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E-TECHNOLOGIES IN TEACHING RESEARCH METHODOLOGY FOR ENGINEERS – A CASE STUDY OF THE COURSE FOR INTERNATIONAL POSTGRADUATE STUDENTS

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Abstract: The Research Methodology course for postgraduate students is challenging, even for an experienced academic teacher. The primary objective of this course is to prepare participants to conduct scientific research and publish the results. This case study presents an original teaching method applied to Research Methodology with Emphasis on Engineering Science, for international engineering students at Blekinge Institute of Technology in Karlskrona, Sweden. The demanding requirements of the course, a varying number of enrolled students, and a large number of assignments which need to be tracked and guided by the teacher are all conditions that need a custom approach and modern tools. The opportunities offered by e-technologies help to fulfill these course requirements. This article shows how e-tools such *Itslearning*, *Doodle*, *Zotero* or scientific database search engines, can be implemented to support the teaching objectives. Using these tools, a single academic teacher can accomplish the eight-week course of Research Methodology, for up to 180 students working in 60 project groups without compromising teaching quality and students' satisfaction. The course also has been appreciated by colleagues and mentioned in the Master program evaluation of the Swedish Higher Education Authority.

Keywords: E-learning, E-tools, Learning Management Systems Problem Based Learning, Research Methodology.

1. INTRODUCTION

A basic research methodology course is required for a Swedish Master of Science degree. The course aims to prepare students to carry out research projects and report their results in the form of final thesis.

The Research Methodology with Emphasis on Engineering Science course, further referred as RM, lectured at Blekinge Institute of Technology, BTH, is a subject of this paper [1]. It presents an approach to teaching and studying research methodology based on Problem Based Learning, PBL [2]. The main goal of the course is to acquaint students with principles of the scientific research as well as their implementation in practice. The initial project phase of the course focuses on defining a research problem and its hypothetical solution. Then the proposed solution has to be implemented and validated quantitatively. The final report of the project has the form of a two-page scientific paper.

To assess the project progress, it is necessary to monitor quality and a way of its execution, which can be a complex and time consuming process from teachers'

perspective for a large number of projects. To enable this task, some supporting tools are needed. The most convenient and suitable for this are e-technologies and e-learning applications. In the course the basic e-learning tool used is the educational platform *Itslearning* [3], which is assisted by several additional supporting applications.

Students' periodical evaluations of the RM course confirm its practicality and positive effect on the quality of the thesis process. This influence is also acknowledged by thesis supervisors, who acknowledge quality improvement of final projects done by students who have passed the RM course. For some BTH study programs, a RM course approval is compulsory for the thesis registration. The RM course has also been highly appreciated in a four-year evaluation of curricula of postgraduate programs, which was carried out on a behalf of the Swedish Higher Education Authority [4].

E-applications and e-tools, also referred to as Information and Communication Technology, ICT, are widely used in mobile learning. They provide a novel learning environment in a form of a virtual classroom which offers various teaching opportunities. They are especially useful for disengaged and disabled students [5]. With the advancement of ICT infrastructure, different Learning Management Systems, LMSs, have been developed and implemented by educational institutions. This powerful software provides automated mechanisms for course management and tracking participants' progress [6]. The paper considers also key advantages of LMS exemplified by the *Moodle* platform, an open source LMS. A usability analysis of standard *Moodle* modules is introduced too. In [7], the author examines the three commonly used community-oriented e-learning systems *Ping Pong*, *Blackboard* and *Moodle*. The author applies three case studies to summarize the main characteristics of analyzed teaching platforms. The case studies focus on available collaborative tools.

The related works show how important it is to share experiences of using different ICT tools. Their usefulness has to be assessed accordingly to course needs. In this paper using the case of multifaceted course, it is demonstrated that even a very sophisticated LMS such as *Itslearning* needs to be supplemented by auxiliary organizational software such as *Doodle* and *MS Excel*, and tools supporting writing a

scientific report such as *LaTeX*, *MS Word*, *Adobe Acrobat*, *Zotero* etc. Each non-standard course requires an individual creative approach to establish a suitable set of e-tools.

2. COURSE DESCRIPTION

The course Research Methodology with Emphasis on Engineering Science, designed at the University of Kalmar has been taught at BTH since 2006. Initially it was designed for Telecommunications and Signal Processing postgraduate programs, but subsequently it has been adapted for the Mechanical Engineering and Computer Science study programs. Moreover, the RM course was also upgraded for PhD candidates.

Due to the international environment of the Master and PhD programs at BTH, the RM is taught in English. In Sweden it is common that master and PhD theses, and other scientific publications in engineering are available in English. Teaching RM in English targets academic and industrial international environments for job placement.

The main objective of the RM course is to prepare students to methodically approach and report a final thesis. For PhD students, the course should help them to understand scientific methods and enhance their capability to publish a scientific paper.

The RM course consists of two main parts: theoretical and practical. The theoretical part, dedicated to the philosophy of science, focuses on various concepts of science. The RM textbook, presents contemporary theories of science such as Popper's falsificationism, Kuhn paradigms, Lakatos' research programs or Fayerabend's anarchist approach to science. Other theories such as experimentalism or the Bayesian approach are also considered [8][9].

In the main project part of the course, participants develop, implement and report a selected research problem. The projects are carried out in groups of 2-3 people. At the beginning, each group member finds and defines a new research problem related to his/her specialization. Then with a teacher at a group meeting called *Brainstorm 1*, they choose the most suitable proposal to be the group project. After many years of teaching the course we can admit that this part of the course is the most challenging, for most students.

The RM project mainly focuses on teaching the following skills:

- to formulate a proper research question and hypothesis,
- to validate the research hypothesis,
- to write the scientific report,
- to properly use conference templates,
- to present research results,
- to discuss obtained results,
- to review a scientific articles,
- to manage a project,
- to cooperate in a multicultural research team.

From the project students also learn how to properly use scientific sources in order to avoid situations which can lead to plagiarism. Ethical aspects of scientific work are discussed during the workshops based on codes of ethics, appropriate to students' majors, such as: "National Society of Professional Engineers, NSPE Code of Ethics for Engineers" [10], "Institute of Electrical and Electronics Engineers, IEEE Code of Ethics" [11], and "American Society of Mechanical Engineering, ASME Code of Ethics"

[12]. This crucial issue is conducted with cooperation of experts from the university library, and is the subject of another paper [13].

The final results of the project are reported as a short two- or three-page scientific paper which is regarded as a *mini-final thesis* consisting of all the elements required in the thesis.

To support development of the mentioned students' skills and to be able to accomplish all course objectives and assignments, the use of unconventional teaching methods and tools is required. E-learning tools, such as *Itslearning*, *Doodle*, *Zotero*, or scientific database search engines such as *IEEE Xplore* or *Google Scholar*, provide the solution for this challenge.

3. THE E-TOOLS USED

In the RM practical module, depending on the specificities of the research problem, different kinds of tools and applications are used. The course participants used different kinds of tools for simulation, design, and development.

Among the listed e-tools of Learning Management System, *Itslearning* is the most important instrument used in the RM course. It is used as a basic software platform with unlimited access for students inside and outside the university. Furthermore, since the beginning of RM course, the students become familiar with database search engines, which are used in the early project stage. Moreover, for reporting project results it is required that students apply editing and presentation tools. They apply various types of paper templates based on *LaTeX* and *MS Word*. To simplify the paper review process, the participants learn how to use *Adobe Acrobat*. *Doodle* application as a scheduling tool supports the management of the course. In this section we show how these tools supporting different course objectives are implemented.

3.1. LMS - Itslearning Platform

The basic LMS e-tool used in RM is an educational platform *Itslearning*. It is one of the globally applied learning platforms designed for the education sector. It is used in both universities and high- or primary- schools. *Itslearning* is easy to use and is supported by popular web browsers. The platform ensures confidentiality requirements of participants' personal data. Messages are delivered to each student individually, although some *Assignments* take place in groups. Figure 1 illustrates functionalities of *Itslearning*.



Fig. 1. *Itslearning* functionalities [14]

The important features for this course available in *Itslearning* include:

- managing e-mail between all course participants,
- scheduling and deadline control of assignments,
- plagiarism detection,
- diversification possibility of teaching methods by forming task groups.

Benefits of using *Itslearning* may be considered from different points of view [3]. From the teachers' point of view the most important are:

- unlimited online availability of all teaching materials i.e. lecture notes or recorded lectures,
- the ability to communicate with students, regardless of their place of residence, also in the form of online discussion,
- all tests and organizational tools are provided to students immediately after their publication,
- learning progress monitoring.

From students' point of view the most important are:

- monitoring of the study progress during the course,
- work scheduling with the available information about work plans, assignment deadlines, etc.,
- communication online with teachers and other course participants.

BTH students since their first year of study have used the *Itslearning* platform on each course, however with a varying intensity. Each course teacher is required to create the site of a course, in which the student is assigned automatically if the course is a part of his/her study program. When the RM course starts, after logging into a course homepage, the participants can read the course rules, its curricula, and the schedule of classes. On the main page the

closest deadlines and recent changes made by the teacher are displayed.

Figure 2 shows three types of elements which the teacher can add to the course directory. *Sources* that can be used i.e. files, lecture notes, drawings and links to lecture material. During the RM classes almost all of these possibilities are used. However, the most important options are those that the 'activity' gives such as assigned tasks for individual students and project groups, online discussions, establishing groups, and also online surveys and tests.

Possible options that can be assigned to an individual *Assignment* include: defining its deadline, adding a description file, defining whether the *Assignment* is dedicated to the individuals or groups, grading of assessments, and the control plagiarism function. The *Itslearning* platform informs students about new *Assignment* upload, among other notifications via e-mail. If it is necessary, it is also possible to send an extra reminder. Ability to communicate with individual students and project groups is particularly useful and a frequently used function during the RM course. The *Itslearning* platform offers also a function of informing teachers about recent *Assignment* submissions.

Among important features of the platform, the crucial one is the availability of a detailed schedule and deadlines, for all required *Assignments*. *Itslearning* warns participants about the impending deadline and allows them to send the *Assignment* only within the specified period of time, beyond which the submission possibility is blocked and the failure is highlighted. Because all *Assignments* that the student receives from the instructor are well defined and scheduled with strictly executed deadlines, students learn the punctuality and proper planning their calendar.

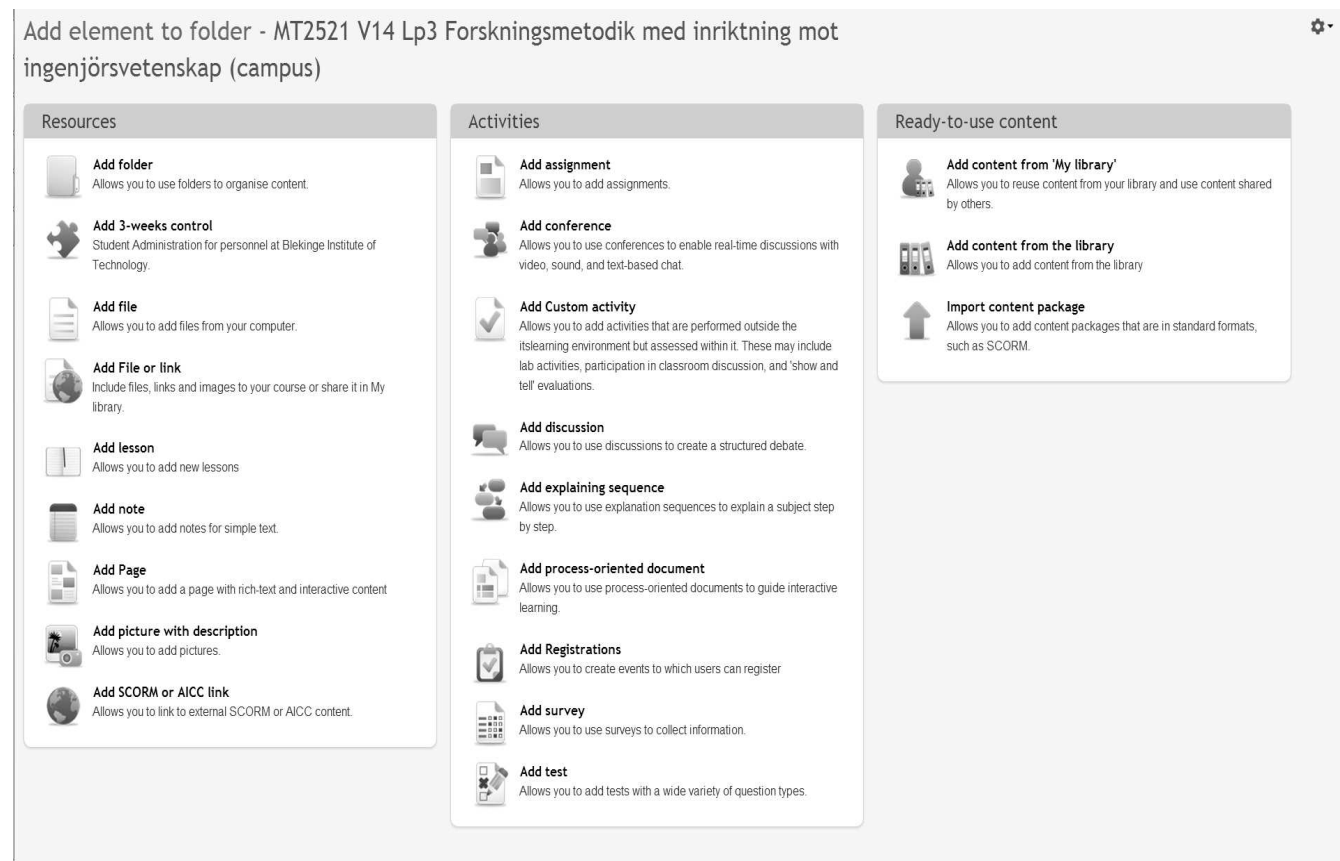


Fig. 2. Types of *Itslearning* available elements

Itslearning significantly facilitates management of uploaded *Assignments*. The RM students are accountable with four workshops and five seminars that must be completed. In addition to seminars and workshops, project groups report the project progress weekly. Furthermore the projects consist of six *Milestones*. With all the tasks assigned to up to 180 students, working in 60 project groups, without support of the platform *Itslearning*, the course implementation would be very difficult.

An optional platform function is checking whether the uploaded text is plagiarism or not. It shows the matching percentage of the text with the text which has been already in the database. The decision whether the text really is actually plagiarism is taken by the course teacher. It seems that the awareness of using of this function greatly reduces students' motivation for risking plagiarism.

Many students, who have completed the RM course, agreed that they never before used the capabilities of the *Itslearning* platform so intensely and extensively, and that it was a great advantage for them.

3.2. E-tools supporting writing report

3.2.1. Scientific database search engines

Students' serious disadvantage is their incompetence in using scientific database search engines. BTH students have a free access to many scientific databases like *IEEE Xplore* or *Elsevier*. Unfortunately, previous teaching experience indicates that most of international students do not use this opportunity until the RM course. Therefore, at the beginning of the project, it is necessary to teach them about available library tools. The first two workshops are dedicated for developing skills of finding and searching on available scientific databases [15]. These workshops are conducted by the course director together with librarians.

During the course, participants learn how to use the available scientific databases and library services both from the campus area and outside the campus. For this purpose, BTH has prepared many search guides related to the different phases of the information retrieval process, including short clips how to find searched items at library website and library *toolbar* [16]. At the workshop, participants have an opportunity to learn how to use these convenient tools. In addition, the students have access to extensive online tutorials clearly describing how to use the scientific databases search engines [17].

The BTH library also provides several different search engines. Besides the most common *Google Scholar* and *IEEE Xplore*, there are local search engines like *Summon@BTH*, *SFX@Blekinge* and *GetIt@BTH* which gives access to full texts and other useful links or services directly from the database. There are also open educational resources, including search engine *OER@BTH*, which are free and openly licensed educational materials that can be used for teaching, learning, research, and other purposes. Moreover, all students have access to *LIBRIS* [18], which is a national search service held by Swedish universities and research and public libraries.

3.2.2 Zotero

In tandem with learning how to use scientific search engines, students learn principles of referencing and citation. For this purpose program *Zotero* is recommended [19]. *Zotero* is available in two installation versions. It can be

installed as a separate application, or as an extension for the web browser *Mozilla Firefox*.

This tool is used for gathering, management and organization of bibliographical resources. *Zotero* creates a database with sources used during the research project and writing the scientific paper or thesis. This application automatically recognizes the bibliographic data of publications from scientific databases such as *Elsevier*, *IEEE Xplore* or *Springer* and adds them to user's personal library. *Zotero* also allows a user to save website addresses, audio, video, and create personal notes for later use. All gathered data can be edited and categorized in various collections, corresponding to a given issue.

The *Zotero* bibliographic database can be used in Word document which requires installing a *plugin* application for bibliographic management. The items from the database can be inserted as a citation to the document, and then one can create a reference list. Format and citation styles can be chosen according to requirement from *IEEE*, *Nature*, *Elsevier*, *Harvard* style etc. In the RM papers *IEEE* style is used.

3.3. Template editing tools

To accomplish the course, the students have to write a short scientific paper and review a paper of other participants. For this purpose there are used suitable templates. The templates are based on *IEEE* conference paper template [20] and a common review template. In both cases the use of the correct edition tools is required.

Teachers' experience and course evaluations show that students attending the RM course meet problems to report the results of their work, both in written and oral form. Students are not frequently familiar with the report templates. Some of students may meet a problem with preparing and performing oral presentation.

3.3.1. MS Word and LaTeX

The course participants report their projects using document templates [20] based on text editors of *MS Word* or *LaTeX*. Very often while writing their reports, students for the first time meet the concept of using professional templates. Therefore some classes are dedicated to learning how to use the basic editing tools. For most of students the commonly used text editing tool is *MS Word*, so a special focus is placed on teaching *MS Word* editing capabilities, especially on using styles, and referencing and review tools.

PhD students and ambitious graduate students are allowed to use a technical text editor *LaTeX* [21]. This is a free document preparation system which is designed for the production of scientific and technical documentation. *LaTeX* is a standard for publication of scientific documents, especially with many equations and diagrams.

3.3.2. Other editing tools

The RM course students are required to prepare and deliver two presentations using *MS Power Point* or *LaTeX*. Some BTH presentation templates are recommended. The students are taught about principles of good slides and their presentations are assessed by the teacher.

Another component of RM course is an anonymous review of another project group's paper. For this purpose, a review template was developed. To properly apply comments and corrections, the skills of using commenting tools in PDF documents are required. The most common applications used for this purpose are *Adobe Acrobat* and

Foxit Reader. Basic functions of editing in *Adobe Acrobat* are presented to students during classes about the rules of reviewing.

Throughout the project module of the RM course, the key targets are focused on the quality and proficiency of reporting and presentation. According to the course curricula, the content of documents and also ways in which available tools are used are assessed.

3.4. Organizational tools

The project requires skills in other basic *MS Office* programs. For weekly reports of the project progress, the participants apply *MS Excel*. Each project team prepares a detailed project plan according to preliminary requirements. The project plan in the form of an extended table, consists of planned hourly division of workload at the specified stages of the course, with clear indication of contributions of each team member. The schedule must be prepared in such a way that the workload is evenly distributed among group members without exceeding the allowed work time limits.

Each team weekly reports a project work plan. This way, the teacher can assure the project systematic progress, and the engagement of individual participants. A weekly project work plan also helps the students to control their project progress and, in a case of any setback, they can make necessary adjustments.

This simple procedure as weekly reporting of work progress indicates that over 90% of the projects are commissioned on time and they meet the appropriate quality level.

Doodle is an online application that provides an electoral calendar/timetable which is sent for all participants. At the fixed time, the system activates a booking form, where users are able to choose a convenient for them time slot.

Doodle application [22] is used for the efficient and effective scheduling of the course. It is used to organize *Brainstorm* meetings of project groups, and a timetable of the presentations.

The teacher uses the functionality of the system *Doodle* to schedule appointments with project groups, or organize presentation sessions. Each group books the preferred meeting time. Taking into account the number of project groups, this method facilitates planning with respecting students preferences.

An anonymous peer review of a paper of another project group is a key component of the course. Selecting a favorable paper is necessary for review quality. Through *Doodle*, participants can choose encoded two favorable articles for the review. This method allows the teacher to distribute reviews in such a way that each project is reviewed by at least two reviewers.

4. CONCLUSION

Research Methodology teaching has an important contribution to the education of postgraduate engineering students. Knowledge and skills gained from the RM course results in a high quality final thesis, research papers and research projects. Therefore, teaching methods of the RM course are important issues of the whole curricula. The quality of the course depends on an appropriate selection and usage of e-tools. The skillful use of e-technologies helps both teachers and students to reach the course multi-dimensional objectives. The RM course benefits not only the

study of postgraduate students, but also can affect their scientific and professional careers.

The main objective of the RM course is to improve participants' skills in writing, presenting, and debating research papers. Using suitable e-tools to complete these tasks is an essential issue when developing this course.

E-tools used in the course can be categorized into three groups, from which the most vital is Learning Management System. Professional and globally used *Itslearning* platform, meets all requirements of such a complex course like RM. *Itslearning* significantly facilitates management of RM course which is a crucial advantage both for teachers and participants.

Participants learn about an information retrieval process and available library tools describing how to use the scientific databases and search engines. Students learn also how to manage and organize bibliographical resources.

The Research Methodology course enhances students' knowledge about e-tools by supporting writing and reviewing a scientific papers. The course improves participants' skills in editing reports based on professional templates offering advanced editing tools.

This article has also shown that applications supporting research project planning help students to effectively manage their time and facilitates teachers to monitor the project progress and involvement of individual participants. This part is especially important while working in teams.

Moreover, this paper presents how organizational tools can facilitate an efficient, flexible, and impartial coordinating of the course which is highly important in the case of large number of participants.

The choice of tools used is adjusted to a number of students, their capacities and even their area of study. Constantly teachers work on improvement of tool selection and their usage, which enhances teaching methods and makes it more effective. Since the e-tools are just auxiliary instruments, they have been introduced using PBL. This learning method needs further consideration and improvement.

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E-TECHNOLOGIE W NAUCZANIU METODYKI PRACY BADAWCZEJ W INŻYNIERII -STUDIUM PRZYPADKU PRZEDMIOTU PROWADZONEGO DLA MIĘDZYNARODOWYCH STUDENTÓW II ORAZ III STOPNIA

Nauczanie metodyki pracy badawczej studentów II stopnia i doktorantów stanowi duże wyzwanie nawet dla doświadczonych wykładowców akademickich. Podstawowym celem takiego kursu jest przygotowanie uczestników do prowadzenia projektów badawczych i publikacji ich wyników. W artykule, jako studium przypadku przedstawiono autorską metodę prowadzenia przedmiotu Metodyka Pracy Badawczej w Inżynierii, prowadzonego dla międzynarodowych studentów kierunków technicznych na Blekinge Institute of Technology w Karlskronie w Szwecji. Złożona struktura przedmiotu, zmieniająca się liczba studentów uczestniczących w kursie w kolejnych latach oraz duża liczba zadań wymagających monitorowania i korekty prowadzącego, potrzebowały zastosowania nieszablonowych rozwiązań i nowoczesnych narzędzi dydaktycznych. Wykorzystanie e-technologii pozwala na taką realizację kursu, która nie byłaby możliwa przy użyciu tradycyjnych narzędzi. W artykule pokazano, jak e-narzędzia takie jak *Itslearning*, *Doodle*, *Zotero* czy biblioteczne narzędzia przeszukiwania naukowych baz danych, ułatwiają realizację celów dydaktycznych przedstawionego przedmiotu. Dzięki tym narzędziom pojedynczy nauczyciel akademicki może w 8 tygodni zrealizować program Metodyki Pracy Badawczej w Inżynierii wykładanej nawet dla 180 studentów, pracujących w 60 grupach projektowych przy jednoczesnym zachowaniu wysokiej jakości nauczania i satysfakcji studentów. Przedmiot został również doceniony w ostatniej ocenie programowej studiów magisterskich realizowanej przez Szwedzki Urząd Kanclerza. Szkolnictwa Wyższego (Swedish Higher Education Authority).

Słowa kluczowe: E-narzędzia, E-nauczanie, Metodyka Badań Naukowych, System Zarządzania Nauczaniem, Uczenie Poprzez Rozwiązywanie Problemu.