

EU FUNDED PROJECTS – BEST TOOLS FOR CONSTRUCTION SPECIALISTS EDUCATION

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Abstract

Paper presents first findings, assumptions and initial results of the two innovative projects for construction industry: Leonardo da Vinci Projects (TRAIN.CON, 2010-2012) – “Augmented Reality Applied to Machinery Maintenance from Construction Sector” and Norwegian Instrument Project (NORW, 2009-2011) - “Distance Learning within Management in Construction”.

Keywords: augmented reality, distance learning, management, machines operators.

INTRODUCTION

Author is the member of research teams for two EU funded projects connected with education of construction personnel in Europe: MAIN.CON project (No: 2010-1-ES1-LEO05-20930), titled: “Augmented Reality Applied to Machinery Maintenance from Construction Sector”, related to the creation of innovative system facilitating construction machinery maintenance, with use of the augmented reality basis. NORW project (No: FSS/2008/X/D5/W/0005/U/0013), titled: “Distance learning within management in construction”, is the part of the Development of Polish Universities Program, donated by Norway, Iceland and Lichtenstein within the Norwegian Financial Instrument project. NORW project is related to development of modern, blended learning types of studies for Polish and Norwegian construction managers. Logos of the Norwegian Financial Instrument and Leonardo da Vinci programs are presented in fig. 1.



Figure 1: Logos of FSS and Leonardo da Vinci projects.

ASSUMPTIONS FOR THE MAIN.CON PROJECT

Introduction

The effectiveness of construction processes implementation today depends on the production capacity of sets of construction machines and equipment. An equipment contains a mechanism or a set of mechanisms aimed at processing of energy or conducting of works, while a machine is a device containing an engine of any type. Nowadays, mechanization of

various construction processes requires application of leading machines, complemented by machines parts, to establish the mechanized construction work lines. The term 'mechanization' encompasses the production-related operation of machines performing tasks related to particular technology. Production-related operation pertains to performance by machines of mechanical works under varying conditions at the building site. The activities of the technical service for any machine include the planned preventive measures, aimed at preventing the excessive use and damages of machines and repairs, restoring the original technical conditions of machines.

Generally speaking, mechanization and automation are forms of technological progress. Significant features of mechanization and automation include recognition of any organizational relations, which take place within the technological operation sequences (storage, transport, production and assembly, operation and maintenance) and using them in the common production process, using the increasingly mechanized lines of machines.

Mechanization is a process related to the development of machines. Progress in the field of mechanization of construction trade depended on technological progress with regard to construction machines. At present, in association with the quick development of industrial automation devices, it is becoming increasingly dependent on the progress of IT science and computer techniques. Regardless of technical progress, the development of the basic theory of mechanization in construction trade was observed relatively recently. In the fifties of the 20th century, the first principles of mechanization of construction works were formulated in Poland, and in the sixties - the principles of complex mechanization.

The gradual automation of processes on the construction sites will depend on the changes in the way of thinking about the building techniques. While the main problem in mechanization of processes is the technology and the technical works equipment (a properly selected set of machines), for automation and then robotics of processes, the problem lies in control (management) of the entire processes or great systems, using the appropriate automatic devices or computer software. Augmented reality can be a vital part of construction technology development

Basis for the project

MAIN.CON project partners are as follows: Labour Foundation for the Construction Sector, Spain (the Promoter), Polish British Construction Partnership, Poland, BZB, Germany, Centro Edile Andrea Palladio, Italy and Ente Scuola per la Formazione delle Maestranze Edili, Italy. The aim of the Leonardo da Vinci MAIN.COM project is to design and apply a training system in basic machinery maintenance using a new technology called augmented reality. This system will improve the basic skills of machinery operators related with a safe maintenance of their machines and not only with their operation. Main assumptions for the project are presented at fig. 2.

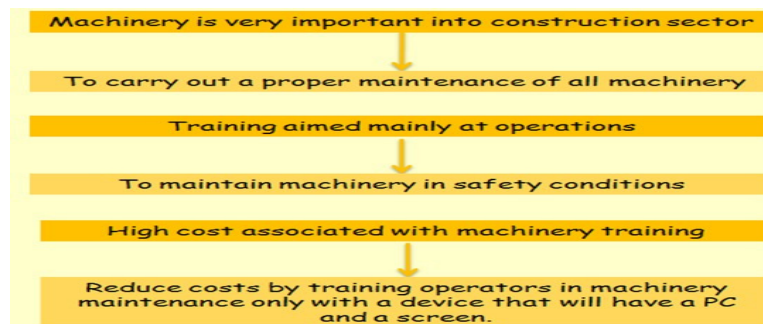


Figure 2: Main goals of the MAIN.CON project [2].

The Augmented Reality (AR) is the term to define a direct or indirect view of the physical environment in the real world, which elements combine with virtual elements in order to create a mixed reality in real time. So, it consists in a group of devices which add virtual information to real information. This is the main difference with virtual reality, because it doesn't replace physical reality, but superimposes virtual data on real world. This project is going to be focused in excavation works for two reasons. Firstly, because of intensive work, which emphasizes the necessity of preventive maintenance. Secondly, because of the enormous quantity of self-employers and SMEs, who own, for example a digging machines and are working for others companies. This project is going to be based upon the outcomes obtained in the project "Training system for mechanical digger operators", in which one of the most important developments was maintenance training. Furthermore, it included an experimental system based on personal digital assistants (PDA) of which function was to support the learning through the use of checklists. The system pretends to enhance the training of operators in the field of maintenance, through the use of Augmented Reality. To reach this aim, the project will provide a system which will allow to select maintenance operations by means of a interface easy to use by the operator. One of the first attempt for use of augmented reality was conducted by car producer – BMW, for easy maintenance of cars. Fig. 3 presents screenshot from BMW movie showing general maintenance of the car engine – replacement of the cooler duct.



Figure 3: BMW system of cars maintenance with use of augmented reality screenshot [4].

Classification of chosen construction machines

Every machine consists of three basic elements: undercarriage, bodywork and working equipment. The type of each of these elements serves as a basis for classification of machines. The MAIN.CON project will base on the standard ISO/TR 12603, which provides the European classification of construction machines according to their use within the framework of individual work groups. For example - group 100 will be the subject of MAIN.CON project. This group consist of earth-moving machines and equipment: (for preliminary earthworks and wide excavations: 110 - bulldozers: wheel, caterpillar, 120 - loaders; wheel, caterpillar, 130 - digger-loaders; wheel, caterpillar; 140 - diggers; hydraulic, drag line excavators, bucket wheel diggers, bucket chain excavators; demolition equipment; transport of soil: 150 - articulated dump trucks, tipper trucks; for earthworks finishing: 160 - scrapers, 170 - graders; narrow and pit excavations: 180 - ditch diggers, 190 - pipe-laying machines) [1].

The process of machine operation is an entire set of organizational and technical tasks, which are aimed at performance of production tasks using machines in accordance with their technical parameters, as well as maintenance of the technical capacity of machines enabling them to perform work.

In the operation process, the following two (A and B) states of machines are recognized:

A). Production-related operation of machines – it is a state of capacity of machines to perform mechanical works (in relation to rented machines, the applicable term is – the state of production-related use of machines). In the state of production-related operation of machines, two significant sub-states can be identified: the sub-state of machines waiting for implementation of tasks and the sub-state of production-related tasks implementation by machines (performance of mechanical work). The basic tasks performed during the production-related operation of machines include:

- formal and legal activities associated with driving machines on public roads,
- transport of machines to construction sites (conditions, securing of transport),
- preparation of machines for work (location of machine, connecting of the power supply),
- performance of tasks and mechanical work of machines (position-related limitations, occupational health and safety),
- disassembly of machines and transport to another work site or to the place of storage.

The time of waiting for task performance is an inevitable time of production-related operation of machines and it amounts to 5 to 15% of their production time. The structure of activities performed in the state of production-related operation of machines and auxiliary equipment is presented in table 1.

Table 1: The structure of construction machines maintenance activities [1].

The structure of activities performed in the state of waiting and performance of production tasks for machines and sets of auxiliary equipment (boarding, scaffolds, templates, etc.)				
Transport arrangements	■			■
Transport of the machine to the construction site	➡			
Assembly and setting for operation		●		
Period of the machine works			▬	
Disassembly and transport of machine				➡
Maintenance and repairs after completion of works			<i>Random events (breakdowns)</i>	●

B). Technical maintenance status of machines - is the status of prevention of breakdowns, repairs or renovation of machines and control of their ability to perform production tasks. The basic tasks performed in the technical maintenance status of machines are as follows:

- washing of working elements of machines and lubricating of those components, which are most sensitive to damages after the end of each working shift,
- periodical inspections, technical and transport servicing of machines and auxiliary equipment after the end of the cycle of works or all works on the building site, as well as the planned repairs and renovations of machines and auxiliary equipment.

The typical features of the process of construction machines operation include:

- frequent changes of the place of operation and the associated frequent transfer of machines between construction sites or places of operation on the site,
- a wide scope of changeability of the conditions of operation due to external conditions (weather, terrain) or technological conditions of works,
- a relatively high frequency of technical maintenance due to sensitivity of drives and auxiliary systems of machines to work overloads.

Depending on the intensity of operation, the production capacity and efficiency of machines lowers as a result of wear of the structure elements and the process of ageing of machines. Restoration (regeneration) of the original technical capacity of machines, that is, their full ability to perform tasks, depends on a number of organizational and technical activities, belonging to the appropriate system of technical maintenance of machines.

System of maintenance and repair of machines

Machines, which have the status of technical maintenance, are either repairable or irreparable. Irreparable machines include those, which are technically unfit or which are repairable from the technical perspective, but their repair is not profitable. The issue of technical maintenance of machines is associated with the concept of repair capacity of machines.

Repair capacity of a machine – is the component of the concept of reliability and it is the adaptation ability based on prevention, identification and elimination of damages (inspections and repairs of the machine), which may arise during operation of the machine or as a result of ageing of the materials and the structure.

The basis for planned operation of machines and technical devices is a schedule of technical maintenance and repairs of machines and devices. The system provides for obligatory technical maintenance and major (general) repairs after the machine performs a specific number of hours of work.

Periodical technical maintenance includes the planned preventive measures, preventing the early damage of the machine. The following types of maintenance can be identified:

- everyday technical maintenance – a set of maintenance tasks: washing, lubrication and inspection of some mechanisms (components of the hydraulic system, bolts, flat runners etc.), which are performed every day, usually after the end of each working shift. Lubrication of the machine mechanisms is based on addition or replacement of lubricant in the lubrication points within specified time intervals. Everyday maintenance is considered to be one of the most significant tasks, decisive for maintenance of the machine in the proper technical condition and for reliability of its work.
- periodical technical maintenance – a set of maintenance tasks: control of the condition of the machine and replacement of some parts or small sub-assemblies, performed prior to each summer or winter season or prior to transfer of the machine to the new construction site. Periodical inspections, apart from the ordinary maintenance tasks, such as replacement of oil, include checking of the main mechanisms of the machine (the gear, clutches, breaks, bearings, hydraulic systems etc.) and determining of the medium-level repair date.
- transport-related technical maintenance – a set of special tasks performed in order to prepare and secure the machine during transport. The transport maintenance may include a partial disassembly and safeguarding of the machine for the transport period.

Planned and preventive repairs are technical tasks, aimed at restoring of the original technical condition of the machine. The following types of repairs can be identified:

- medium-level repair – is a set of maintenance and repair tasks performed after a specific number of hours of work of the machine (e.g. about 2.5 thousand hours for a loader); it includes elimination of defects or replacement of sub-assemblies of the hydraulic and

electric system, mechanisms of work tools, etc. The most significant inspection tasks include: measurement of clearances in the machine driving mechanisms and work tools (gear wheels, bearings, bolts etc.), inspection of rubber seals of pumps, cylinders and hydraulic pipes, checking of wear of electric sub-assemblies and parts, etc.

- major repair – a set of renovation tasks performed after a large number of working hours of the machine (e.g. about 5 thousand hours for a loader); it includes verification of all parts and sub-assemblies, repair or replacement of the main sub-assemblies of the machine. The most significant tasks include: replacement of seals and flexible pipes, hydraulic pumps and manipulators, main electrical sub-assemblies, disassembly and repair of the main machine assemblies, the engine, the gearbox, the driving mechanisms and work tools, replacement of parts and sub-assemblies.
- breakdown repair – it includes the full scope of repairs resulting from damage.

Initial results of the project

MAIN.CON project consist of several general work packages (WP), leading to the achievement of project goals:

- WP I - analysis of construction earthworks machinery. In this work package Partners will carry out a Focus Group in each partners' country in which they will analyze and select the most appropriate machine for its implementation under Augmented Reality (AR). First meetings with construction personnel in Poland showed that the most used machinery for earthworks are medium size diggers.
- WP II - definition and establishment of a map of basic skills in machinery maintenance. This work package consist of: analysis of machinery operators, definition of key functions and main functions, definition of the elements of the operators' skills, identification of performance evidences, definition of the implementation criteria, identification of knowledge evidences, establishment the different levels of the skills. Fig. 4 shows possible connections between real world and artificial reality.

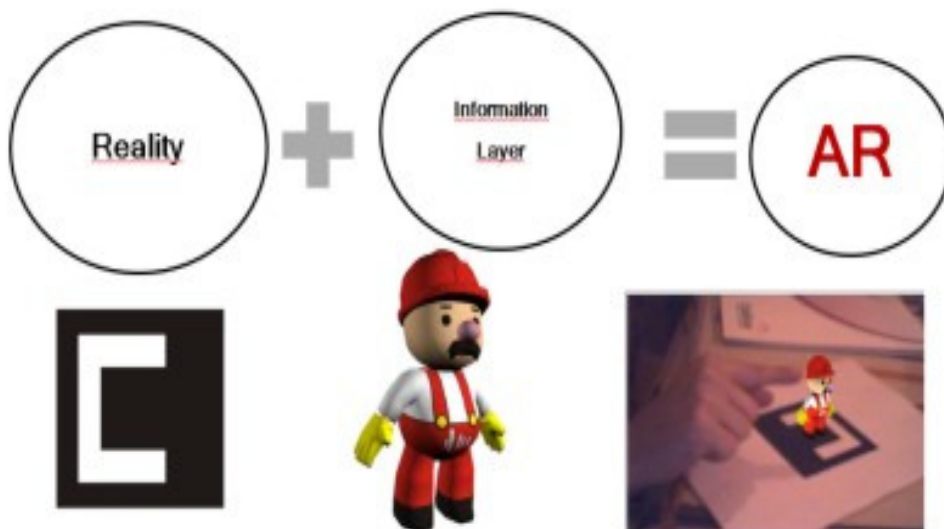


Figure 4: Ramon (in Poland – Roman) - animated PDA - character facilitating operators training created in the MAIN.CON project [2].

- WP III - development of the software and hardware based on Augmented Reality for maintenance training. This work package consist of: development of the contents, make graphic design, building the graphics under Augmented Reality rules, design of the training system, design of assessment system, make the needed devices to carry the hardware. Fig. 5 shows possible elements of the future training system.

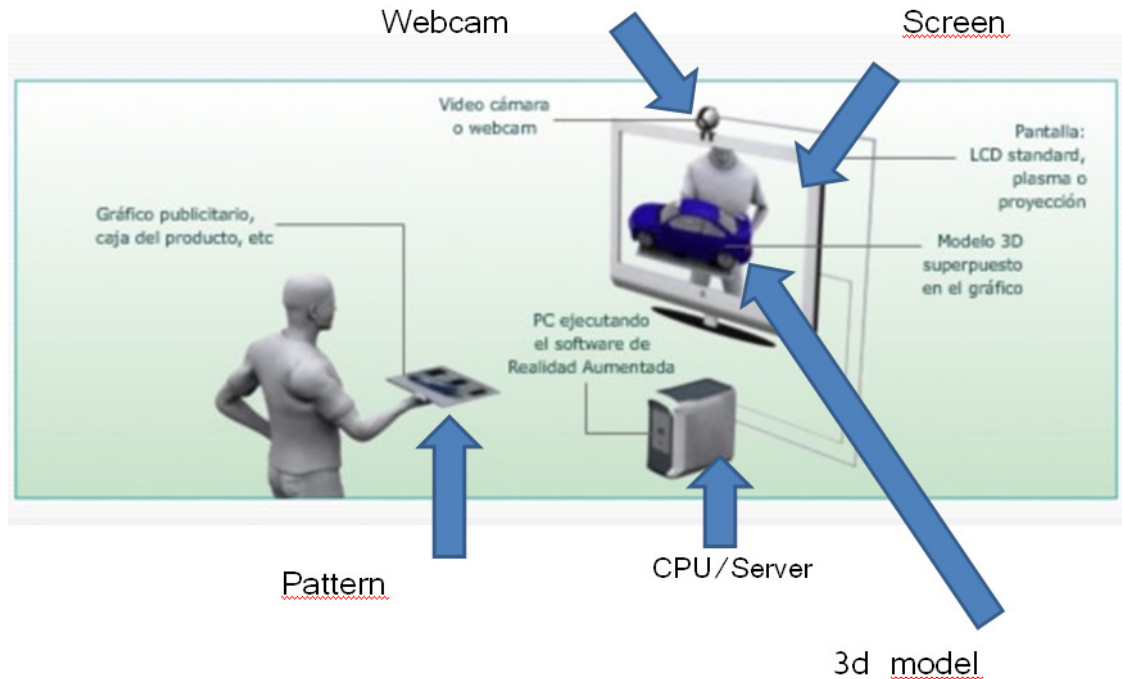


Figure 5: *Augmented Reality of the MAIN.CON project [2].*

All products of the project will be tested and evaluated. Full, usable version of the Augmented Reality system for machines operators should be ready at the end of the year 2012.

Initial results of the survey held in Poland

The survey was made among Polish operators of the construction machinery, to find what excavators are the most useful / popular in the country and what kind of maintenance operations could be run at the building site by themselves.

Focus Groups in Poland took place on 19.02.2011, during weekly meeting of excavators operators course, organized by “LEKTOR” – Centre for Continuous Education of Drivers and Machine Operators, ul 1-go Maja 7, 05-250 Radzymin, Poland. Each focus group was composed by 10 to 15 experts in the field of machinery maintenance. The duration of the focus group was around 2 hours. The focus group was managed by a moderator who follow the following steps (as agreed with Partners and Promoter of the Main-Con project):

Step 1: Overview about the project.

Step 2: Explanation about the aims of the focus group.

Step 3: Asking opened questions included in the questionnaire. Recording and moderation of the debate.

Step 4: Provide the questionnaire with closed questions to the experts.

Step 5: Collect the questionnaires and closure.

Results shows that operators can perform chosen maintenance operations on site. Summary of the results are shown in table 2.

Table 2: Results of the survey in Poland (first five most popular answers – yes)

CONTROLS:	YES	NO
Oil leakage from hydraulic system	39	2
Proper running of bucket	38	0
Proper running of indicator lights and instrumentation	36	2
Condition of hoses and metal pipes	35	3
Abnormal noise of axles	35	3
Oil leakage from transmission and reductors	35	2
Tires wear and tear	35	5
INSPECTION REGISTRATIONS:	YES	NO
Cleaning of electrical poles and battery terminals	24	12
Cleaning of the filter element of engine vent	23	11
Cleaning of plug and filter fuel tank	14	19
Empty sediments from fuel tank	10	24
Empty sediments from reservoirs	10	24
FILTERS AND LUBRICANTS:	YES	NO
Check of hydraulic oil level	38	1
Check coolant level	36	2
Inspection and cleaning of cabin air filters	25	11
Inspection and cleaning of secondary air filter	20	14
Replacement of air primary filter	19	16
Cleaning of air pre-filter and check of turbine pre-filter	19	16
LUBRICATION:	YES	NO
Greasing of loader unit	37	3
Backhoe greasing	36	3
Greasing of oscillator of front axle	25	9
Greasing of rear axle support	23	11
Supports and cross pieces of drive shaft	22	13
SAFETY:	YES	NO
Proper running of lighting devices	37	1
Proper running of parking brake	37	1
Proper running of auxiliary brake	36	2
Proper running of the wiper	34	1
Proper working of rear-view mirrors	33	3

The following (few chosen as the example) questions were asked during debate:

1. Which heavy machine is the most used for carrying out the excavation?
Caterpillar or wheeled excavator are the most useful machines – 8 answers; 6 persons are convinced that JCB excavator are the most popular machines (medium size, for example JCB JS130W); one person mentioned VOLVO excavators; all agreed that backhoes are the most useful (both on wheels or caterpillars).
2. Which are the typical works for maintenance and services that can be made on the machine by the operator?

Lubrication (10 persons fully agree); checking the oils and fluids (5 persons fully agree); technical check of tires; checking the wires and electrical equipment; minor reviews before and after the work (battery, cables, tires); checking the state of the petrol tank and other tanks.

3. Which operations are done daily? All agreed:

Checking the hydraulic ducts; lubrication; checking the possible leakage; checking the blades; checking the tires and wheel clamping; exchange the filters.

4. Which operations are done monthly?

Overall clearing; checking and changing the tires; technical review; checking the wires / hydraulic; checking and cleaning / exchange the filters; conservation of electric wires; checking the lubricates / exchange.

5. Which of the listed operations are particularly uneasy to fulfill?

Checking the levels of lubricates and exchange of lubricates and filters; checking and changing the tires; exchange of wires / hydraulic ducts; conservation of electric wires.

6. Do you think that “Augmented Reality” could be useful for training operators on maintenance works?

All courses are important for better professionalism; 16 answers YES (one – very useful); 3 answers NO; 10 answers – NOT SURE.

Focus Groups show interest of machinery operators in final results of the project - Augmented Reality distance learning courses and didactic materials - which will be the final results of the project.

FINDINGS OF THE FSS NORWEGIAN PROJECT

Introduction

The NORW project is related to development of studies in English for construction managers in Poland and Norway (English as a language of instruction for the lectures and workshops). The project will develop some new courses, modules and curriculum as well as modify the existing ones.

New curriculums were created in cooperation with sector of small and medium - sized enterprises. The project will create two first courses organized in the blended learning mode of teaching (face to face mixed with e-learning):

- “Economy and Financial Management in Construction” and
- “Construction Management”.

Need for the courses was confirmed during numerous research works and projects and contacts with Polish, Norwegian and other European construction companies. Operational goals of the project are: increasing the attractiveness of teaching at Universities and increasing the professionalism of construction managers running the European funded projects in construction infrastructure (roads, bridges, airports, water and waste water treatment plants, sewage networks, etc.). Detailed goal of the project is creation of the didactical internet platform for teaching elements of management in construction together with didactical materials and methodology, both in English and Polish. Partners of the project are: Department of Construction Engineering and Management, Civil Engineering Faculty of Warsaw University of Technology (the Promoter), Poland, Polish British Construction Partnership, Poland, Norwegian University of Science and Technology (NTNU) in Trondheim and SINTEF in Oslo (Norway). Results of the project – distance learning courses – will be used in Poland and Norway for postgraduate study and then transferred to other EU countries.

For the distance learning courses, created in the NORW project, the It's Learning platform located at NTNU will be used. General website of the platform is shown at the figure 6.



Figure 6: Main It's Learning website screenshot [5].

Main content – related assumptions of the NORW project's courses

Economy and Financial Management in Construction Course

The process of decision making is not an individual but iteration process, conducted from general to detailed approach in three stages of preparatory procedure:

- opportunity study,
- pre-feasibility study,
- feasibility study.

All three stages employ, to a larger or smaller extent, methods and analyses which were presented in the first manual converted into distance learning mode of study. The manual "Economy and Financial Management in Construction" consist of the following elements [6]:

- the basic method is the method of determining the present net value (NPV). It is based on discounting cash flows from the future periods to the present period. Discount rate has to be usually at least equal to the percentage rate of the capitals in banks increased by appropriate percentage rates connected with inflation and applicable risk. Percentage rate where the NPV value is equal to zero is called the boundary internal rate of return (IRR). Obviously while making investment decisions various scenarios should be taken into account (optimistic, neutral, pessimistic) in order to gain attitude towards the project's behavior in various economic situations. In these scenarios it should be specified which of the factors for analysis of cash flows have the biggest influence on the final result of the NPV value.
- capital asset pricing method (CAPM) - determining discount rates, trends concerning rates of return from other projects and the will to bear risk by potential investors should be taken into account. All such research may be conducted including the strategy of games and the risk, which means establishment of a large group of operation research methods and probability-static methods.
- the unique application of the Fuzzy Theory for the analysis of NPV method value is emphasized.

- financing methods of investment projects and methods of organization structure selection for management of investments, especially covering the structures useful for launching projects in the public private partnership (PPP) are also analyzed.
- the basic principles of Value Management Method are presented. The Value and Risk Management method (V-RM) may also analyze risks and related probability of achieving the expected advantages.

For all the issues presented above – set of over hundred different exercises were created. Example of such an exercise from NTNU It's Learning platform is shown on fig. 7.

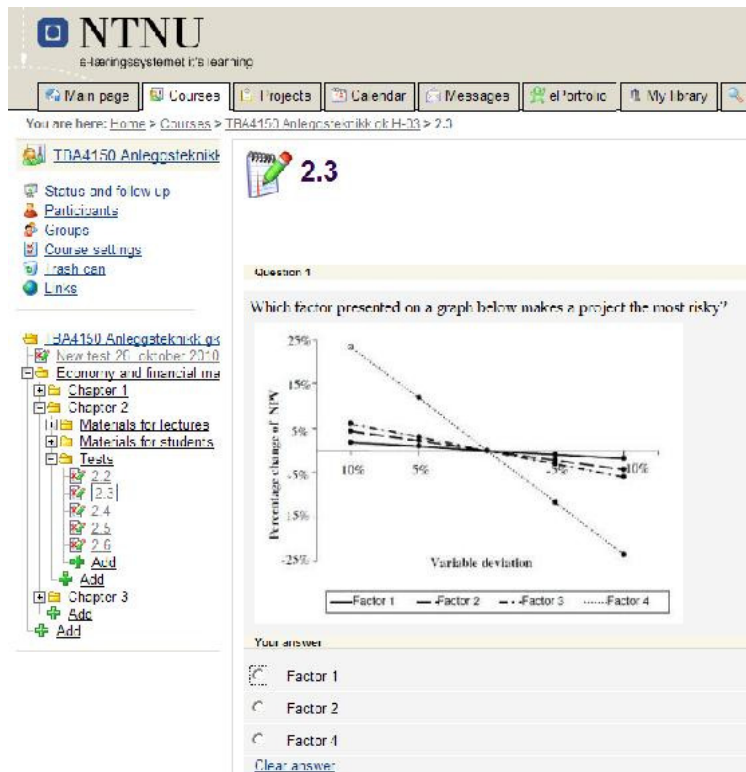


Figure 7: Example of the “financial” exercise on It’s Learning NORW Platform – screenshot from the prepared course.

Example of the exercise “sensitivity analysis” is presented below.

“SENSITIVITY ANALYSIS - Introduction - Sensitivity analysis is an analytical method indicating how NPV and IRR change together with modification of a single variable and other factors remaining unchanged. The starting point for this analysis is the basic presented during lectures. Then a few or more than ten variants of calculations are conducted. Each time the same variable is changed by the same percentage below and over the expected value, for example $-10%$, $-5%$, $+5%$, $+10%$. The other factors remain unchanged. Therefore it is possible to answer the question what would happen to a given project if the variable assumed in the analysis was different. Thanks to the sensitivity analysis by single changes new NPV values are obtained. Then charts picturing dependence of NPV on the changed factors are prepared, which enables obtaining sensitivity curves. Inclination of the curves shows how a given project is sensitive for the course of a given variable. The

bigger is the NPV curve inclination, the more a given project is sensitive to the analyzed factor. A project with a bigger curve inclination is considered more risky. After presenting all sensitivity curves on one chart it is possible to assess which data is the most sensitive and should be estimated in the most detailed and probable way at the stage of budgeting the investment. Try to answer the question below:

Which factor presented on a graph below makes a project the most risky?

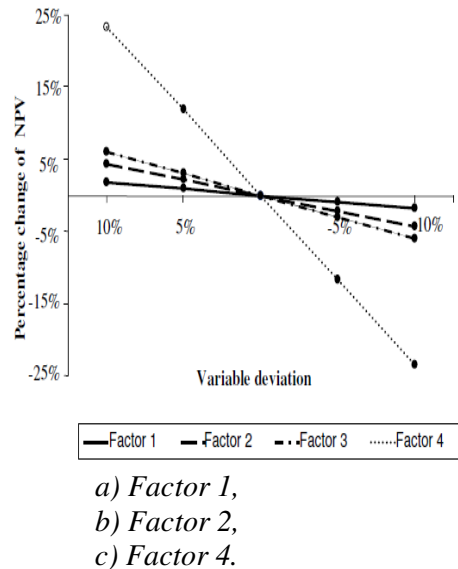


Figure 8: Exercise on the sensitivity analysis [3].

Solution

Factor 4 has a bigger curve inclination, therefore it makes a project the most risky. Answer c) is correct.”

Construction Management Course

The manual “Construction Management” consist of the following elements [7]:

- chapter 2 introduces the construction industry in general. The chapter also gives data on construction in the European Union and presents the construction company, including some of their traditional organisational hierarchies, and the link between the firm and the construction site.
- chapters 3 and 4 examine the contractual documents and the different agents that appear in the construction phase. Documents of the design project and tendering documentation are analysed. Chapter 4 introduces other interesting issues such as communications, decision making and negotiation.
- chapter 5 analyses information flow, documentation and record keeping. It develops mainly the daily logs, the reports, the diary and the meetings.
- next chapters explain basic issues related to the execution of works, such as: machinery and equipment (6), productivity and performance (7), site setup and planning (8) and technology and quality (9). Chapter 6 takes into consideration the selection of machinery, the calculation of its cost and, finally, the machinery maintenance. Chapter 7 presents the study of works, techniques of work measurement, equipment performance and productivity assessment; two fresh concepts are also introduced: value engineering and

benchmarking. Chapter 8 considers constraints of the site and the equipment, storage of materials, temporary facilities, jobsite offices and jobsite security. Finally, chapter 9 summarises construction processes and procedures in building and civil works, and it explores the temporary works, innovation and quality management at the construction site.

- chapter 10 is focused on health and safety in the construction site. Taking into account the European Union directives, the general principles of prevention and the involved agents and their duties are explained. Site specific safety plans and incidents during the execution of works are also considered.
- chapter 11 shows the environmental management at the construction site; the issue of sustainability is also explained. Chapter 12 analyses supply chain management in construction, introducing the issue of lean construction.
- chapter 13 describes resources management, investigating the scope of activities, the assignment of resources to activities, their sequence, duration and monitoring. It develops the bar and network diagrams, cost of resources and cost control.
- chapter 14 considers changes and claims during the construction phase.
- chapter 15 focuses on progress payment procedures.
- chapter 16 describes the closeout process of the construction works and also the construction contract. It analyses the testing and commissioning procedures, handover and occupation. It introduces the operation and maintenance manual and the as-built documents.

8. Site setup and planning

8.1 Site constraints

For site setups, a planning approach must consider:

- All types of physical conditions and constraints of the construction site
- Space needed for all auxiliary facilities, supply of materials and provisional works
- Access and transport for the functions.

Three categories: singular, linear or extensive

Singular site:
Undersized plots,
with space
problems

*Example of layout
for singular
infrastructure.*

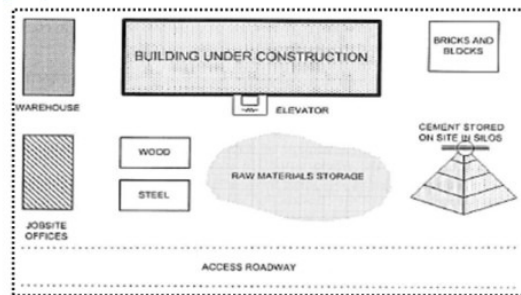


Figure 9: Example of the exercise on It's Learning NORW Platform – Construction Management Course.

For all the chapters presented above, as for the previous course - set of different exercises were created, for example - the exercises connected with design of different building site layouts for different types and sizes of the construction project. Example of the exercise is presented on figure 9 (exercises for Chapter 8: “Site setup and planning”, subchapter 8.1: “Site constraints”).

SUMMARY

Results of both projects presented above should significantly improve education system of construction industry personnel. NORW project will allow to take a part in the postgraduate

study in construction project management for those engineers, who are very busy at infrastructure construction project, having no time to gain their knowledge via stationary, face to face courses. E-learning will allow them distance learning mode of study – from home or from the site office. Results of the MAIN.CON project will improve daily work of construction machines operators. Transport works (including earth moved with excavation preparation) in construction are important element of building process, for example for 1 m² of apartment there is a need for transport of 1800 – 2400 kg of materials and elements. (depends on the technology and materials). [1]. Better maintenance of the construction machinery will significantly improve work capacity. Training provide with augmented reality system will decrease costs of construction machinery maintenance courses for operators.

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