Description of an e-learning tutorial in geostatistics delivered at one university and at one company

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INTRODUCTION

The e-learning tutorial which is described in this paper has been designed and developed to address the specific needs of a PhD thesis research. The research objective is to make explicit the assumptions and decisions for the design of digital learning resources in engineering education. In particular, we try to define design methods for blended learning application in both academia and industry. The specificity of the PhD work comes from the fact that it was improbable to find an existing work matching the conditions that would allow investigating the collaborative design of an e-learning content between academia and industry and in the particular context of blended learning in engineering. Consequently, we decided to set and implement innovative educational practices and to study them at the same time. Using design based research methodology, also called development or formative research, we have engineered an e-learning module in geostatistics, in real world settings and in collaboration with instructors from industry and teachers from university (Fig. 1). The current publication doesn't cover the overall research methodology and results but only provides a description of the learning content itself.
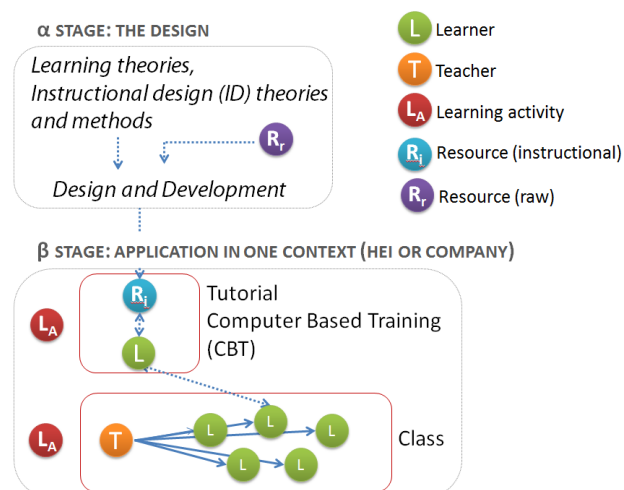

Fig. 1. The research study: learning resources design for blended learning at HEI and company

1   THE E-LEARNING MODULE

1.1 The main characteristics

The module gives an introduction to the main principles of geostatistics and their application to geological reservoir modeling. Following Gagné's categories [1], the instructional delivery strategy is of a tutorial nature to allow self-pace learning in order to help learners to be prepared for class, the instructional media are diverse (multimedia with audio, text, 2D & 3D graphics and animations), and the instruction is delivered using Computer Based Training method (online learning).

The digital learning resource has originally been built to address the needs of engineering education and training in the Oil & Gas industry. The learners get an introduction to the most important concepts, all in an interactive and visual manner. The module is composed of four chapters, namely "spatial analysis", "spatial correlation", "spatial estimations" and "spatial simulations". It includes exercises for practice and two Quizzes for self-assessment. It is SCORM compliant and it allows tracking the students' progress through the module. The entire module has been designed to last around 40 minutes although it has been observed that committed learners could spend more than 1 hour and 30 minutes, especially on solving the exercises.

The module can be modified to adapt the course structure within the "client" organization. As way of example, in the context of corporate training, we split the module in two sub-modules (or tracks). The "track 1" covers the first two chapters "Spatial analysis" and "Spatial correlation". The "track 2" covers the following chapters, "Spatial estimations" and "Spatial simulations" (Fig. 2).
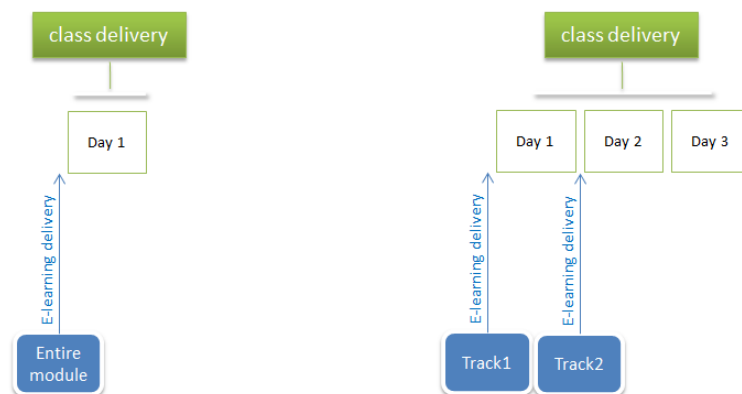
Fig. 2. Example of two different delivery methods

1.2 Functional description

When entering the module, the learner is given the composition of the module. An illustration represents the general organization of the course as it is usually taught. Furthermore, it has been graphically designed so that the relationship between the course topics is made explicit from the beginning trying to avoid later confusions between new concepts. That is the reason why we consider this first view to be a *graphic organizer* in the sense that it "visually depicts key facts, concepts and important relationships" [2].

All along the module, the main information is displayed on the "main screen" (Fig. 3). The content is very illustrative, with short sentences and very little text. For each "scene" we tried to get as close as possible to scientific and mental representations. It generally involves 2D & 3D illustrations and interactive animations. In addition, a natural voice-over explains the concepts synchronously with the animations on screen. The speech is also written in the "descriptive text" area. At any time of the module, the learner knows exactly at which point he / she stands in the learning process by the mean of three features:

- a "progress bar",
- a "visual label" symbolizing the main concept explained in the current section of the module,

- a "navigation dropdown menu". In the "navigation dropdown menu", the sections that have already been covered appear in green, and the current section appears with a blue borderline.

To finish, the user also has access to a contextual menu. It allows switching the sound on and off, to go back to the graphic organizer, to deactivate the animations for a fast review and also to open a printable file of the module in "pdf" format.
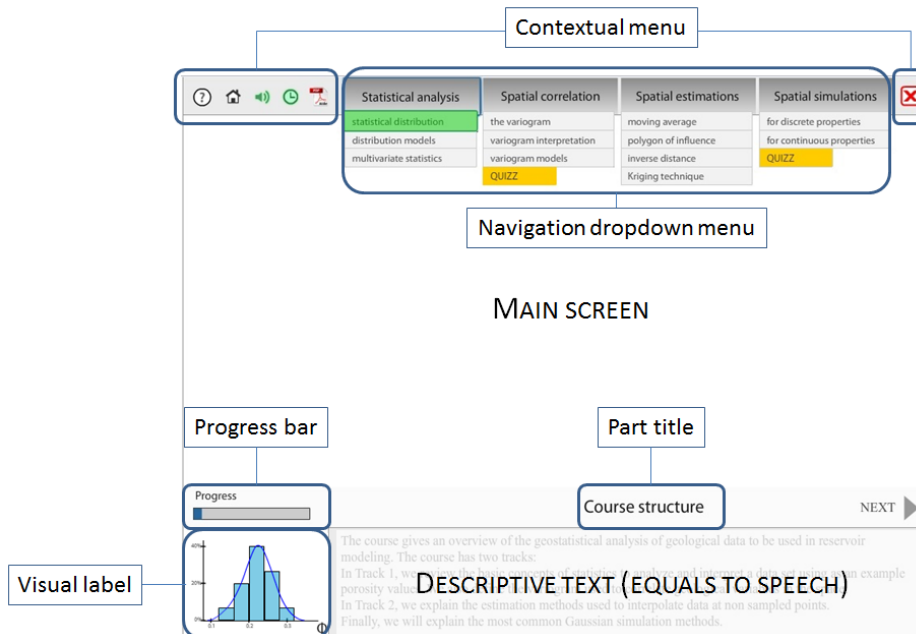

Fig. 3. Composition and organization of the screen layout

The module includes 5 exercises to be done with Excel™, and two interactive and auto-corrected exercises are embedded in the module itself. In addition, there are two scored Quizzes, one at the end of chapter 2 and one at the end of chapter 4. The module is SCORM™ compliant in both "1.2" and "2004" version. For its delivery and hosting, we covered various possibilities: hosted on a dedicated MOODLE™ Learning Management System (LMS) or hosted on a corporate specific LMS. Thanks to the tracking system in place, we have access to general information as the day and time of the tentative, the time spent completing the module, the Quizzes' results, and also the time spent for each section of the module, including the exercises (Fig. 4). Each time the module has been used for a course, all the information on the module usage has been sent to the instructor or the teacher on the morning before class start.
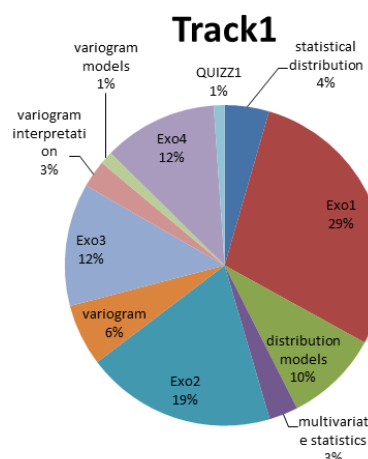

Fig. 4. Example of average time spent on each section of the module

1.3 The design: an iterative process

Beginning of 2013, we initiated a pilot project. The same e-learning resource has been implemented in parallel with class lectures for blended learning at one multinational company and at one engineering school. We collected the feedback of the instructors, of the teachers and of the students and we improved the e-learning content end of 2013. Then, the module has been applied again in company and in the engineering school (Fig. 5). Each time, the module has been enhanced and also adapted to the course constraints of the "client" institution. For example, the navigation system has been improved, the instructions for exercises have been further detailed, a natural voice-over has been added, and as we said, the module can be split in two distinct parts if needed. More recently, the Quizzes have been enriched for the engineering school so that the teacher can use learners' results to open up the conversation at the beginning of the class.
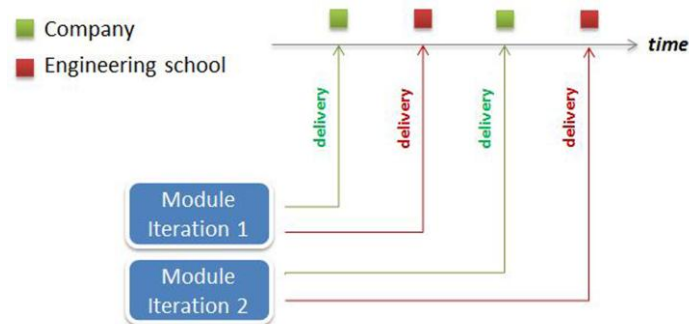

Fig. 5. The e-learning design process: an iterative approach

2 DISCUSSION

2.1 The disciplinary content

Geostatistics, called the discipline or content knowledge in our learning situation, has been funded by Professor Georges Matheron in the 50ies. Geostatistics is a science field interested in the application of statistics to spatial or spatiotemporal datasets. It enables the interpretation of spatial continuity and of uncertainty. In the following example, we consider one concept which is introduced in the tutorial: the semivariogram. Because the course is an introduction to geostatistics, it is very likely that the learners discover the notion of semivariogram for the first time.

The semivariogram is a function that measures the spatial degree of data relationship. It is defined by the formula (1):

$$\gamma(h) = \frac{1}{2n} \sum_{i}^{n} \left(\Phi(u_i) - \Phi(u_i + h) \right)^2 \tag{1}.$$

u_i is the coordinate in space of one point of the dataset

$\Phi()$ is the porosity

n is the number of data pairs separated by the vector h

$|h|$ is called the lag

As many statistical analysis methods, the semivariogram is formalized mathematically. However, the meaning of the equation is tightly linked to spatial considerations. Therefore, we decided to use an interactive graph which represents for each lag selected by the user both the pair of points selected among the experimental data of rock porosity and the corresponding isotropic semivariogram value (Fig. 6). It facilitated the direct visualization of the effect of the lag $|h|$ on the pair of selected points for

the construction of the $\gamma(h)$ histogram. Of course, we considered a simplified example in order to allow off-loading learner's cognitive work for two main reasons: to stay focused on the new concept the learner is discovering (to avoid distraction) and to keep pace allowing other inquiries in a short duration of time (the entire module is 40 minutes !). Besides, the concept can be further developped in class with the notion of orientation of the vector h also called azimuth.
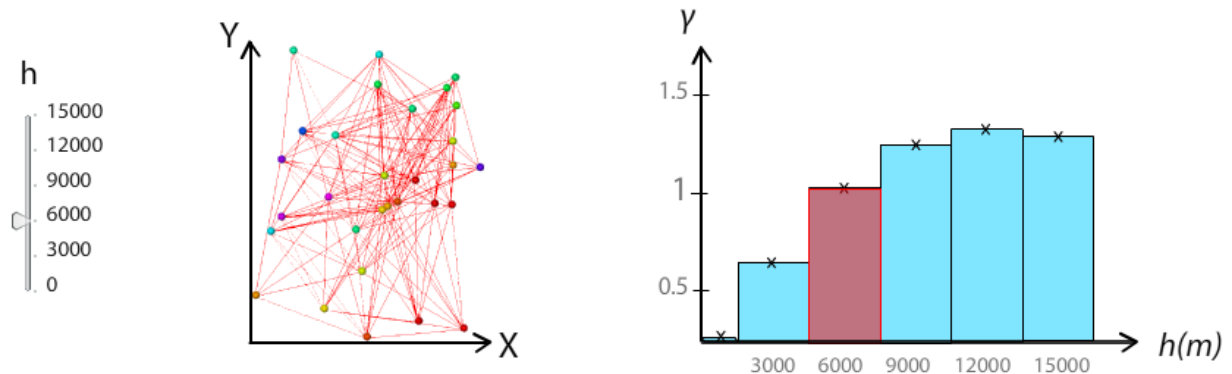

Fig. 6. The variogram as it is represented in the module

This example is one among several in the module where the nature of the concept influenced the way it is represented and explained (pedagogical knowledge). In the case of the semivariogram, the interactivity (technology) enables to link a mathematical formula (statistics) to spatial aspects, hence allowing the learner to individually construct understanding and raise questions on what will be a basic tool for advanced estimation and simulation analysis. Furthermore, the explanation is followed by an exercise where learners are asked to construct the semivariogram themselves in order to apply and reinforce learning.

2.2 The technological choices

According to ASTD, e-learning describes "the fact of using electronic technologies to deliver information and facilitate the development of skills and knowledge" [3]. In this part, we discuss the choices of technology that have been made to support learning in the particular context of the study.

Gagné defined the term "affordances" as the properties or functions of technology that extend our learning and perceptual capabilities [1]. As suggested in Basque and Lundgren-Cayrol's work [4], we argue that rather than technology / learning strategy association, we select technology and media according to their respective "affordance" within given instructional delivery strategies (see Table 1).

Table 1. Technology selection factors. Adapted from [1].

Modalities of technology application	Affordance depending on context and discipline	Example of particular contexts	Instructor's role
Web conferencing 2D & 3D static illustrations 2D & 3D dynamic illustrations Interactive graphics Simulators Serious games	Productive tools Cognitive tools Immersive technologies Assessing tools Communication tools	Security issues Risk to damage costly equipment Cost and time of physical use Limited physical or computational access 3D, complex mental construction Dynamic phenomenon	Knowledge transmission Facilitation (project, workshop, practical work) Mentoring

Hereafter we explicit some choices we made concerning technology selection (software) and also concerning interactive activities.

The module is a tutorial which can be accessed from the web via a LMS directly from the workplace, from the engineering school and from home. Consequently, the technology selection has been done against two main criteria. First, the learner would have to access the learning resource without further software installation (particularly in companies for security reasons). Second, the technology would have to allow advanced interactive constructions. Therefore, we decided to develop the resource with FLASH® technology. Indeed, given the population of targeted learners, it has been considered that in their academic or professional environments, engineers would most likely work from a Personal Computer (PC) with the Flash Player already installed in their browser. It represents the first "E" of the 4-E model where the environment is compatible with the technology selection [5]. Considering the 2D & 3D graphics, they have been designed either from instructor's drawings, available graphs, from the dataset itself, from Excel® spreadsheet or from simulation results.

The module includes many interactions in order to make the learners active and allow them to almost "touch" the data and concepts (see Table 2).

Table 2. Some examples of interaction in the module.

Check button: example of variogram model selection	*Slider: example of the sensitivity of the "moving average method" against the major / minor range ratio*
Clickable graph: the covariance and correlation coefficient of the selected graph are provided	*Input text: example of the "simple Kriging method" exercise*

- Radio and check buttons: radio button are used to allow the learners getting access to dataset characteristics for statistical analysis. Radio buttons make the module flexible around the needs of the learners. Users are not forced to follow a given track of explanations. Check buttons are used to display mathematical models on top of the experimental semivariogram diagram for instance. It allows the learners to make quick and detailed comparisons between the dataset and the models of their choice,

- Sliders: in the previous part, we described how the semivariogram introduction relied on slider interactions. Indeed, sliders allow parametric sensitivity study. As way of example, we also

used sliders to explain estimation methods. We used the parameter "major / minor range ratio" to visualize its influence on the estimation results,

- Clickable graphs: we give the possibility to the learners to directly click on graphs in order to display further information related to the graph and understand the maths behind,

- Input texts: they are used in one exercise where students have to use the "simple Kriging method". They have to fill a matrix system from spatial information available on screen. The false entries are in red and the right one in green. It allows live auto correction and guides the users for concept reinforcement. Input text is also used to collect users' feedback when they exit the module. It allows feedback collection at the moment students just completed the tutorial activity.

3   CONCLUSION AND FUTURE ORIENTATIONS

This paper provides a detailed description of the tutorial module as it has been designed for blended learning in one company and in one engineering school. We described the module's features, we detailed the nature of the discipline content with one example and we explained how technology has been selected. In particular, we reflected on how the technology application depends on the nature of the content involved (content knowledge) and also on the instructional goals (pedagogical content).

The module is currently used by other companies and engineering schools. We are in the process of collecting the following data from academia and industry: instructors', teachers' and learners' feedback, semi-structured interviews, users' actions during the completion of the tutorial. The research results and their implications on the design methods for common learning resources between universities and companies should be made available in the coming year as part of the PhD work.

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