IMPLEMENTING THE PRACTICAL APPLICATION OF MATHEMATICS IN E-LEARNING USING MULTI-DOMAIN PROBLEM SOLVING

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Abstract: *Organizing study process in mathematics, we face two major problems. First, engineers do not apply directly the problem solving skills of higher mathematics. Usually the problem is defined, mathematical equations are created, IT software is used for calculations and problem solving. This means that students need skills to use IT programs as well as knowledge of mathematics, to understand software operations. Second, studying higher mathematics, students get an insufficient idea of its usability. This means that it is necessary to include the use of mathematics in the study process.The purpose of this paper is to find the way how to organize the self-directed study of mathematics' practical application based on didactic approach and e-learning features.. As practical example for self-directed study organization we chose Moodle computerized learning system (CMS), which is one of the main teaching tools in Latvia University of Agriculture. Moodle has two main tools for problem solution mentioned before – the glossary auto-linking filter and the lesson module. Combination of these tools can improve usability of mathematics in specific subjects and students' knowledge about mathematical operations in their learning subject.*

Keywords: mathematical application, self-directed learning, e-learning

Introduction

Mathematics studies have both a direct and indirect impact on the development of outcomes necessary for university graduates. First, Mathematics serves as a tool for solving and calculating various problems. But much greater is indirect impact of mathematics which provides the other outcomes such as development of skills to formulate and solve problems. Competencies of the future specialist, which are connected to his/her future working area, are also established:

1. Practical implementation (technical specialist).
2. Theoretical perception (engineer-integrator).
3. Creativity and novelty (engineer-performer of the changes). (ABET, 2006)

The results of the research regarding employers' opinion about importance of mathematics studies in higher education show that studying higher mathematics students get an insufficient idea of its usability. Therefore, organization of the mathematics study process is very import. Two main problems hamper improvement of the mathematics study process at university:

1. The number of ECTS has been reduced in mathematics and there is no time to solve practical mathematical tasks;
2. Teachers of mathematics as nonprofessionals are supposed to explain technical concepts which have been taken out of the context and therefore they are not easy understandable for students.

Implementation of the practical application of mathematics in the study course can be done using e-learning tools for self-directed study process organization. The purpose of this paper is to attract the attention to the potential of auto-linking mechanism which allows select proper information resources automatically from knowledge repository. Auto-linking is the mechanism that determines automatically which libraries to link while building C or C++ programs. Inspired by this idea we wanted to implement auto-linking feature in multi-domain problem solving.

Materials and methods

Mathematics studies have both a direct and indirect impact on the development of the necessary outcomes. First, Mathematics serves as a tool for solving and calculating various problems. But much greater is the role of indirect impact of Mathematics which provides such outcomes like formulate and solve problems. For developing the ability to solve problems it is necessary: 1) the knowledge; 2) the ability to formulate a problem in cognitive sphere; 3) the ability to construct the solution of a problem; 4) the ability to apply a constructive solution of a problem to the real situation. In mathematics study process the skills are trained to directly apply the formal rules, which are sometimes quite abstract and complex, demanding to choose exactly that one which is necessary from the long list of known rules to complete the task, to build a sequence of applicable regulations. (Zeidmane, 2011). Organizing study process in mathematics, we face two major problems. First, specialists in manufacturing do not apply directly the skills of solving problems of higher mathematics. Usually the problem is defined, Mathematical equations are created, but IT software is used for calculations. This means that students need skills to use IT programs as well as knowledge of mathematics, to ensure understanding of what IT programs do. Second, studying higher mathematics, students get an insufficient idea of its usability. This means that it is necessary to include the use of mathematics in the study process.

In order to satisfy the above-mentioned problems in mathematics, in accordance with the requirements of the Bologna process, the mathematics curriculum must be developed in compliance with the credit-module system. The term **″module″** in the Longman Dictionary of Contemporary English is explained as one of the units that a course of study has been divided into, each of which can be studied separately. The objective of a study module is to provide definite knowledge and skills which are realized integrating separately differentiated study modules.

Study modules contain certain information, they are mutually coordinated (have an entrance and exit) and they are coordinated with professional and didactic tasks (Zeidmane and Vintere, 2009).

In the authors' opinion it is necessary to form modules for separate study subjects by elements and approaches. Therefore the course of mathematics was designed according to **study module** principle (Zeidmane, 2003). For realizing separate subject syllabus development we can divide the study process into STUDY FORMS modules, for realizing cognitive development we can divide the study process into STUDY CONTENT modules. In order to optimize the study process in mathematics the following should be observed which can be seen in Figure 1:

1. The course should be divided into separate themes ("The **TITLE")**, the sequence of which is appropriate to the logic of the given science;
2. The goal of this module **BACKGROUND KNOWLEDGE** is to indicate, which questions should be known in order to follow the solution of the scheme successfully. Thus this module is structured into *methods, concepts,* and *regularities*;

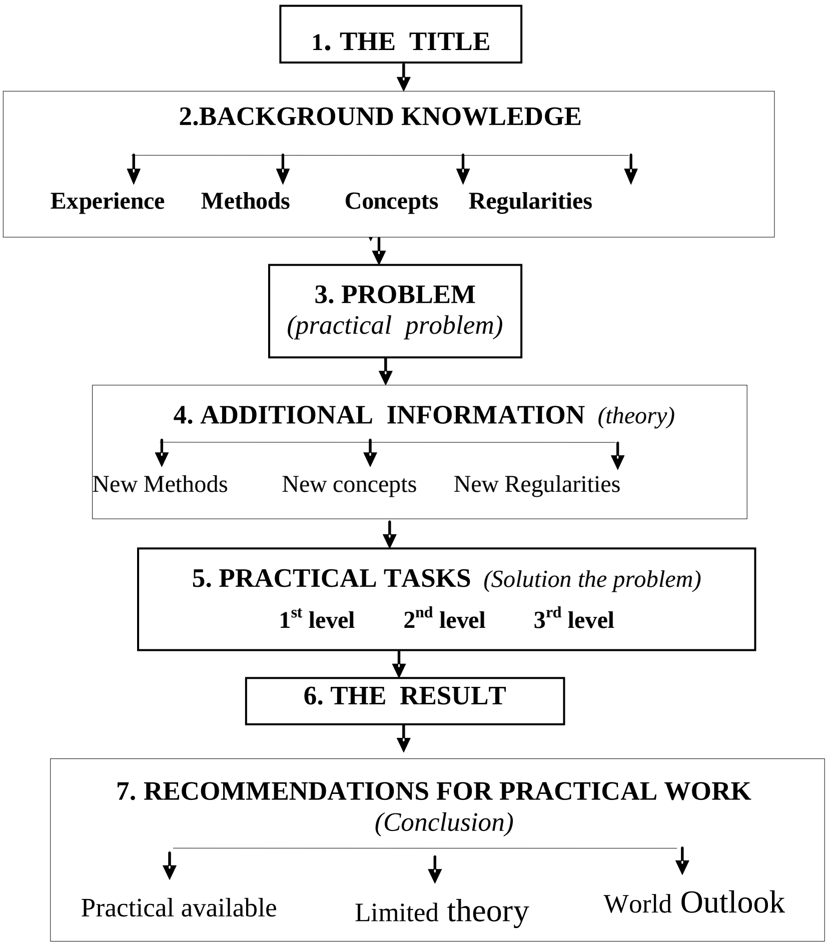

Fig. 1. **Structural scheme of study matter modules**

3. In the module PROBLEM it is important to formulate the problem, including: 1) motivation, why this problem exists or why it is not sufficient with background knowledge to acquire the given theme; 2) concise and clear formulation of the problem, so that the module theme solution could solve this problem.

4. The module ADDITIONAL INFORMATION is considered as the continuation of the module BACKGROUND KNOWLEDGE. If the questions included in BACKGROUND KNOWLEDGE can't comply with the solution, then there is necessity to study new methods or come to an agreement about new concepts. This module contains also regularities, which are not learned before, but which will be necessary for the solution.
5. The module PRACTICAL TASKS as a logic solution of regularities is presented which is based on the background knowledge and additional information and that leads to the solution of the problem. It is very important divide task solving process in separate tasks.
6. The module THE RESULT is necessary to review a theme solution once more, shortly formulating concepts and laws, and classifying them according to causal relationship or analogy, thus encouraging the process of memorizing;
7. The perception of an individual is always selective and everyone in his/ her lifetime has created the evaluation criteria, according to which all new information is classified into significant, less significant and negligible. Consequently, the module RECOMMENDATIONS FOR PRACTICAL WORK or conclusion is considered to be of great importance.

Two major problems create obstacles in the implementation of the mathematical studies of the above mentioned modules: 1) The number of ECTS has been reduced in mathematics and there is no time to solve practical mathematical tasks; 2) Teachers of mathematics as nonprofessionals are supposed to explain technical concepts which has been taken out of the context and therefore they are not easy understandable for students. The solution will be to design the e-study materials which consist of the practical mathematics tasks and insert links to relevant explanations of terms.

Learning nowadays is connected with different information technologies. E-learning is one of modern approaches in educations field. The introduction of e-studies in the higher educational establishments does not mean only the creation of data basis which provides access to materials (Kellner, 2001). It also requires the organization of new teaching forms as well as a new way of assessing the acquired level of knowledge. E-learning gives opportunity to follow up every student, his/her abilities, requirements and deliver to him/her only the information he/she wants. In fact, combined teaching is used in the studies – work in the lecture-room is combined with the work on e-learning website. In such case, students can benefit from e-learning technologies and interact with teacher or other students. E-learning part brings adaptive ability in exercises. Thus with planning, e-learning can customize given content to each student with no further action required by the teacher, but the same time can improve outcomes of learning process. That makes online learning more effective and gives extra advantage in face to face learning. For using e-learning materials, students have to obtain the skills of self-directed studies, which raise students' responsibility for the learning process and promote the ability to acquire knowledge, skills and abilities independently. Students take part in the setting the study aim themselves, they plan the acquisition of the theme, create presentations, as well as evaluate their own work and then agree about the final assessment with teachers and their colleges. Teacher only marks the "cognition steps" in this process.

In order to raise the student's accountability for the study process and facilitate the ability for independent learning it is of a paramount importance to create intrinsic environment for self-motivated studies. The students themselves are involved in setting their objectives, plan the study process, presentations, as well as evaluate their work and together with course mentors and lecturers agree on the final assessment. (Lamb, 2008). Consequently, the self-motivated studies are defined as the student's active participation in the creation of the study plan, as well as in the acquisition of knowledge and skills, and the assessment of their own results. (Gibbon, 2009). Students are more aware of the study process and the expected results; they have greater self-evaluation skills, determination, intrinsic motivation and responsibility. Everyone has to be able to analyze his/her own input in the creation of the process and determine his/her own stumbling blocks which blocked the way for the development.

E-learning is learning (self-education, study) through electronic teaching tool, books, textbooks, that can be distributed in various ways and the educated can obtain study materials and information also by means of new information and communication technologies. At the same time, it is based on voluntary approach, consciousness, responsibility and ambitions of an individual student who is self-responsible for the selection of his study materials, the way he/she studies, his/her specialization as well as the search for possibilities of obtaining a certificate for his/her knowledge. He/she himself/herself states (programmes) the goals of his education and adapts them to his/her needs, conditions, life rhythm and lifestyle. This form of education plays an important role in life-long education process, e-learning can be also a part of an organized form of study (education, learning), for example, distance learning as well as attendance form of study. (Čerņajeva S., Zeidmane, 2010).

Consequently, **self-directed** studies are students' active involvement and participation in the planning of the syllabus of the studies, acquisition of the knowledge and abilities and in the assessment of their own results. It requires greater understanding about the learning process, prospective results, self-evaluation abilities, determination, self-motivation, self-responsibility and self-movement. Each student must be able to analyze his/her own yield in the creation of the work and determine their "stumbling blocks", which had been holding back from making progress in the studies.

The purpose of this paper is to find the way how to organize the self-directed study of mathematics' practical application based on didactic approach and e-learning features. To achieve this goal we chose Moodle computerized learning system (CMS), which is one of the largest e-learning systems (Lahins and Ezis, 2010) and Latvia University of Agriculture use this system as e-learning tool since September 2010. Moodle has two meanings, first of all it is Modular Object-Oriented Dynamic Learning Environment, and secondly, the word Moodle symbolizes lazily meandering through something that often leads to creativity. Moodle was created from teachers from teachers and its community has grown to two hundred millions of users. This community gives real power to create new features to Moodle and has translated it to more than 70 languages. Moodle has two main tools for problem's solution mentioned before – glossary auto-linking filter and lesson module, shown in Figure 2.

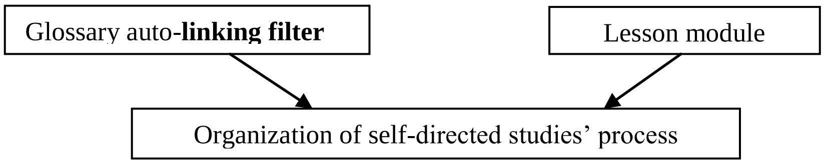

Fig. 2. **The introduction of e-learning in the study process of the higher educational establishments**

The Glossary activity is one of the Moodle features which can store a list of definitions for specific terms, it is like a vocabulary. Moodle's glossary can be used like a regular vocabulary, but there is extra possibility to link terms in text with Moodle's glossary. Glossary auto-linking filter is creating links to glossary activity entry where the word or phrase of the glossary entry is used within the same course in which glossary is located (Glossary auto-linking filter, 2011). When this setting is turned on, whenever a word from a Glossary appears in the course, it is highlighted in gray. Clicking on the word brings up a pop-up window containing the word's Glossary entry. Glossary also allows implementation of specific terms in the particular area in a practical task. Becoming an expert in specific area, like construction or software development, specialists are using terms by practitioners and experts in that area. Each Moodle has its own set of glossaries, and teacher can ask students to edit these terms and make extra activity for them. Teacher can edit and change every entry if students do some mistakes. The lesson module presents a series of HTML pages to the student who is usually asked to make some sort of choice underneath the content area (Lesson module, 2011). Each page of lesson module can have a button or a question at the bottom of the page, the next page in module depends on the answer or choice of student. The choice will send them to a specific page in the Lesson. In a Lesson page's simplest form, the student can select a continue button at the bottom of the page, which will send them to the next page in the Lesson. There is a hidden potential in this module that makes it much more interesting than it at first appears. It is possible to take advantage of the ability of each step to link to any other page, what is usable in several scenario simulations. This is not the case of this research, but could be a possible topic for next research activities.

Results and discussion

Organization of self-directed studies' process has been used to provide practical application of mathematics. For understanding practical application of mathematics it is necessary to have additional knowledge in specific terms and regularities. Often students need to refresh knowledge in mathematics. Therefore for creation of data basis with corresponding information resources we created a glossary with multi-domain terms and regularities in specific fields and mathematics in Moodle. This is just one of the Moodle feature filters, which provide extra possibilities for teachers. Filters are enabled by Moodle administrator and provide possibility to build in materials multimedia players, convert mathematical expressions or other features. This is great possibility for teachers to reduce their work but improve result of learning outcomes.

the Lesson module with scenario based steps and links to created glossary has been made for successful organization of self-directed studies, so that students can independently solve the problems using knowledge in mathematics. (See Figure 3).

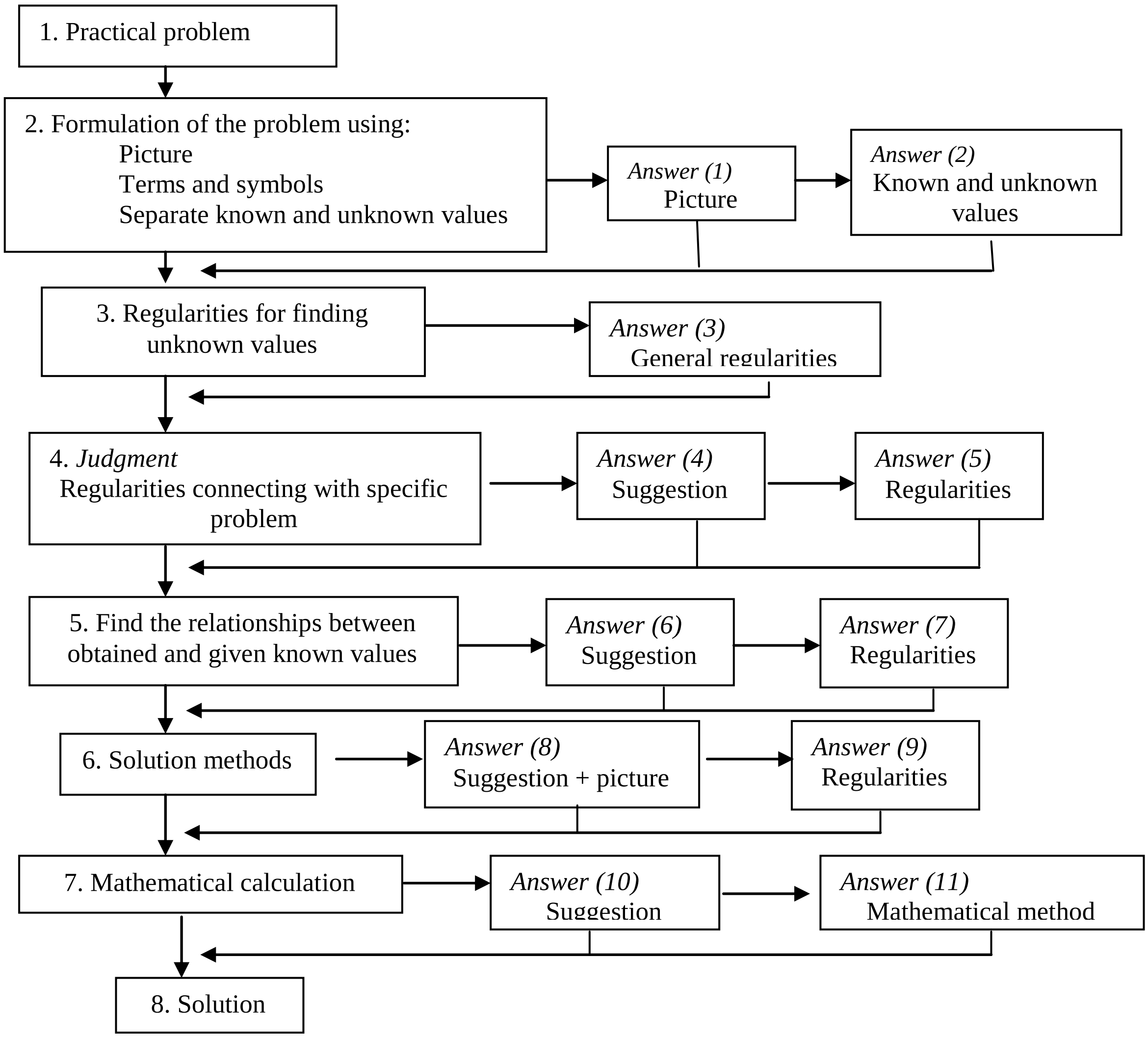

Fig. 3**. Framework for organization of practical problem solving in mathematics**

At first, students receive a practical problem from which they must express picture and task related values. If he/she has a problem to solve this step, he/she can get answer for each step separately. Each term that is related with specific area is linked with Moodle vocabulary. Such linked explanation can contain also links to other entries of glossary. The problem must be formulated by picture, terms and symbols and the known values must be separated from the unknown values. After problem formulation students have to express regularities for unknown values, respectively, the help with an included answer can be received. In this step just general regularities are expressed, but as regards the problem specific regularities, students must judge independently, again there is some problem for this solution, extra answers (Answer 4 and 5) can be received. When regularities are obtained, it is necessary to choose a correct solution method, for any case students have access to Answer 6, where correct mathematical method is given. Then it is necessary to find out relationship between the obtained and the given known value, extra regularities (Answer 7..n) are given for extra support. Next mathematical calculation follows giving problem solution for students, again this solution is given step by step to provide better explanation of calculation process; the mathematical calculation is supported by suggestions and mathematical methods to provide better explanation of the calculation process.

As a practical example the lesson activity exercise screenshots from Moodle e-learning environment of Latvia University of Agriculture is provided, where the student has to calculate the work which has to be done to sink cylindrical pudding below the water, which half sunken is floating in the water. This exercise is related to mathematics and physics, terms from physics are linked with Moodle glossary, but mathematical calculations and ”cognition steps” are provided with lesson activity. In this case we did not give any questions in these steps, but just provided practical application steps in the exercise calculation. Because of the limits of publication we illustrate the main steps of practical task without extra answers and suggestions, see Figure 4:

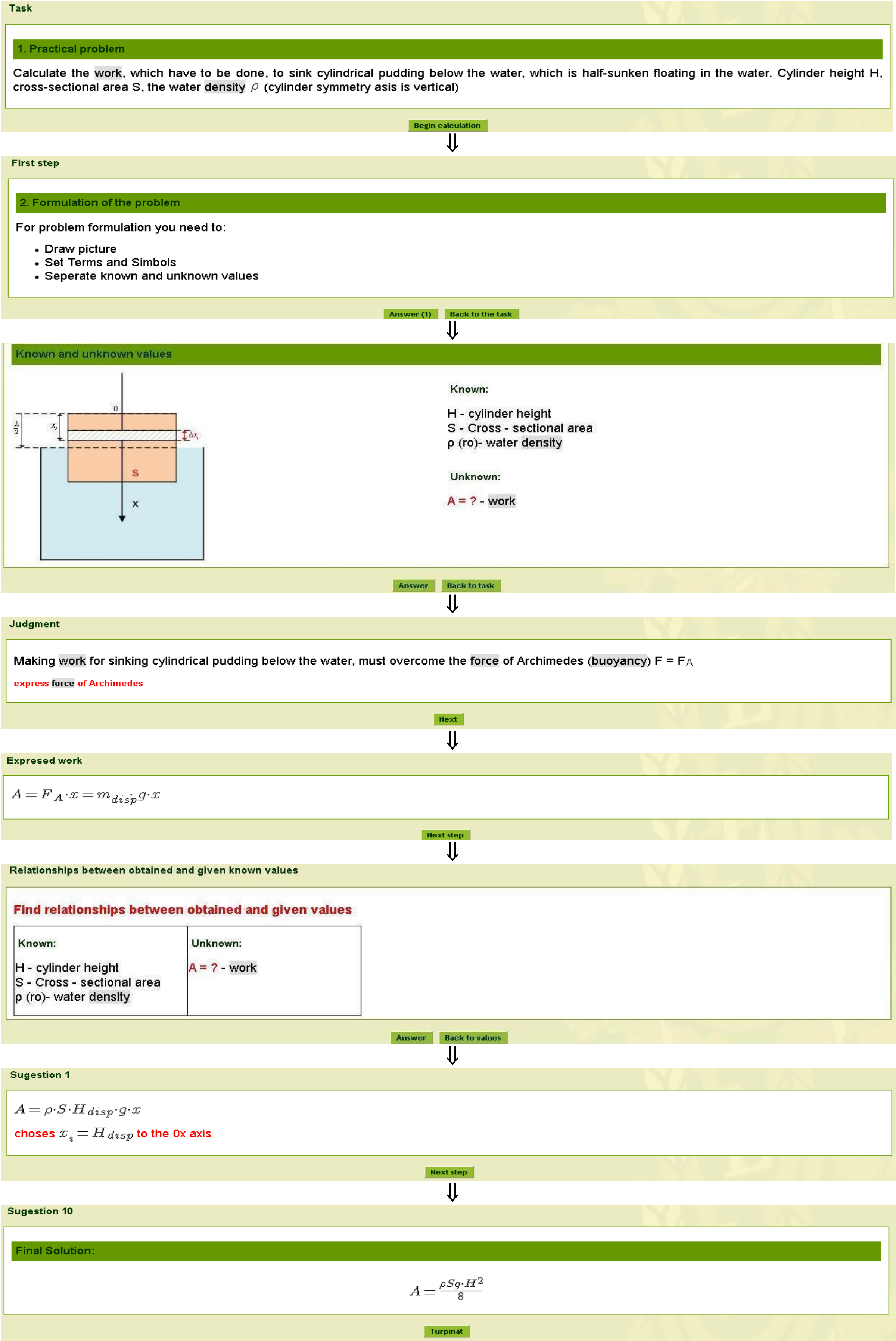

Fig. 4. **Practical example of problem solving in mathematics**

Conclusion

This paper presents the way how to organize the self-directed study of mathematics' practical application based on didactic approach and e-learning features. Nowadays is great possibility to use several IT software solutions for specific problem solving, but it is necessary keep student's competencies about operations which is included in such task solving. Students have to obtain the skills of self-directed studies, which raise students' responsibility for the learning process and promote the ability to acquire knowledge. E-learning is one of the best solutions to improve student's possibilities to organize their study process. As a practical example of e-learning possibilities we used Moodle system. We provided model glossary and lesson modules for practical applications of mathematics in problem solving. Model provided in Figure 3 allows students to engage applications of mathematics in practical examples and link them with particular study area. Such model brings extra benefits to teachers, allowing them just mark the "cognition steps" in this process and allow students organize the learning process by themselves.

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