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Examples of the Teaching of the Health Questions of Electric and Magnetic Fields at Tampere University of Technology in Finland

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Abstract: The objective of the article is to present the examples of the teaching of the health questions of electric and magnetic fields at TUT (Tampere university of technology) in Finland. At TUT, the education of the health questions of electric and magnetic fields has been integrated into part of four courses, which also include other environmental issues. TUT also products two times per year situation report bulletins on medical-oriented studies related to electric and magnetic fields so that graduates and people working in transmission line projects can follow new studies of the area. It is important to develop more education of EMF health questions, so people can more easily understand how new devices and technologies work.

Key words: Electric field, magnetic field, education, health.

1. Introduction

The health questions of electric and magnetic fields are a quite interesting topic in the media nowadays. People are talking on electro smog, electromagnetic sensitivity and different symptoms that are claimed to be caused by electromagnetic fields. There is a new legislation in this field, and there is a lot of discussion on the adverse effects of electromagnetic fields at work, home and leisure time activities. People cannot feel or taste these fields. They are recognized only by suitable meters. This means that understanding of the relative importance is difficult. Although electromagnetic fields are basic things taught in physics, there is a huge amount of new technology that is being applied. In the applied technology the waveforms and frequencies have begun to be more and more complex. In addition, there are new claims on health effects of these fields, for example on cell level, psychological level, thermal effects and even combined effects, together with different environmental parameters like chemical and physical factors. For example, a combined effect of accidents and the use of mobile phones is interesting [1, 2]. The measurement methods and risk assessment of electromagnetic fields have been developed. Therefore, it is also important that we are trained to this topic.

In Finland, at high school level, many students study physics, and the electromagnetic fields are part of those courses. It is relatively brief, perhaps a couple of hours. The situation in college is probably at the same level. Physics education concentrates on the physical phenomenon and theoretical issues of electromagnetic fields, and then the health related aspects are not usually considered.

At the universities of applied sciences, the teaching of physics of electromagnetic fields is roughly a few hours (3-5 h, depending on the line). In the electrical engineering area, electrical engineering students have also only a few hours. In environmental education, materials there also cover less than 3 h on electromagnetic fields in the environment and another 3 h of optical radiations in the environment (mainly solar radiation, soil infrared radiation and lighting). Discussion of the EMF exposure of the population or

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the employee's point of view, is quite limited - probably less than an hour. There may also be some practical exercises, lasting 3 h each, of electromagnetic fields, if the teacher is very familiar with the topic and has enough interest. In the education of nurses, there are subjects dealing with physics for 4 h every year, and this area is less than an hour, and it is typically dealing with radiation exposure.

In the education of hygiene in universities, there is 2-3 h of education on electromagnetic fields. This includes the exposure, measurement, evaluation and specifications of the fields.

The Finnish Institute of Occupational Health also organizes education for occupational safety managers and for occupational health employees. This education includes about 1-2 h of topics on electromagnetic fields. There have been some separate courses on this topic, but the trend that the emphasis of physical factors is diminishing and mental factors are increasing. The Finnish Institute of Occupational Health has published books and guidelines for safety and health that consider also the health effects and their detection in safety and health [3, 4].

At technical universities, there are some courses on the technical issues of electromagnetic fields. These are typically in the electric area. At Aalto University, there has been one course (about 10-20 h) dealing with the different issues of electromagnetic fields in the radio technology area. At the University of Eastern Finland, there is education for occupational and environmental hygienists. This education includes some courses on ionizing/non-ionizing radiation and electromagnetic fields.

STUK – Finnish Radiation and Nuclear Safety Authority has published a book series about radiation in Finnish. It includes seven books, and two of the books are in the non-ionizing radiation area. Book six is on electromagnetic fields, and book seven is on ultraviolet and laser radiation. All books are available on the STUK's webpage.

Nowadays, the environmental health area is an important part of an engineer's work. Therefore, education is needed in this area. WWW materials and courses to support teaching have been developed at the TUT (Tampere University of Technology) already for a few years. The interactive WWW-based education in electrical engineering has also been developed at TUT. For example, the courses Electric Power Engineering Virtual Course and Environmental Issues of Electric and Electronics Industry have been developed and used earlier [5, 6].

The Internet provides new learning opportunities. However, pure online learning also has certain limitations. According to Dodero et al., compared to pure virtual e-learning, hybrid learning encourages more student participation [7]. Hybrid learning is a mixture of traditional face-to-face learning and online learning. Hybrid learning has been studied and applied in several places [8, 11].

In TUT, it is possible to study technology or architecture. Students can get examinations from Masters of Science in Technology and Architecture, Doctors in Technology or Architecture and Doctors of Philosophy.

At TUT, it takes at least three years to complete a bachelor's degree, and the extent of the first-cycle degree studies is 180 credits (cr) according to the ECTS (European Credit Transfer and Accumulation System), and one credit is equivalent to approximately 27 h of work [12]. Students who successfully complete the entrance examination are entitled to study for the first- and second-cycle degrees within the same degree program. TUT offers, for the international students who do not speak Finnish, a number of international master's degree programs.

In order to complete the masters, the students need to achieve 120 credits ECTS. In general, the masters are a compound of five principal modules: Basic and common studies (20 cr), major subject (35 cr), minor subject (25 cr), elective studies (10 cr) and master's thesis (30 cr).

The goal of this article is to present the examples of the teaching of the health issues of electric and magnetic fields at Tampere University of Technology in Finland. In addition, the aim is to describe how TUT support people working in transmission line projects can follow new studies of the area.

2. Description of the Courses

Several courses had been developed: the Environmental Health Basic course, the WWW-course "Electricity, Electronics, and Environment", the Health Issues in Energy Engineering course and the Technological Development and Health Issues course. All those courses include health issues of EMF. In addition, it is possible to do an MSc student research project in the "electromagnetic fields and health" area. Details of this possibility have been published in our earlier paper [12].

2.1 Environmental Health Basic Course

This course is developed for students who are in the second year of their degree in the environmental technology area. Some of our courses required background information, but the environment health course does not specifically require any, and it is also open to students from other degree programs. For example, in 2014, the course was attended by 62 students. There are six lectures, and the duration of each lecture is two hours.

The topic of lecture four is "Exposure to electromagnetic fields", which includes e.g., the subtopics: 4.1) What are electromagnetic fields? 4.2) Health Effects - general; 4.3) Legislation (background, national, EU directive, the situation); and 4.4) Examples (exposure situations - MRI, Mobile networks, toys). The details of the experiences of the course have been published earlier [13].

2.2 WWW-Course "Electricity, Electronics and Environment"

This course is developed for students who are in the second year of their degree in the electrical engineering area. In this course, the content of the course includes all the material related to the course as well as exercises and feedback forms for each lecture in the Moodle environment. Students study lectures independently from the Moodle environment.

The lesson topics were headlined as: (1) introduction; (2) environmental effects of electricity production; (3) environmental effects of electricity system; (4) electromagnetic radiation as an environmental question; (5) electricity related risks and environmental hazards; (6) the life cycle of electricity and electronic appliances; (7) the evaluation of environmental and health effects. The material includes health issues of electromagnetic fields.

In addition, a book was prepared especially for this course, to be used alongside the web material. The book contained further information on the lesson topics. At least three times during the course, students submitted an electronic feedback diary, in which the students also gave their comments and development ideas for the course. In addition, they answered the statements: (1) I enjoy studying the WWW-course; (2) The material of this lesson is really adoptable and (3) There were enough exercises. The answer options were: I fully agree, I agree, I don't know, I don't agree and I absolutely don't agree.

The course began with a traditional face-to-face lesson or a meeting with the students. After the meeting, students independently studied the course material and completed a minimum of three feedback diaries. There was a final exam at the end of the course. Students could participate in three exams. In these exams the zero is classed as rejected and five is the highest score (score 0-5).

2.3 Technological Development and Health Issues Course

This course is developed for students who are in the fourth year of their degree in the electrical engineering area. There are six lectures, and in two of them, the

topic is health issues of electromagnetic fields (RF-area). Students also read articles from this area and present them to others. They also use the book "Electromagnetic fields" by STUK.

2.4 Health Issues in Energy Engineering Course

This course is developed for students who are in the fourth year of their degree in the environmental technology or power engineering area. In the Health Issues in Energy Engineering course, students study lectures independently. Firstly, there is an introductory video at the beginning of each lecture and then the actual lecture material (html-pages implemented with text editor provided in Moodle). This material includes the health issues of electric and magnetic fields caused by power systems. Students also read articles from this area, present them, and discuss on them with each others.

3. MSc Student Research Projects in "the Electric and Magnetic Fields and Health" Area

In Finland, Master of Science (MSc) students undertake their theses at companies or universities, choosing a topic which is interesting to both the student and organization. Typically a thesis spans a six month working period. Since 2004, TUT has integrated ten MSc theses into EMF research projects. Generally the MSc thesis project comprises four parts: 1) a literature research, 2) different measurements or experiments 3) analysis of results and 4) report. In research projects, it is important that any student work supports the project and allows for high quality research and the production of new data. To facilitate this, our research group develops a linear connection between individual student works. As an example; a student compiled their thesis around the development of a human-shaped phantom to test pacemakers and defibrillators. The following student conducted experiments with the phantom under 400 kV power lines. A third student did further experiments under power lines and also at 400 kV substations whilst a fourth did experiments in a high voltage laboratory and calculated experimental situation. Typically, earlier students can teach the newer students and detailed planning takes place before experiments, e.g. ensuring correct measurement diaries are kept, or that any meters are calibrated and students can use these meters correctly. Senior researchers typically participate in the experiments and all experiments are photographed. All results are analyzed with an aim to find solutions to possible problems. These results are always planned for publication in articles or conference papers and this helps to ensure that all experiments are conducted to the highest standards. The project work however is only part of the student's overall MSc study program, so it is important that he or she is afforded learning opportunities during the process. By example, we teach students skills to undertake, analyze and report their experiments correctly. Additionally, they learn how to conduct scientific projects [14].

4. Support to Graduated Persons and Others

4.1 Situation Report Bulletins

TUT started to produce the situation report bulletins at 2009. It is a reviewed summary of medical-oriented studies related to electric and magnetic fields, which TUT publishes two times per year. The bulletins include studies, which are particularly interesting from the perspective of the population exposure of electric and magnetic fields. The objective is to achieve and maintain a clearer picture of the current situation with regard to different reports/studies and their significance. This can also equip the people working in transmission line projects to discuss the various questions with the interest groups. The focus of the situation report bulletins is on public exposure to electric and magnetic fields and the associated medical issues. The bulletin includes short (200 words) summaries of articles, an Editorial and Editor-in-chief's comment.

The main bulletin is on Finnish. TUT publishes also an English version, which is a summary of the Finnish bulletin. Fingrid Oyj funds the bulletin (in Finnish).

The graduated persons and other interested persons can order to their email the newsletter of situation report bulletin (in Finnish). The Finnish and English versions are available on Internet.

4.2 TUT - Environmental Health Twitter

TUT has also a Twitter (TTY Ympäristöterveys) on Finnish. On the twitter Environmental health research group publishes the news of the environmental questions and what new articles they have published. Students and others can follow the twitter.

4.3 Seminars of Health Questions and Exposure to Electric and Magnetic Fields

TUT has organized to the topical days of the Health Questions and Exposure to Electric and Magnetic Fields many years. The seminar is not every years, but TUT organizes it when there are some new important knowledge or companies have asked it. This activity is one way to support graduated persons, industry and other persons who are active on the area.

5. Discussion

Nowadays, it is important that education from the new technologies is available. For example, about 20 years ago, people did not use wireless smart phones or table computers daily. Today, the situation is very much different. At TUT, the education of the health issues of electromagnetic fields has been integrated into part of the courses, which also include other environmental issues. In this case, students can easily compare different topics. In addition, many students can gain some basic knowledge about the health issues of EMF, because we have four courses which include this issue.

In Finland and often also in other countries, the teaching is concentrated on traditional areas of science and the interdisciplinary areas can sometimes be forgotten. Health effects of electromagnetic fields can be one such issue. However, in practical world borderlines of science are more and more important areas for application, and then also this point of view has some value.

TUT has also produced the support material for workers who need the current knowledge of the EMF and health questions. TUT has published the Situation report bulletin from 2009 (six years). The feedback of the bulletin has been positive, the situation report bulletin is the quick and easy way to follow new researches and articles. The editorial includes also news, what had happened on the area, during the last half year.

Twitter is a very quick way to send info to all persons, who are interested on the EMF and health questions. Typically TUT - environmental health group put to the twitter their new articles or conference papers, but also links to materials, e.g., of conferences which all can find from Internet. They have 28 followers. On the Internet, there are also other good services to follow, e.g. researchers. For example the Research Gate is a possible place to follow researchers and their articles.

6. Conclusions

In the future, it is important to develop more education of EMF health issues, so people can more easily understand how new devices and technologies work.

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