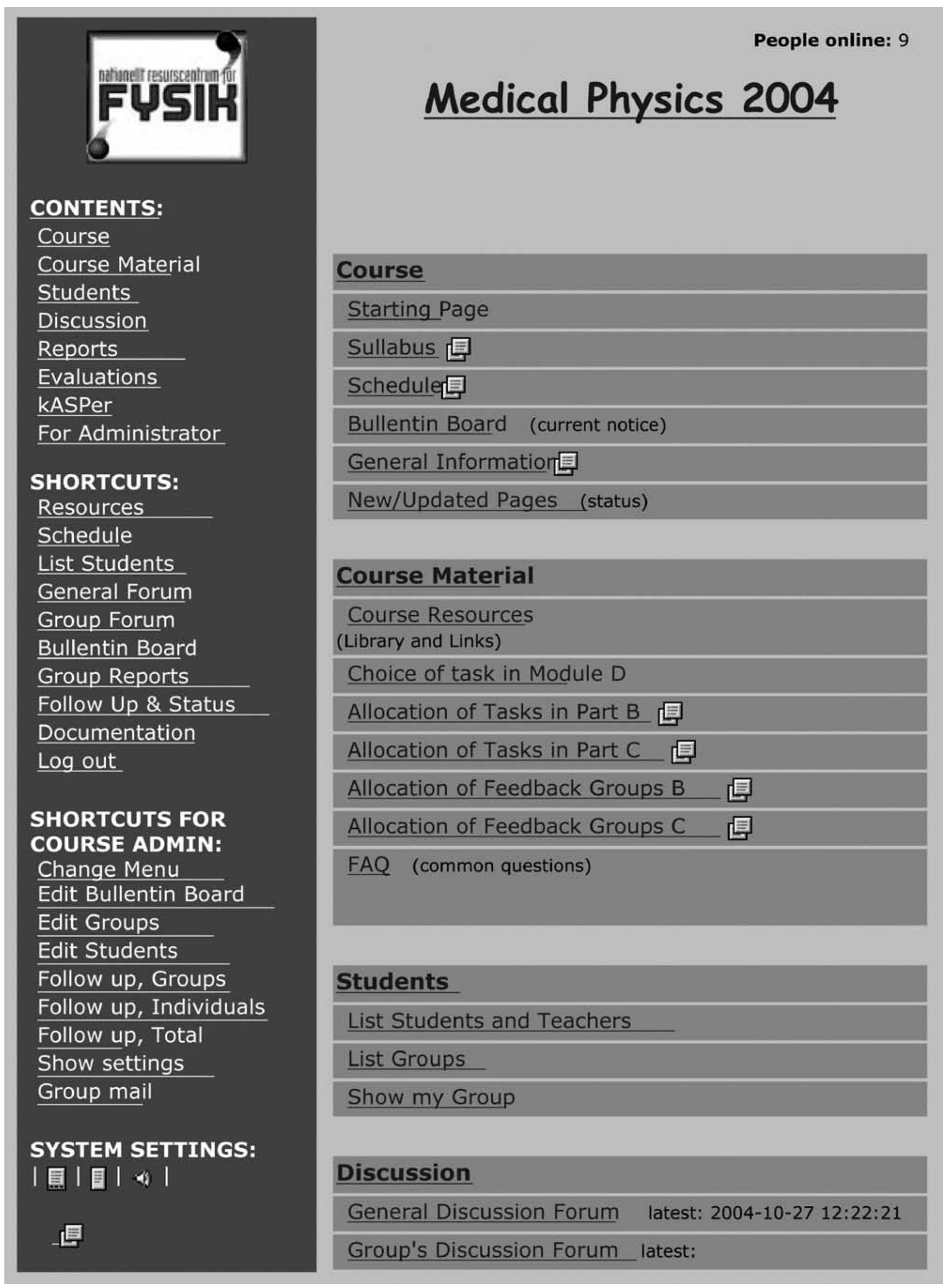

Fig. 4. Screen shot of the learning management system (LMS) and the web-design for the course "Medical Physics for teachers" (here translated from the original webpages in Swedish). The LMS, kASPer developed by Dr. Peter Ekström, Department of Physics, is an in-house made framework for e-courses, in that it contains modules for administration of participants, communication, handling of reports, follow-up on participant's progress, calendar, course evaluation, etc. Relevant parts, e.g. schedule, discussion forum, follow-up on participant's progress, database with course resources and course evaluation can also be used for traditional courses. The system has support for English and Swedish, but the detailed documentation is only available in Swedish.

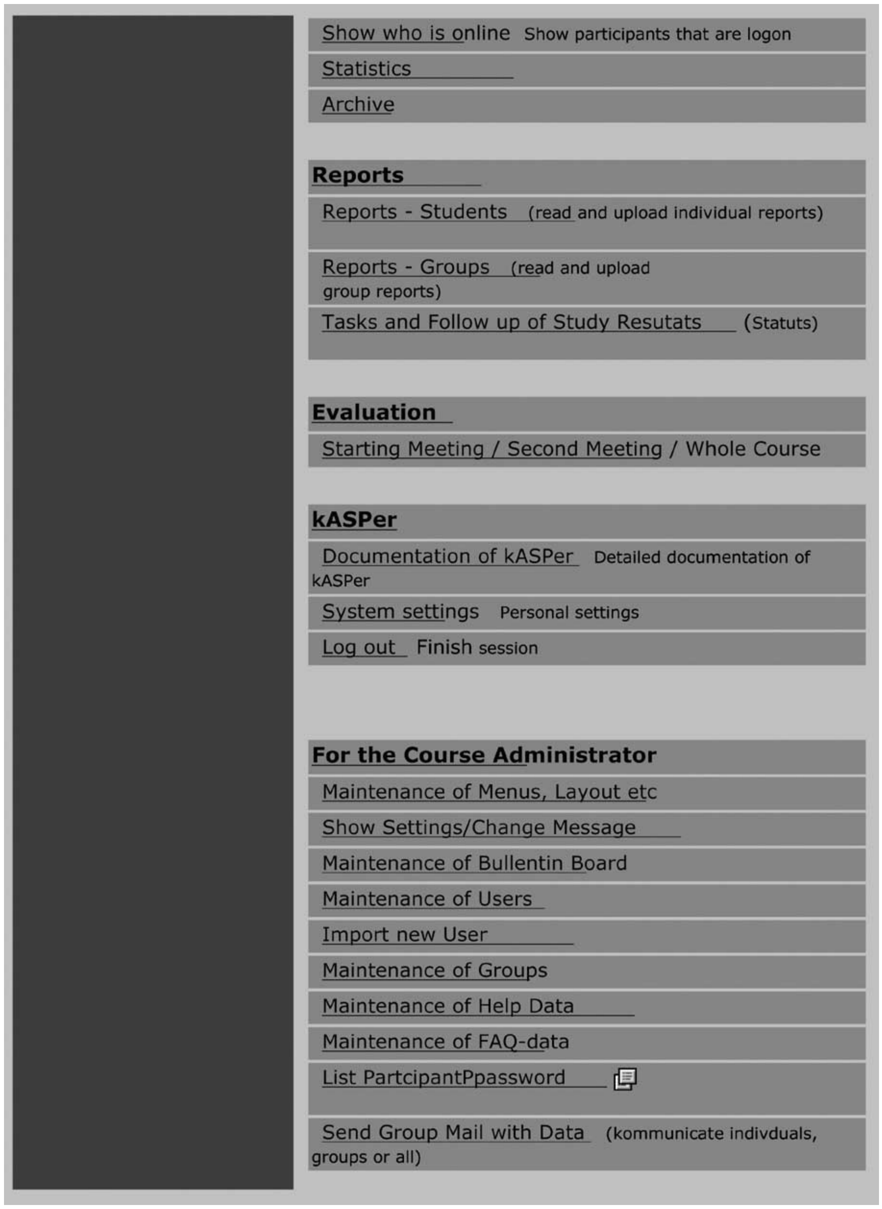

Fig. 4. (*Continued*)

has been performed qualitatively, i.e. written comments and criticism as well as quantitatively (grades). Table 4 summarises only quantitative evaluation due to limited space.

The course examination is a continual one. It consists of group writing with peer review. Although one might argue against such a group examination, one should bear in mind that the group is an adult and professionally anchored one with a very clear goal, that of learning about a subject field they have clear application for in their work. One would expect that in such a group an inactive member would be admonished by the others to do better.

Swedish universities have no tuition fee, all courses being entirely free of charge. All study spots are financed by the Swedish Government. The reader might wonder how expensive the course is, since a variety of professors and medical physicists participate in the teaching held during the face-to-face meetings, and facilities in the medical departments are made use of during demonstrations. In addition, development of the course requires a considerable input of time and resources. In view of the fact, however, that the goal of the course is to provide the teachers who participate as learners better preparation for the teaching they do, such that it can increase the interest of the high school students they teach in physics, medical engineering and physics and science generally, financing the course can be seen as an important and a marketing activity to gain more students in the future.

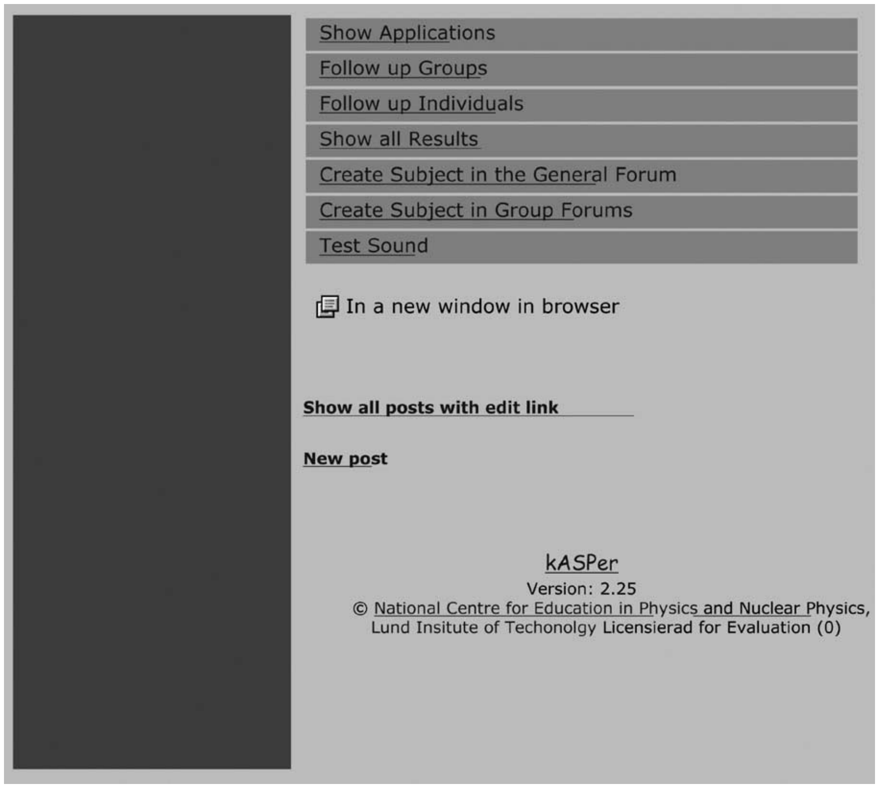

Fig. 4. (*Continued*).

Table 4
Summary of a selection of the evaluation from three courses (number of answers: 71)

Question (face-to-face meetings)	Answers (%)			
	Very good	Good	Neither nor	Bad
How did the information before and about the starting meeting work?	76.7	20.6	2.7	–
What is your impression about the practical arrangement during the face-to-face meeting?	93.0	7.0	–	–
How did the demonstrations of equipment work?	75.6	24.4	–	–
What is your overall opinion about the level of the inspiration lectures?	47.8	42.0	8.7	1.5
Did you get enough time during the starting meeting to establish contacts with the other learners? ($n = 43$)	60.5	37.2	2.3	–
Question/statement (whole course)	Answers (%)			
	Agree	Partly agree	Neither nor	Do not agree
Did you feel that the course had an appropriate tempo?	–	29.1	52.7	18.2 (to fast)
My interest for the course and medical physics raised during the course	40.0	47.3	7.3	5.4
The course goal and purpose were evident?	40.5	47.6	11.9	–
I was goal-directed in my learning	59.5	40.5	–	–
The course as whole fulfilled my expectations	71.4	28.6	–	–
Response on others reports constitutes a suitable learning occasion	11.9	57.1	31.0	–
How much time did you spend on the course?	<5 h/week: 74.6	6–10 h/week: 21.8	>10 h/week: 3.6	
Have your group used the opportunity to make any study visit to any hospital (medical physics, radiology dept)?	Yes: 27.3	No: 72.7		
Do you think that your learning have been better working with problem-based tasks than an ordinary examination	Better: 57.2	Neither nor: 33.3	Worse: 9.5	
How do you judge the quality of this online course compared with a traditional course with lectures?	Better: 25.0	Neither nor: 55.0	Worse: 20.0	

Evaluation was performed after the starting meeting, during the course and after the course was finished. Participants were given the possibilities to write qualitative comments and criticism, but due to limited space only quantitative data is given here.

9. Conclusions

In e-learning it is important that the teacher move from a teaching to a learning perspective. In the course described, the teacher prepares and helps create learning situations for the students and situations in which they can interact. For any e-learning course to be successful, a number of support mechanisms need to be developed and function properly. Success is not automatic. It is thought, however, that the paradigms discussed can suggest to teachers who are endeavouring to create their own online courses how these might best be designed and how they can best take account of the needs of the target group.

In a more specific sense, the paper considers in some detail an e-learning course aimed at providing upper secondary school teachers of physics information, insights, skills and experience in dealing with topics in medical physics in their teaching, doing so in a way encouraging and inspiring many high school students to go on later with studies in the area of science and possibly even of medical engineering and physics, and also contributing in at least some small way to making adults in general more conversant with science and with various medical applications of physics. The basic approach described is also not limited to upper secondary school teachers of physics, but could in a broad sense be applied to medical and nursing training generally and to continuing professional development of persons in a variety of fields.

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References

[1] Hannover B, Kessels U. Self-to-prototype matching as a strategy for making academic choices. Why high school students do not like math and science. Learn Instr 2004;14:51–67.
[2] Teitelbaum MS. Do we need more scientists? Public Interest 2003:40–53.
[3] Hoffmann L. Promoting girls' interest and achievement in physics classes for beginners. Learn Instr 2002;12:447–65.
[4] Benckert S. Context and conversation – a way to create a more gender-inclusive physics education? The Council for the Renewal of Higher Education, Sweden 2001: http://www.hgur.se/activities/projects/financed_projects/a-b/benckert_sylvia_97.htm (June 2004).
[5] Lenaerts J, Wieme W, Janssens F, Hoecke TV. Designing digital resources for a physics course. Eur J Phys 2002;23:175–82.
[6] Zollman D. Modern miracle medical machines: a course in contemporary physics for future physicians. Proceedings of the international research group on physics teaching (Groupe International de Recherche sur l'Enseignement de la Physique, GIREP) 2002: http://web.phys.ksu.edu/papers/2003/girep-contemp.pdf (June 2004).
[7] Wells PNT. Physics and engineering: milestones in medicine. Med Eng Phys 2001;23:147–53.
[8] Garrison DR, Kanuka H. Blended learning: uncovering its transformative potential in higher education. Internet High Educ 2004;7:95–105.
[9] Barr RB, Tagg J. From teaching to learning—a new paradigm for undergraduate education. Change 1995;27:12–26.
[10] Alexander S. E-learning developments and experiences. Educ Train 2001;43:240–8.
[11] Stephenson J, editor. Teaching and learning online pedagogies for new technologies. London: Kogan Page; 2001.
[12] Lau F, Bates J. A Review of e-learning practices for undergraduate medical education. J Med Syst 2004;28:71–87.
[13] Coomey M, Stephenson J. Online learning: it is all about dialogue, involvement, support and control – according to research. In: Stephenson J, editor. Teaching and learning online pedagogies for new technologies. London: Kogan Page; 2001. p. 37–52.
[14] Pope J. Medical physics imaging. Oxford: Heineman Advanced Science; 1999.
[15] Hollins M. Medical physics. Cheltenham: Nelson Thornes, Bath Advanced Science; 2001.
[16] Bushberg JT, Seibert JA, Leidholt, EM, Boone, JM, editors. The essential physics of medical imaging. Philadelphia: Lippincott Williams & Wilkins Publishers; 2001.
[17] Dendy PP, Heaton B, editors. Physics for diagnostic radiology. London: Institute of Physics Publishing; 1999.
[18] Tabakov S, Roberts VC, Jonsson BA, Ljungberg M, Milano F, Lewis CA, et al. Medical physics e-learning training materials Information Technology Applications in Biomedicine. In: Proceedings of the Fourth International IEEE EMBS Special Topic Conference. 2003. p. 94–7.
[19] Tabakov S, Roberts VC, Jonsson BA, Ljungberg M, Lewis CA, Wirestam R, et al. Development of educational image databases and e-books for medical physics training. Med Eng Phys 2005;27(7).