

Development of a petroleum knowledge tutorial system for university and corporate training

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Abstract: The increasingly rapid development of the disciplines of petroleum engineering and petroleum geology has led to new methodologies and interpretation techniques forming new knowledge that should be offered quickly and efficiently to modern engineers and geologists. This need is equally important for students as well as for young professionals. Access and training to all scientific information is necessary to ensure success in their future careers. Today, e-learning has become a common medium for the management and distribution of on-line educational content. Learning Management Systems (LMSs) were not only developed to handle a large variety of multimedia content that provides an organized knowledge repository used to accelerate access to information and skill acquisition; but, LMSs can also keep detailed statistics on the use of the available material offering a powerful training and educational tool. In this document, the Petroleum Knowledge Tutorial System, an LMS platform offering a variety of online educational and training options to petroleum engineers and geologists, is presented. It was created using Moodle, open-source software that can be used to create on-line courses. The platform covers fundamental educational concepts in a structured way. It follows an optimized “workflow” that can be applied not only to solve a specific exercise but also any similar problem encountered over the course of one’s career. The platform was designed to offer a repository of learning material in various forms and to favor user-platform interactions. It can be used for training and evaluation purposes through exercises and problem solving that the user can perform online by using browsing software along with internet access. Special tools were created and implemented on the platform to assist the user in completing a variety of tasks including performing exercises involving calculations with given data and plots of points or lines on graphs without leaving the learning environment. Furthermore, videos with detailed explanations follow each learning module and provide the full solution to every exercise. The LMS automatically keeps a large statistical database including the users’ access to activities on the platform that can be exported and further processed to improve the platform functionality and evaluate the users’ performance.

Key words: E-learning, training, petroleum, engineering, tutorial

1 Introduction

Industrial petroleum engineering and geological applications have grown at a fast pace over the last several decades. Although the basics behind them have obviously remained the same, due to the parallel improvement of other disciplines like numerical modeling, mathematic computation and applied technology, new methodologies and techniques were introduced in the fields of hydrocarbon exploration, development and production. The interactions among them have given birth to new interpretation techniques that are also based on statistical and probabilistic approaches to geo-engineering problems and to the creation

of highly sophisticated software packages for modeling and interpretation purposes. This has led to a new generation of high technology tools used in petroleum exploration, drilling, characterization and field performance evaluation.

In this new environment, petroleum engineers and geologists need to have quick access to new scientific knowledge and receive updates on new trends in the oil industry. The fulfillment of this need is equally important for young professionals as well as for students who have not completed their education but will likely be involved in the technical work in the future. Thus, educational institutions should incorporate all of those changes into the learning process in order to complement traditional learning. By the end of their studies, students should be able to adjust to the requirements of their future careers; and as professionals, they will be expected to combine all of the accumulated knowledge

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and skills in order to make important decisions quickly and efficiently. In addition, senior petroleum engineers should have the possibility to refresh and update their knowledge in a rather rapid yet effective way that does not have a large impact on their everyday workload and coincides with their need for flexibility in accommodating frequent changes in their business schedule.

Today, the internet provides instructors with a large variety of tools and applications that can significantly improve learning at every stage of the educational process. Students from elementary school through University level can benefit from internet based learning tools. E-learning has become a sector of information technology that exploits the internet by using tools like the web, e-mail and file transfer protocol (ftp) in order to distribute on-line educational multimedia content. By using the internet, various forms of training can be delivered allowing potential users to access the on-line content at any moment from any internet-enabled location. This type of technological platform is called LMS (Learning Management System). LMS can handle the distribution and completion of the training as well as permit the subscription to courses and the control of the completion of tests associated with them for final evaluation of individual performance. Furthermore, benefits such as keeping statistical logs on the user's activity are also readily available.

Although several free and commercial products are currently available in the e-learning world, none applies to the petroleum engineering and geology fields. Furthermore, specific tools such as teaching support for technical disciplines and/or completion of engineering exercises—typically involving calculations, plots, diagrams, etc.—were not found. Therefore, a need was identified for developing a system that would provide a theoretical background; simple and/or guided exercises to apply the concepts and methods learned through books, presentation, or any other conventional source of knowledge; and, in case, more complex sessions involving analysis of case histories all the way through the definition of a problem-based solution. Due to this lack of e-learning materials offered for the very lively niche of petroleum engineering and geology, the idea of setting up the Petroleum Knowledge Tutorial System was conceived.

Various e-learning platforms are available today. Some of them are under commercial licenses while others are open-source. For the construction of the Petroleum Knowledge Tutorial System, the platform Moodle (<http://www.moodle.org>) was selected (Dougiamas, 2001). This platform was created by Martin Dougiamas and is being developed and maintained by the Moodle Pty Ltd, an open-source community of users and commercial partners around the world. Moodle is a software package that can be used to produce web lessons on the internet. At the same time, it is a project under continuous development designed to offer an educational environment based on Social Constructivism (Dougiamas and Taylor, 2003).

In this paper, the structure, contents and functionality of the Petroleum Knowledge Tutorial System will be described. During its construction, special care was devoted to covering the fundamental concepts of each petroleum engineering and

petroleum geological application developed. Every topic was divided into sub-topics which correspond to a theoretical part and exercises. Furthermore, a series of tools were developed and implemented in order to increase the functionality of the platform and allow the prospective users to easily identify solutions to some of the technical questions.

2 E-learning in the university and corporate environments

Information and communication technology has become a critical issue for the internal coordination of today's companies. In developed countries, networking for information, standards sharing and collaboration among employees on specific projects has become the basis of the working structure of many companies. In universities and other educational institutions, e-learning is becoming the basis for the teaching of various courses. It allows the students to "attend" the lessons, exchange information or acquire additional skills from a distance. In this way, a rewarding continuous connection between the source of knowledge and the individual is established.

In the university environment, traditional teaching through lectures and presentations still characterizes the main way of training. At the same time, strong efforts are applied towards learning technologies because the implementation of these e-learning technologies within the educational process offers a series of advantages to the teachers and the students (Cannan et al, 2005). A network is created through which teachers and students can continuously communicate and exchange information like educational material, opinions and advice at any time and from any place. The teachers can better organize their courses and find other ways to complete their educational program through the use of online material. The purpose of evaluating the progress and performance of the students can also be accomplished through the same channels. The deployment of e-learning in the university lies mainly in the hands of the professors. They, in the first place, should find the use of such practices in their lessons and in the education of their students very beneficial. Mahdizadeh et al (2008) showed that the university professors' use of e-learning or similar learning technologies depends on their own perception of the added value of those applications in the educational system.

In a corporate environment, knowledge is typically considered a resource that needs to be managed. The management of knowledge in a modern company is tightly connected with the organization and the handling of the intellectual and creative resources. It refers to the systematic effort to find, organize and make available the company's intellectual capital by sustaining a culture of continuous learning and knowledge sharing so that the organizational activities can be built on the knowledge already acquired. The company's intellectual capital is the sum of information, experience, practical knowledge, relationships, processes, innovations and discoveries developed and retained within the same company (Daft, 2007). In modern companies, work and learning are two concepts that are tightly coupled. The normal working day is a continuous process of learning

and working that is based on the exchange of information and experience. This is especially true in the petroleum sector. Modern petroleum engineers and geologists are bound to cooperate in an environment where the continuous communication and exchange of data and experience is part of the everyday work experience. Usually, the specialist who acquires the data and the one who is called upon to interpret the same data are located hundreds or thousands of kilometers apart. Furthermore, during the interpretation process, the communication with others (usually more experienced professionals who share and suggest solutions to complicated projects) is often necessary. To this end, the implementation of learning platforms in a company's working environment, can bring significant benefits for both new and experienced employees and represents a powerful tool for the company itself. A learning platform can be exploited in the following ways:

- Permanent source of scientific material
- Information exchange center
- Test, training and skill development center
- Thematic database

Young petroleum engineers and geologists can use this system in order to find information relevant to their work, enrich their knowledge and test their skills. For experienced engineers or geologists, it acts as a repository of knowledge that can always be visited in order to refresh or deepen their knowledge on various subjects of petroleum science. In the oil industry, the movement of personal between various sectors is common. Due to this movement, employees should have versatility in their knowledge and education.

Through a learning platform, anyone can refresh their knowledge or learn about new issues related to their current occupation. For the company, it can be a powerful training and evaluation tool. The abilities and skills of the company's personnel can be tested and improved. The general structure of the training and learning system can be adjusted according to specific needs that may likely change over time.

The Moodle platform

Current learning platforms include a number of features including "Learning 2.0". Learning 2.0 is the combination of e-learning with new 2.0 web-based services including wikis, blogs, podcasts, bookmarks and media sharing. These features constitute what can be defined as social constructivism. They allow the traditional reader to become an active collaborator in a community that handles and manipulates contents in order to understand and explain concepts (McKevitt, 2007). Additionally, a potential instructor acts in a facilitated way to form the educational environment and assure the quality and continuity of the learning process.

The Learning Management System (LMS) is a platform for processing and delivering e-learning contents. The LMS handles the distribution of on-line courses, the users' subscription, and the on line activity. A LMS is usually working in cooperation with a Learning Content Management System (LCMS) that directly deals with the contents while the LMS manages the users and the analysis of the various statistics.

There exist various LMS or LCMS, some being "open source". Open source means that software applications can be used freely under a Gnu Public License (GPL). GPL is a license for free software (GNU, 2010). Other systems are commercial and, therefore, a paid license is needed. Among all the LMS platforms available on the market, Moodle was selected for developing the project described in this paper. Moodle is an open-source software that can be used to make courses available on the internet and is widely used by more than 32 million users worldwide (Moodle, 2010). Moodle fulfills all of the characteristics and functionalities described above. To date, it is used for many applications in the higher and university learning environments (e.g. Brine et al, 2007; Rice, 2006; 2007; Martin-Blas and Serrano-Fernandez, 2009). Some of the basic features of Moodle are:

- Plug-in management: Expansions, Layout options, Languages
- Compatibility with the standard Sharable Content Object Reference Model (SCORM)
- Ample examples of proprietary Learning Objects (homework, lectures, quizzes, etc.)
- Registration and authentication of users with their profile
- Assignment of roles and privileges to different user accounts
- Community modules
- Detailed tracking of the users activity

The Moodle environment features a simple, light and efficient graphical interface. As an application, it can be adjusted to various levels of complexity to handle a large number of online courses. It also offers the possibility to easily implement external graphical tools. One such tool was created to assist the user during the learning process for the application described in this paper.

3 Methodological facts

In complex projects like the Petroleum Knowledge Tutorial System, the process of setting up courses is a critical issue that needs to be kept under control. This is accomplished through the sharing of an efficient methodology among the final users, the provider of the didactic contents and the technical/informatics sector.

The adopted methodology combined the guidelines inherited from traditional e-learning along with those derived from the more recent development of Rapid Learning. This approach allowed the following of a structured workflow so as to rationalize materials and activities; yet, leaving a good margin for a progressive optimization of the system during its development. This semi-structured methodology is extremely effective in avoiding misalignments between the targets of the project and the implementation of the system.

The typical activities that were carried out to complete each module of the Petroleum Knowledge Tutorial System are outlined in the following.

3.1 Didactic strategy

- The strategy to truly render the didactics effective implies:
- Definition of the educational targets of each module
 - Definition of the typology of the activity and related

Learning Objects (lecture, quiz, video, numerical simulations, etc.)

- Structuring of the course in the LMS (hierarchy of their contents and introductory modules)
- Definition of the scoring model (max grade, number of attempts, offset, grade to pass, etc.)
- Definition of the users (roles and users' groups) as a function of the course needs

3.2 Creative activities

The main creative activities typically were:

- Design of the storyboard for the Learning Objects
- Design of the functional extensions of each Learning Object (GraphToolBox, Digital Library, etc.)
- Creation and implementation of the graphical templates on the contents (for videos, lectures, interactive quizzes, introductory workflow to the course, etc.)

3.3 Technical activities

The technical activities consist of:

- Implementation of the Learning Objects and their functional extensions developed with the external authoring tools and with the Moodle instruments
- Setting of the SCORM parameters of the Learning Objects
- Implementation of the selected scoring model, roles and groups
- Publication and testing of the contents

3.4 Systemic application activities

The systemic application activities are comprised of:

- Installation and setup of the operational framework which includes the development environment, a staging area and the user issuing environment
- Management of the internal upgrades and releases of the Moodle development community (to this end, a hybrid system integrating the Moodle CVS and the SVN was successfully experimented)
- Continuous management of the service for the release of new contents

The didactic design phase was followed with special attention because it represented the bridge among educational needs, availability of didactic material, and technical potential of the platform and authoring tools. During this phase, a storyboard was produced for each Learning Object based on the list defined during the analysis of each module and on the available material. The production of a storyboard is the most common method used to generate a visual scheme of didactic contents. It contains a set of operational information and a sequence of sketch pictures with actions and options describing the workflow. This method formalizes the designer's idea so that the developer can more easily implement it.

Furthermore, in the storyboards produced for the Petroleum Knowledge Tutorial System, the "Learning Objects Requirements Specifications" were defined as listed below:

- The type of Learning Object
- The educational target of the Learning Object

- The intermediate educational target, if any
 - The duration
 - The narration scheme (with linear or non-linear structures)
 - The introduction of self-assessment tools in the Learning Object
 - Specific needs for the re-use of the Learning Object
- Among the different types of Learning Objects, the following are worth mentioning.

3.4.1 Lectures

Lectures are typically a means of providing the students with educational content, which is mainly text:

- Theoretical introduction to the topic,
- Possible introductory parts depending on the student's needs

3.4.2 Quizzes

A quiz is a tool for verifying the learning of objective data about the lecture and the contents. A quiz is answered autonomously by the student at the end of the learning block, and can be subdivided into categories according to the following answering ways:

- Multiple choice
- True or false
- Question to answer
- Short answer
- Correspondence
- Sequence
- Classification on a Likert scale

3.4.3 Audio-video lecture

Theoretical contributions were integrated in dashboards which simultaneously reproduced video, text and audio.

3.4.4 Interactive demo

Interactive demos were used for the generation of modules for assisted training or for training in the use of a specific tool, software, model, etc.

3.4.5 Live exercise

Live exercises are designed for the students to practice with the newly gained skills by working on real world case scenarios and/or case histories.

4 Construction of the Petroleum Knowledge Tutorial System

4.1 Structure of the platform and roles of the users

Moodle, as an e-learning application, offers a wide variety of options in order to adjust the platform to various needs. The typical Moodle interface includes separate areas, each of which has a different functionality. The main area, usually the central one, carries the structure of the e-learning modules that in the case of the application presented in this paper, coincide with the tutorial categories. The rest of the page is occupied by a large variety of support tools that can be activated or deactivated depending on the needs and scope of the application. These tools include activities like chat, wikis, glossary and forum along with search engine and boards for news and notifications of upcoming events.

The Petroleum Knowledge Tutorial System was developed primarily as a platform for learning and training.

The environments for which it was primarily developed are universities and corporate settings. Its main objective was to offer a series of lessons that cover topics related to petroleum engineering and geology. The tutorial was designed in a straightforward way with the use of theory and practice through questions and exercises. Additionally, the design supports a repository of educational and updated informational material and acts as a center of experience exchange. Since it is a web-based application, it can be easily installed in both local area networks (LAN) or on remote servers that can be accessed through internet connections.

The structure of the e-learning platform for the Petroleum Knowledge Tutorial System is presented in Fig. 1. The learning process was divided into several thematic areas covering a large variety of subjects of petroleum engineering and petroleum geology, such as reservoir and fluid characterization and reservoir modeling. Every thematic area was further subdivided into categories that focus on specific topics and related methodologies used by engineers or geologists to process and interpret field or laboratory data. Each of these topics corresponds to a single learning module. Each module exhibits a common general structure. An example of the structure of the “Well Correlation” module is presented in Fig. 2. It consists of an introductory section where the basic information regarding the method and the exercise is provided. Then, a theoretical and a practical section follow where the user can review important theoretical concepts and perform guided exercises using real data. At the end of this module, there is a repository that provides additional information necessary for the user’s completion of the exercise.

One of the characteristics of Moodle is the possibility to define “roles” for the users. Roles are used to assign access privileges. Usually a “System Administrator” has full access to all courses, all users’ accounts and can perform changes of any type on the platform. The system administrator can also enable users to access modules in sequence, define deadlines, and review the users’ performance. Other account types can be created like, for example, “Content Editor”, “Supervisor”, “Tutor”, “Student” and “Guest”, each given different restrictions or privileges in accessing the platform. In this way, some users can be supervisors or can upload or edit files online, while others can have only viewing/interactive working authorizations, but cannot modify the platform content. This feature can be extremely important for large companies where one or more persons are appointed for the overall design, planning and scheduling of the training. Professionals and specialists are given the task to provide the technical content to be uploaded or elaborated in the system regardless of form. The learning progress of the employees is overseen and monitored by their direct superiors. In a similar way, in the university environment, more privileges are given to the professors who need the ability to modify the content of their courses and control the performance of their students. Students can be allowed to view the content of the courses and perform exercises or exchange files in order to complete various tasks. Fewer privileges can also be given to users who are not enrolled in the course but who should have the ability to view its contents without any kind of interaction.

TUTORIAL CATEGORIES

- 01 - Reservoir Characterisation
 - 1.1 - Logs Acquisition, QC and Follow up
 - 1.2 - Preliminary formation evaluation
 - 1.3 - Standard Formation Evaluation
 - 1.4 - Log Facies Analysis
- 02 - Fluid Characterization
 - 2.1 - Differential Liberation Expansion Test
- 03 - Reservoir Modelling: 3D Geo-Modelling
 - 3.1 - Internal Reservoir Geometry Definition
 - 3.2 - AVO & Fluid Inversion
 - 3.3 - Geostatistical Res. Character.
 - 3.4 - Volumetric Evaluation
- 04 - Production Data Analysis
 - 4.1 - Material Balance for Gas Reservoir
- 05 - Reservoir Modelling: 3D Dynamic Simulation
- 06 - Risk Analysis & Uncertainties
- 07 - Reservoir Management
- 08 - Production Logs and Cased Hole Logs
- 09 - Production Analysis
- 10 - IAM
 - 10.1 - Integrated Asset Modelling
- 11 - Well Testing
 - 11.1 - Well Test Interpretation
- 12 - Flow Assurance

Fig. 1 General scheme of the learning modules inside the Petroleum Knowledge Tutorial System. Various thematic categories, covering a wide range of topics on petroleum engineering and petroleum geology problems are shown

4.2 Learning modules, contents and access

Each learning module (Fig. 2) usually begins with an introductory video where the users have no interaction with the platform. Depending on the scope of the module, a theoretical part could follow that can include questions as part of a preliminary evaluation stage. After answering these questions, the user has the possibility to review their answers and watch short videos explaining the correct answers. This preliminary step may also indicate to the user that some additional study or review of the educational material is necessary before proceeding. This step could help ensure that the user completes the module successfully. This feature is particularly useful in the case where an evaluation or score is recorded upon completion of the module.

The main page of the exercise is usually divided in various blocks as shown in Fig. 3. In the center, lies the main activity that the user should perform. The activity can be a simple or complicated calculation as well as it might require the use of a map, the construction of a curve, etc. Any necessary item

WELL CORRELATION

Module presentation

01 - Theoretical Background

- Basics for Well Correlation
- Evaluation Test
- Hints for well correlation

02 - Field case history

- Field: geological background
- Definition of the well sections to perform Well Correlation
- Stratigraphic correlation

03 - Well Correlation using the software

- Wizard for Test Project
- Download project / file for final test
- Test Results and Assessment

04 - Additional Resources

- Resources repository



Fig. 2 Structure of the Well Correlation module where the different parts of the module are shown: a) theoretical part that contains basic information on the well correlation technique and on the use of a specific software for data elaboration, b) introduction to the oil field that is used as an example for the exercise, c) exercise part including the necessary files to download, d) repository, where additional files can be stored

for performing this step is provided with separate hyperlinks in the same page or a file with additional data, an image, a toolbox or an explanation video. In all cases, a help button in the same page always links to a short video that describes the basic actions to perform in order to complete the exercise. In case of difficulties in completing a task, the user can receive indications by clicking on that button.

Depending on the nature of the questions, different methods for submitting the answer were conceived. Effort was given to offer a variety of ways to answer in order to keep the users' attention at a high level throughout the completion of subsequent modules. For example, options such as using a number or a text string, drop down menus, single and multiple choice boxes, drag 'n' drop options, etc. were used to answer a question including the more traditional way of typing the answer directly into a text box. Every time that a module is opened, the workflow to be followed by the user is clearly indicated by the numbering and the title of each object. In this way, a work guideline is provided when dealing with engineering and geological problems. On the platform, no restrictions exist that necessitate the sequential opening of the hyperlinks because the objects are usually independent from each other. Nevertheless, for certain types of modules, an order should be kept when viewing the objects or performing the exercises because the introduction to some advanced problem items might contain or show the answers to previous questions. In other cases, the exercise should be visualized gradually in a step by step process, in

Fig. 3 Example of a typical exercise window. The main activity (a), always lies in the center of the page, includes the questions but also describes the steps that should be completed by the user in order to proceed. In case the exercise needs external resources such as files, toolboxes, maps etc. these can be found in the Tools area (b). At all times, users can also consult explanation videos through the Help button (c)

order to give the user the freedom to evaluate all possibilities before making a choice or selecting an answer to a problem. For that reason, a series of locks were implemented on the platform to prevent access if a number of conditions such as viewing an introductory video or providing the solution to a

previous problem, are not met. An example is shown in Fig. 4. The image on the left is the one that users see when they access the module for the first time; the one on the right is the image of the same module after completion of the locked steps.

a) Locked view	b) Unlocked view
<p>1 Basic Petrophysics 01</p> <p>📺 Welcome video</p> <p>01 - Logs Interpretation</p> <p>📺 Log Interpretation</p> <p>02 - Porosity Evaluation</p> <p>📺 Introduction to porosity evaluation</p> <p>📺 Porosity Evaluation 🔒</p> <p>03 - Salinity Estimation</p> <p>📺 Introduction to salinity estimation 🔒</p> <p>📺 Salinity Estimation 🔒</p> <p>04 - Calculation of Sw</p> <p>📺 Calculation of Sw 🔒</p> <p>05 - Net / Gross Estimation</p> <p>📺 Net to Gross Estimation 🔒</p>	<p>1 Basic Petrophysics 01</p> <p>📺 Welcome video</p> <p>01 - Logs Interpretation</p> <p>📺 Log Interpretation</p> <p>02 - Porosity Evaluation</p> <p>📺 Introduction to porosity evaluation</p> <p>📺 Porosity Evaluation ☑</p> <p>03 - Salinity Estimation</p> <p>📺 Introduction to salinity estimation ☑</p> <p>📺 Salinity Estimation ☑</p> <p>04 - Calculation of Sw</p> <p>📺 Calculation of Sw ☑</p> <p>05 - Net / Gross Estimation</p> <p>📺 Net to Gross Estimation ☑</p>

Fig. 4 a) Locked view of a learning module. In this case, the user should complete the prerequisite steps in order to proceed to the next one. This is used in the modules that require a specific sequence in opening the modules. b) Unlocked view of a learning module. In this case, the user completed all the steps according to a sequence suggested during the development of the exercise

4.3 Development of additional features

One of the primary concerns of the authors was to create a learning platform that could offer the users all the necessary tools to complete the learning modules without the need to work outside of this environment. For this reason, some additional features were developed in order to:

- Simulate the working environment of external software
- Process data with special tools (Toolboxes)
- Answer questions

In the petroleum industry, a large part of the data processing and interpretation is done through the use of sophisticated software packages that are not always available to the potential platform user (one of the reasons being the number of the software licenses that can be used simultaneously). For this reason, several modules were implemented on the platform where the users are given the ability to work on various software applications widely used in the petroleum engineering and petroleum geology industry by using an interactive simulation of the software working environment. In order to simulate the software environment, videos were created through the use of Adobe Captivate® (Adobe systems Inc, 2010). For each piece of the scientific software implemented on the LMS, some of the functions that are used to solve complicated engineering or geological

problems and specific tasks were selected. During the interactive simulation, the users watch a series of screenshots that were assembled so as to reproduce a workflow. In order to make this process interactive, a variety of actions like clicking on specific areas or entering values in text boxes were implemented giving the users the ability to proceed. The clicking areas were selected carefully in order to reproduce the software environment in a realistic way. Furthermore, every step taken by the users is controlled for correctness and indications are given frequently on how the users should move forward to complete the module.

In the current everyday practice, engineers and geologists often have to use graphs or nomograms in order to obtain the solution to a problem. In the Petroleum Knowledge Tutorial System, the use of nomograms was extensively applied specifically for introductory exercises where an approximate answer can be appropriate and useful. An effort was made in moving the nomograms inside the platform by developing interactive applications that offer the user the same experience as working with paper and pencil or with ad hoc web tools but with increased functionality. These applications are called “Toolboxes” and are available to users through hyperlinks inside the exercise page. An example of a Toolbox is presented in Fig. 5. A classical nomogram or cross-plot (Schlumberger, 2009) is shown. It is used for the

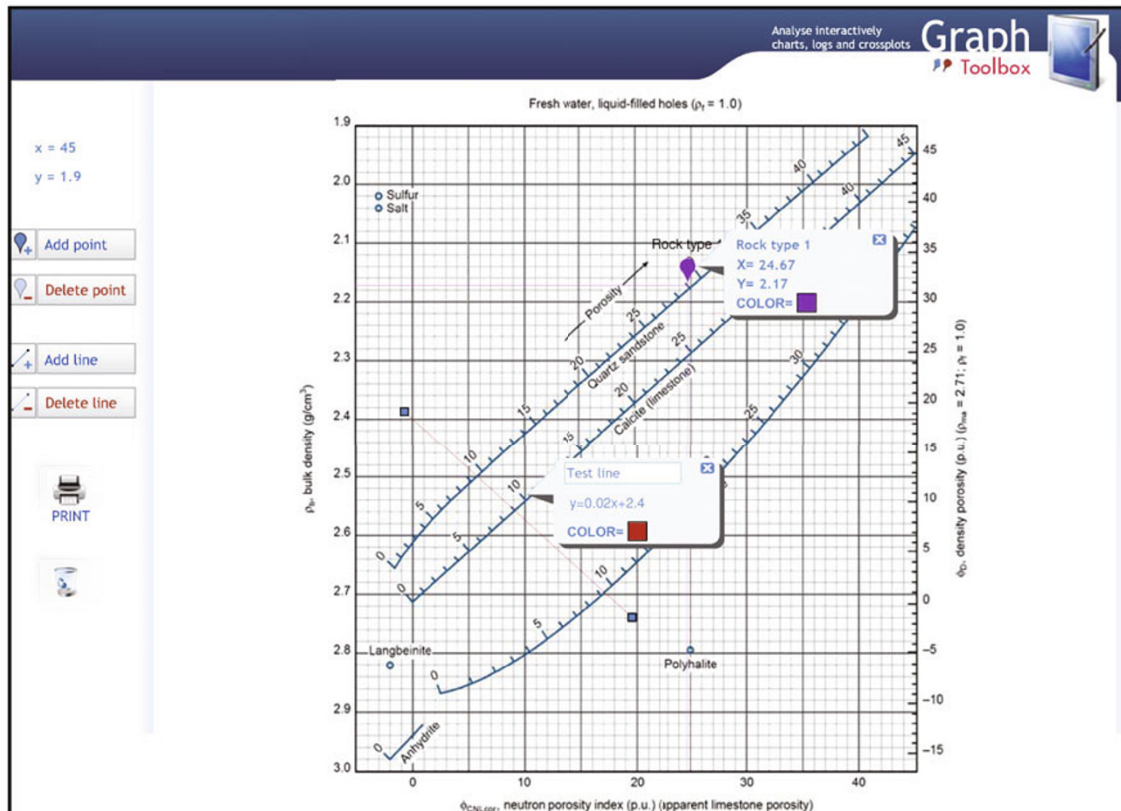


Fig. 5 Example of a Toolbox. This type of toolbox is used to calculate the total porosity of a sedimentary formation using pairs of values extracted from the RHOB (density) and NPHI (Neutron porosity) logs. The user has the possibility to add points or lines and move them to the correct position by either using the mouse or editing the object coordinates. The straight line mathematical equation is also provided. Other options like color changing, naming or printing of the plot are also available

calculation of the formation porosity based on continuous measurements (logs) recorded along a well drilled for hydrocarbon production. Here the user has to plot points on the graph using pairs of log values (bulk density and neutron porosity) that correspond to different rock types. Inside the toolbox, a point can be located in its correct position either by directly moving the point by dragging it with the mouse or by entering the point coordinates in the text boxes. The total porosity value is then read from the cross-plot after projecting the point on the appropriate line, i.e. on that line which corresponds to the rock type of the investigated formation.

During the construction of the modules and the implementation of the questions, one of the main issues encountered was that of keeping a logical continuity of the workflow while having the possibility to control the knowledge and comprehension of the users at every step. For that reason, intermediate questions were created that served as “checkpoints” for the users’ progress. Usually these are non-trivial questions to which users cannot answer by simply writing a number or selecting an option from a list. An example is shown in Fig. 6, where the description of the Havlena-Odeh diagnostic plot, typically used in reservoir engineering, is requested from the user. This plot is used to assess the production mechanism of a given reservoir and, possibly, the volume of hydrocarbons originally in place based on historical rates and pressure data from the same reservoir. A “drag ‘n’ drop” exercise was created where the user must position the correct expression or formula on the

plot. In this way, the comprehension of this interpretation method by the user can be checked with a single exercise before the user is allowed to proceed and attempt the application of the method to real data.

Another example is given in an exercise where the user is asked to identify a number of “sealing” faults limiting geological compartments on a map (“sealing” meaning that they do not allow flow of fluids). An interactive map was constructed where the user is given the ability to highlight each fault trace simply by moving the mouse over it and then to select the correct property (sealing or transmitting) from a multiple choice list (Fig. 7).

4.4 Answers feedback, scores and user logs

The Petroleum Knowledge Tutorial System was not intended to function solely as a platform that examines the knowledge level of petroleum engineers and geologists. It also serves as a tool that offers a repository of documents, research papers, graphs etc. to be shared within a scientific community and to which anyone can refer for answers and solutions to various problems. Furthermore, the implemented tutorials are a means to explain in detail how a problem should be approached and solved. This first happens through detailed videos that accompany every question inside a module. Then, after performing calculations and reporting the results on the platform, the user receives two types of feedback from the system. The first is a direct message which simply confirms whether the answer is correct, incorrect or

Q.01 Havlena-Odeh method

Complete the diagnostic Havlena-Odeh plot

1. Drag items on the right to fill placeholders in the plot.
2. Pay attention to drop items inside the placeholders!
3. Put unused answers in the basket
4. Submit page and then see the correct "Solution".

▶ **DISSOLVED GAS DRIVE**

▶ **STRONG WATER DRIVE**

▶ **WEAK WATER DRIVE**

▶ **WATER DRIVE STRONG AQUIFER***

▶ **GAS CAP DRIVE**

▶ **DEPLETION DRIVE**

▶ **WATER DRIVE MODERATE AQUIFER***

▶ $(G_p B_g + W_p B_w) / (B_g - B_{gr})$

▶ $(G_p B_g + W_p B_w) / (B_{gr} - B_g)$

▶ $W_e B_w / (B_g - B_{gr})$

▶ $W_e B_w$

▶ p_i / z_i

▶ p/z

▶ **GOIP**

▶ G_p

▶ **unused answers**

* if gas production kept approximately constant

Fig. 6 Example of a question on the Havlena-Odeh method. The user has to move the formulas or expressions to the correct place on the plot to demonstrate knowledge and understanding of the plot as a diagnostic tool

partially correct. This is easily recognized from the color of the answer box that usually varies from green (correct answer), to red (incorrect answer) and yellow (partially correct answer) depending on the answer. With a simple "mouse-over" over each box, the correct answer can also be seen. The second is a hyperlink to a video file that describes the complete solution of the exercise by explaining the steps to be followed to arrive to the proper answer in a detailed and illustrative way. An example of the page after the submission of the answers by the user is shown in Fig. 8: the answers provided by the system as well as the link to the explanation video are visible.

The user performance is tracked and registered inside the platform in the form of a score that is updated as a user completes the exercises. The score may vary depending on the difficulty of the module and the correctness of the response. Usually answers are either correct or incorrect. However, there is also the possibility that submitted answers are partially correct. For each of those answers, the user is assigned a different mark. A margin of error was also implemented for questions requiring the reading of values from a plot or graph and for questions that call for mathematical calculations, so as to compensate for small errors due to rounding of rational numbers.

The platform offers a variety of logs that provide complete monitoring of the users' and platform's activity. This information can be retrieved for each user and for each module. The visualization of the activity of all users on a certain module is also possible, with details on the times they logged in, which exercises they performed and their scores, how much time they stayed connected, and more. Various types of statistics regarding the platform usage can also be easily created and usage data can be exported in various formats (Excel, XML, ASCII file).

5 Students' experience

The Petroleum Knowledge Tutorial System was presented to the students for the first time during the international course for the Master of Science in Petroleum Engineering of the Politecnico di Torino, Italy, in 2009-10. Students mainly come from Asia, Africa and South America and lectures are held in English. It was the first time that an online tool was used within the Master courses and served as an opportunity to receive feedback from the students that interacted with a part of the system, namely the Well Testing Interpretation exercises module. For this reason, a survey was performed using a questionnaire with 9 questions that were sent by

Geological consideration - Blocks identification

The purpose of the exercise is to select those faults that contribute in defining geological blocks.

Open the link "Geological Consideration" below and browse over the image in order to visualise the faults present.

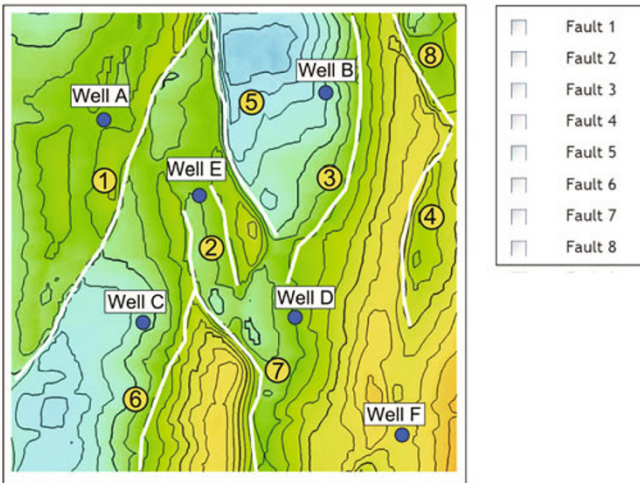


Fig. 7 Identification of "sealing" faults on a map during a Modular Formation Dynamics Test (MDT) exercise. The user can visualize the areal extension of the faults by moving the mouse over each one of them (e.g., fault drawn with dashed lines) in order to select the faults defining geological compartments

email to all the participants of the course. The purpose of this survey was to evaluate the various aspects of the implemented modules: the overall structure, the educational level of the

included material and the ease of completing tasks and exercises.

From the time of its first use, the e-learning system has become a permanent application that accompanies the courses provided within the Petroleum Engineering program. More than 100 feedbacks were received from the students in two years. The general opinion of the students about the tutorials is reflected from the answers presented in Fig. 9. Overall the received feedback was always positive. Although for almost half of the students, it was the first time they used online tutorials, 80% of the students found it easy to navigate through the modules and to complete the exercises. The wide acceptance of the interactive tools implemented in the platform like the Toolboxes or the "drag 'n' drop" feature was also very encouraging. This feedback combined with the international character of the courses, where students from many different countries have the opportunity to work together and share different educational background also through a new communication and learning system, proved the validity of the tool and triggered new developments also based on a constructive discussion with the users. In particular, improvements for better interactivity, web access, online data exchange and live communication were implemented.

The students confirmed their willingness to extend the use of the platform for their studies in more and more courses. On the opposite side, they were more skeptical toward the possibility of taking their final exams using a similar on-line tool.

Q.01 Calculation of V_{sh} using the Density-Neutron separation

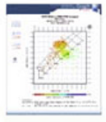
You are provided with a Density-Neutron cross plot.

You are asked to calculate the V_{sh} volume for the following depths utilizing the N-D plot:


a) Depth 2540 m;
b) Depth 2556 m;
c) Depth 2588 m.

Toolbox and graphics resources

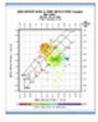
Utilize the toolbox and the log image below to perform your exercise




Toolbox
XPlot
RHOB-NPHI



Log
RHOB-NPHI



XPlot
RHOB-NPHI



LIBRARY
Full access to all resources of the library

Results table


Fill the empty boxes in the table.

Depth	V_{sh} Density - Neutron (%)	Status
Depth 2540 m	51	✓ %
Depth 2556 m	78	✓ %
Depth 2588 m	15	✗ %

[Animated Explanation](#)

Quick Help

Click on the below icon for further assistance:



Control of the answers.
Green : Value inside range
Red : Value outside range

Correct answer visible during mouseover each box

Correct Answer and Feedback

Correct answer: 11.1
Incorrect answer

Fig. 8 Typical window after the submission of the final answers of a learning module. The user has the possibility to immediately assess the correctness of their answers (green/red colors) as well as visualize the correct response with a simple "mouse-over". Furthermore, a special link points to an animated video containing a complete explanation of the exercise



Fig. 9 Examples of student answers to the questions included in the conducted survey regarding the user experience of the learning platform. The positive response from the students is reflected in their answers

6 Conclusions

The Petroleum Knowledge Tutorial System is a web-based platform developed for sharing technical knowledge, scientific documents, guidelines and so on for specific training of petroleum engineers and geologists. The web-based environment offers all the advantages of the internet and of modern web applications (wiki, chat, forum, etc.). Additionally, it is easily accessible from anywhere with an internet connection. It can be readily updated with more content or new modules and it can handle a large number of users who can interact with the platform and/or amongst themselves. It can be used by companies in the petroleum industry to offer education and learning opportunities to their employees as well as it can also constitute a very valuable tool for university students to review topics of their courses and practice “hands-on” synthetic or real data set from the industry. Furthermore, it includes characteristics that help to evaluate the performance and the educational level of engineers and geologists through various types of exercises. At the same time, it can trace the activity and usage of the system and store the data for future use. The platform can also function as a permanent link between users who can share knowledge, information, suggestions and files. Moodle, the core of the system, is a versatile software application that offers many possibilities for managing modules, courses and learning objects, and also a flexible platform allowing integration with externally developed applications.

One of the main advantages of web-based learning using Moodle is that material of any type posted on the platform can be potentially modified by a large number of users when new data becomes available or when corrections and updates

are needed. In the petroleum industry, people have to travel frequently and spend long periods of time away from their office. In this case, the platform can be a constant reference point for documentation search and exchange of any type of information. Additionally, it can serve as a consultable scientific source repository to which the users can refer in order to find material about topics outside their knowledge area.

The petroleum system can become a useful training tool which can be easily integrated into any continuous educational program for engineers and geologists. Numerous courses can be uploaded on the platform with any type of contents that cover the full range of petroleum engineering and geological issues. Because the content of the learning modules can be modified with limited effort, exercises can be varied in a minimal amount of time without the need for a complete revision of the tutorial.

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