Development of a Computer-Based Instructional Design tool - Analysis and Design Phases

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Abstract - *This paper discusses the computerization of an existent tool called GRASP. It helps teachers to design an instructional system. Currently, GRASP has the form of a grid. Teachers complete it to first clarify their instructional problem and then to design an instructional system. This tool covers the analysis and design phases of the ADDIE (Analyze, Design, Develop, Implement and Evaluate) model. GRASP has been validated in a two-phase evaluation. The paper discusses the pertinence and the adequate way to realize the computerization of GRASP; the proposed system is called CB-GRASP. For this, the paper begins with the context of the work. Then a review literature informs about instructional design. GRASP and its use are then described. The analysis and design phases of CB-GRASP are presented. The perspectives of this work conclude this paper.*

Keywords: Instructional Design; Instructional Design method, Instructional Design tool

1 Introduction

This paper is in the field of Instructional Design (ID). A non-computerized tool named GRASP (GRid bASed Pedagogical design) that assists teachers during analysis and design phases of an Instructional System has been created; this tool is detailed in [1]. Teachers answer to successive questions in order to clarify their instructional problem and design a pedagogical environment.

To provide an example, this tool has enabled the design of an instructional system for teaching databases, intended for undergraduate learners in a short cycle class [1]. With the help of GRASP, the teacher has refined the instructional problem (e.g., develop skills in designing 3NF databases while working on transversal competences such as planning, organization and resource management). This teacher has produced a collaborative instructional system to develop the skills needed on the job and the transversal competences needed to remedy the deficiencies in project management.

The tool (in its textual form) has been evaluated on a public composed of 15 teachers [1]. The results show its ability to help teachers to develop pedagogical devices tailored to their professionalization goals and demonstrate implementation of more active learning activities. However, during the evaluation phase, several teachers underlined the importance and the interest for this tool to be computerized. The paper describes the work done in this direction.

This paper reviews the terminology related to ID. It presents briefly GRASP and its evaluation. The issues of this tool in a computerized form (called CB-GRASP) are then discussed. The conclusion discusses the opened perspectives.

2 The Instructional Design Domain: Literature review

2.1 Instructional Design and Instructional System

Instructional Design (ID) is a method or process used to produce plans and models describing the organization of learning and teaching activities, resources and actors involvement that compose an Instructional System or a Learning Environment [2]. Many authors summarize ID as a *systematic planning of instruction* [3].

Instruction is the intentional facilitation of learning towards identified learning goals [4]. The Instructional System is a complex system, either computerized or not, designed to manage an instructional problem. It combines organizational conditions, arrangement of resources and procedures allowing the instruction to take place. The instructional problem is a set of variables concerning the learner, the teacher and the environment (such as the learner's profile, the instruction domain, the teacher's expertise, his/her preferences, the number of learners, the size of the room, the pedagogical material, and so on) that will affect the learning process. Figure 1 gives a pictorial vision of these concepts.

2.2 Theories, Models and Methods in ID

It is not easy to structure the ID world. In fact, literature of ID is full of terms sometimes used as synonyms due to misuse of language.

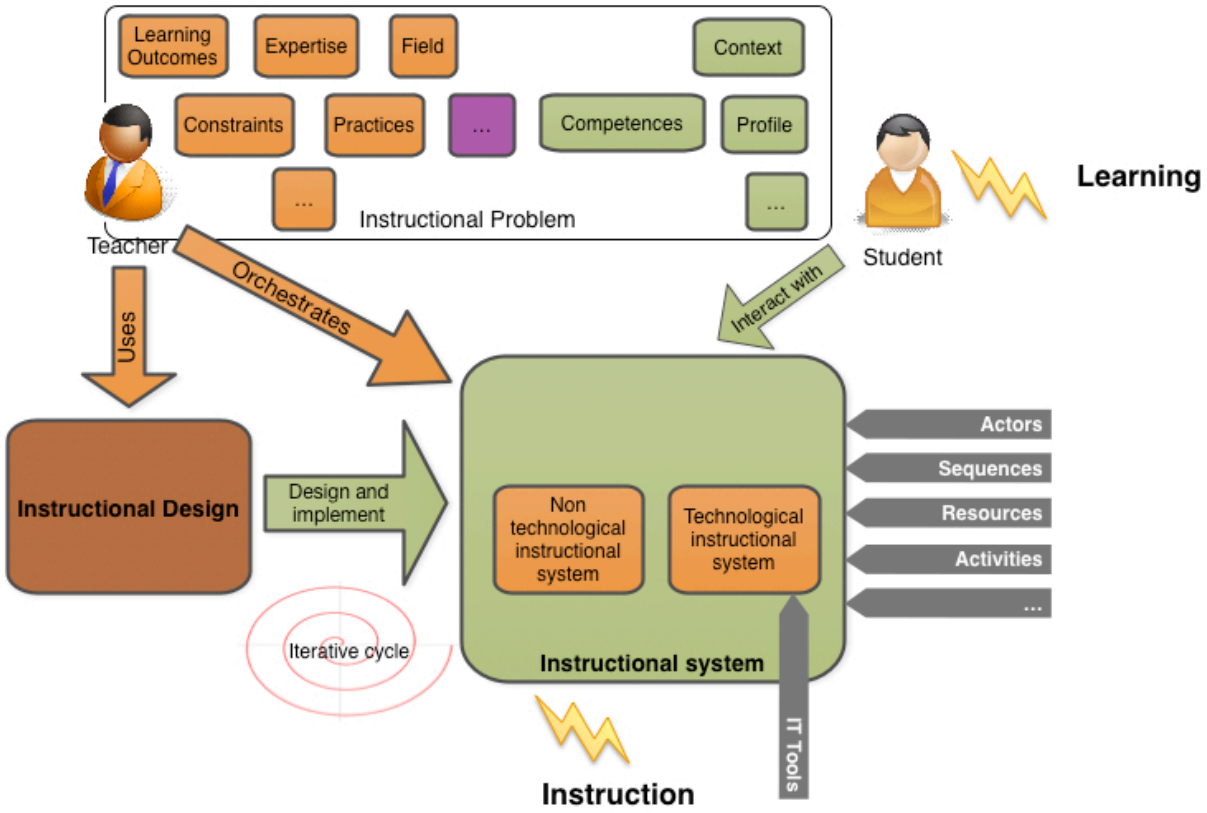


Fig. 1. Situating Instructional design

A review of literature has allowed synthesizing this complex domain. The concepts are described in the following paragraphs and pictured this into figure 2.

A designer uses an **Instructional Design Method** to organize the design of an instructional system in order to solve an ID problem. The ID Method defines a process, models and/or tools used during this process.

The ID method applies an **Instructional Design Model**, which proposes a structure and a meaning to a specific ID problem. According to [5] an ID model provides a procedural framework for the systematic production of instruction and incorporates elements of the ID process and may be used in different contexts. It prescribes how combination of instructional strategy components should be integrated to produce a course of instruction. According to [6] "*the role of models in Instructional Development is to: provide us with conceptual and communication tools that we can use to visualize, direct and manage processes for generating episodes of guided learning; allow us to view both the linear and concurrent aspects of instructional development; and to allow us to select or develop appropriate operational tools*".

An ID model refers to an **ID theory**. The theory explains phenomena, focuses on the ways to attain learning goals and "*offers explicit guidance on how to better help people learn and develop*" [7].

Instructional methods are principles and methods used for instruction. They rest on an **instructional model**. The choice of an instructional method depends on the ID theory.

Learning theories inform on the process of how human learn. Learning theories consider the variables that influence the learning process and provide explanations on how this influence occurs. Learning theory serves as the bridge between research and education [8]. It helps to define educational frameworks, which define the principles through which the theory can be applied to learning and teaching practices.

2.3 Instructional Designers' Practices and Tools

Several authors [9,10,11,12,5] have examined how ID designers work. Observations show that many designers do not work in the linear process proposed by common ID models.

Approaches marrying prototyping, zigzagging, top-down and bottom-up design are commonly practiced and instructional designers exploit problem solving and decision-making skills [13].

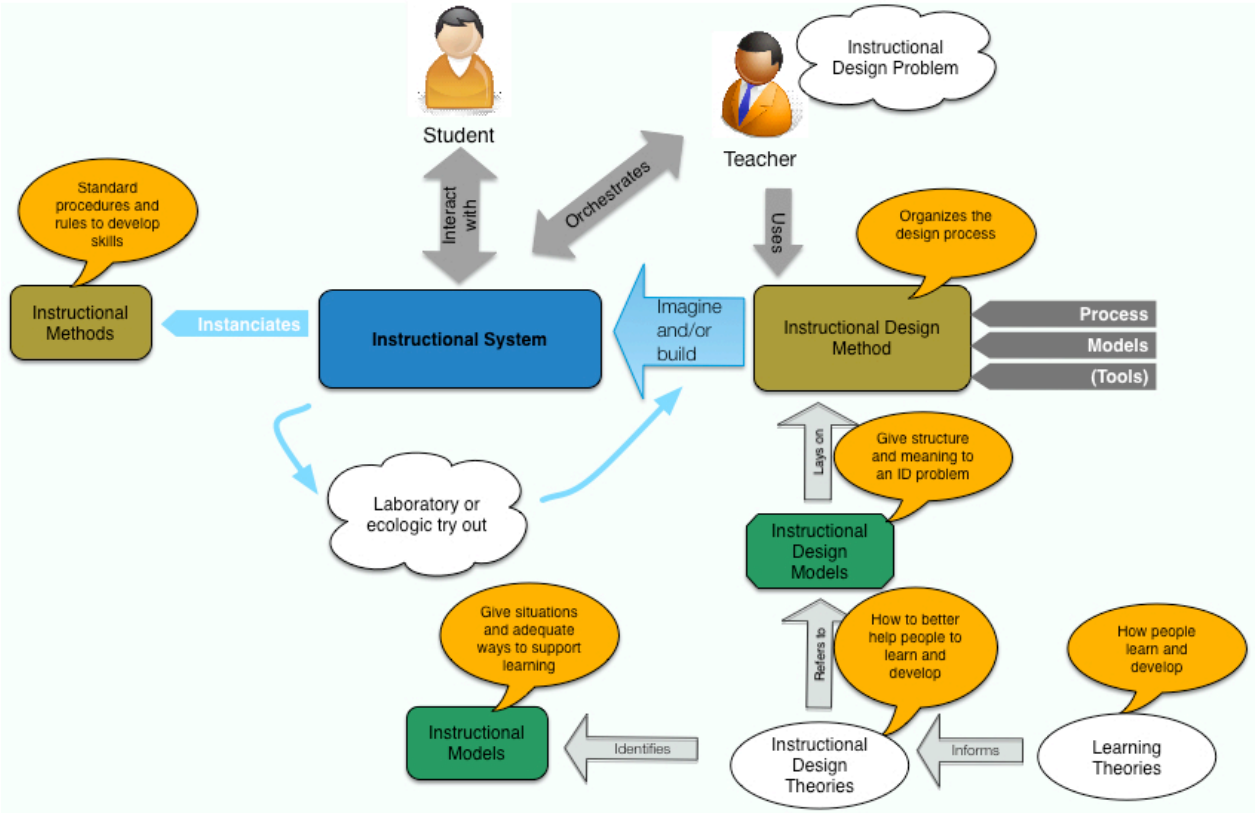


Fig. 2. Concepts of Instructional Design

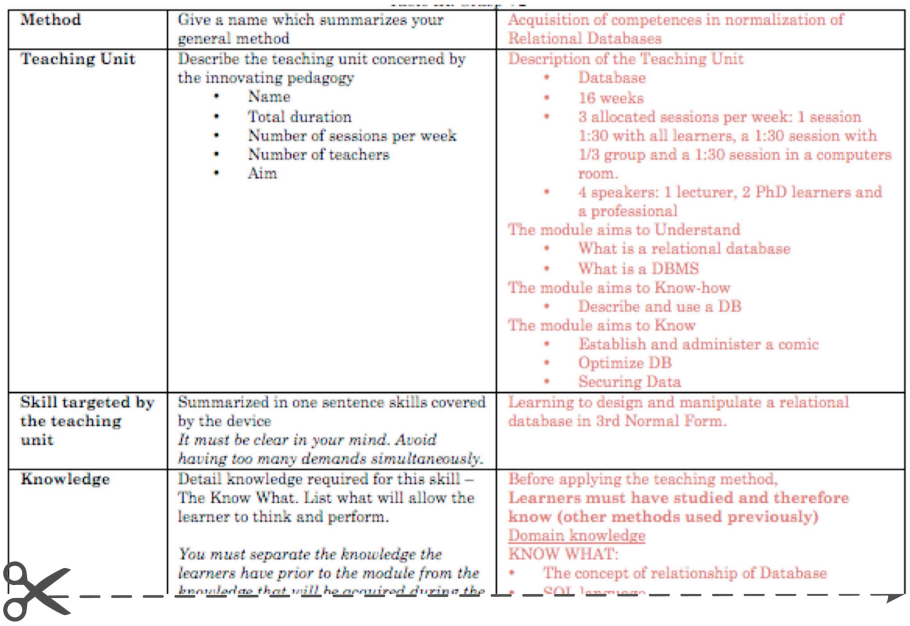
Rowland [11] observes that while designers refer to ID model by applying some suggested activities they often omit one or more activities for reasons such as lack of time and the fact that they are considered as unnecessary. According to [14] designers use three different approaches to design and implement instructional systems: (1) designs based on instructional theory, (2) designs based on best practices and (3) designs based on patterns in best practices. Concerning the use of tools to support the design process, they are used at different moments and under different forms. Van Merriënboer and Martens [12] describe a range of ID tools: (1) pre-authoring systems that support needs assessment or the whole analysis and design process before a final medium selection is made, (2) systems for the selection of methods and media and (3) systems for supporting the implementation and evaluation of instructional systems after the instruction has been developed.

2.4 Instructional Design Models

An **Instructional Design Model** provides a procedural framework for the systematic production of instruction. It incorporates elements of the ID process and may be used in different contexts [5]. The model prescribes how combinations of instructional strategy components should be integrated to produce instruction.

A model of Instructional Design focuses on different components and strategies [3]. Needs analysis and strategic planning are still one of the most important areas of ID and Instructional Systems development today. In 1980, Andrews and Goodson [15] already announced more than 40 ID models. The most often cited ID model is ADDIE (Analyze, Design, Develop, Implement and Evaluate) even if according to Molenda [16], the ADDIE model is rather to be seen as a family of procedural and systematic ID models.

A constructive approach of ID views it as the preparation of resources and learning processes in order to facilitate students learning in a constructivist approach. Rather than emphasizing predetermined design steps, the constructive approach focuses on the iterative development and implementation of learning environments offering opportunities for inquiry and discovery learning [3]. The family of constructivist instructional models offers an approach closely related to complex problem solving.



Method	Give a name which summarizes your general method	Acquisition of competences in normalization of Relational Databases
Teaching Unit	Describe the teaching unit concerned by the innovating pedagogy • Name • Total duration • Number of sessions per week • Number of teachers • Aim	Description of the Teaching Unit • Database • 16 weeks • 3 allocated sessions per week: 1 session 1:30 with all learners, a 1:30 session with 1/3 group and a 1:30 session in a computers room. • 4 speakers: 1 lecturer, 2 PhD learners and a professional The module aims to Understand • What is a relational database • What is a DBMS The module aims to Know-how • Describe and use a DB The module aims to Know • Establish and administer a comic • Optimize DB • Securing Data
Skill targeted by the teaching unit	Summarized in one sentence skills covered by the device *It must be clear in your mind. Avoid having too many demands simultaneously.*	Learning to design and manipulate a relational database in 3rd Normal Form.
Knowledge	Detail knowledge required for this skill – The Know What. List what will allow the learner to think and perform. *You must separate the knowledge the learners have prior to the module from the knowledge that will be acquired during the*	Before applying the teaching method, **Learners must have studied and therefore know (other methods used previously)** Domain knowledge KNOW WHAT: • The concept of relationship of Database • SQL language

Fig. 3. Extract from GRASP 2.0

It shares the approach with the areas of architecture, design engineering, graphic design, and other fields of design with a larger place to creativity [17,18]. This family favors rapid prototyping [19] after a succinct needs analysis.

3 The GRASP tool (textual version)

The GRASP tool offers a support to designers in the instructional design process for the development of innovative pedagogical environments. The work was based on the observation that the teachers are ready to change their systems but need help and do not want to perform a too long process. The design of the tool has followed a prototypal approach in 4 steps (1) stating the problem defining the context and aim, (2) inspecting learning theories and the ID domain, (3) developing a tool (in a textual version) and (4) evaluating it. An iterative application of these steps results in the production of the GRASP V1.0 and GRASP 2.0 grids and their evaluation. GRASP 1.0 was evaluated by three teachers. The aim was to test the feasibility of using this tool in an academic environment. Another evaluation tested the validity and usability of GRASP V2.0 with 15 teachers from various fields. An evaluator was at the side of each teacher to answer possible questions and to make choices explicit according to the explicitation interview [20]. The detail of these evaluations modalities is available in [1].

3.1 GRASP 2.0 (second version)

GRASP is a grid divided in three parts. Teachers must fill successive cells to answer questions. The instructional system is designed through three main steps (the three parts of the grid). The first part focuses on target skills (the Intended Learning Outcomes). In the second part teachers define their educational context and constraints. The third part is dedicated to the design choices: role of the teacher, resources for the learners, type of process, etc. Teachers build their teaching scenario. Here follows an extract from GRASP 2.0 (figure 3 - in red an example concerning an instructional system dedicated to database management learning that can help the teacher)

3.2 Evaluation Results and opened perspectives

The evaluations [1] showed that GRASP interests teachers and that they don't notice difficulties in using this tool. Teachers have designed instructional systems implementing more active forms of pedagogies and have become aware of the need to assess differently.

An interesting point of the evaluation was the discovery that the interaction between the teacher and the evaluator has promoted confrontation of ideas. This confrontation was favorable to questioning the old methods and moving towards a more innovative education, which better fits the needs of students and teachers.

Several teachers asked when they should use a computerized version of the tool. But this computerization may take various forms: from a simple grid to an intelligent assistance tool. The question is what form of assistance would be the best. This paper tries to give elements to answer this question. To design and implement the tool we are currently applying a prototypal design process. It first implies an analysis and design of the computer-based tool, called CB-GRASP (Computer-Based GRid bASed Pedagogical design).

4 Toward a computerized version of GRASP

It is usual to establish a definition of requirements during the specification phase of a project. The content of this document structure the activities by defining clear orientations for the work to be done. In order to be clear with the finalities of the project, this section presents the specific context of the work obtained from different evaluations and literature.

4.1 Requirements Analysis

The aim of the project is to produce a computer-based GRASP tool to help teachers/designers during the analysis and design of instructional systems.

4.1.1 Scope of the tool

During evaluations of GRASP, teachers explained that they essentially need assistance during the analysis and design phase. The analysis is the process of gathering data to identify specific needs — the *Who, What, Where, When, and Why* of the design process. The design Phase takes the information compiled from the analysis phase and builds an instructional system definition. The tool concentrates on this problematic and consequently, the development, implementation and evaluation phases are not the scope of our current work.

As Van Merrinboër et al. [12] noted, "*The field of ID tools has been dominated, and still is dominated, by authoring tools for the development or production of computer-based instruction… But until now, there has been less interest in computer-based ID tools that support the analysis and design activities that are undertaken before a final medium selection is made and the instruction, which may be not computer-based, is actually produced*".

The tool concentrates on the analysis and design phases of the instructional design lifecycle.

4.1.2 Instructional design process

The analysis and design process must reflect natural practices of designers. These practices depend from individuals and experience. Studies show that, often, the designers do not act according to a linear process. Many designers explore the solution while specifying the problem and expert designers realize cycles of try-out and improvement [10]. For example, constraints are rarely identified during the first analysis step but are rather introduced at every step of the process [21].

We want to favor cyclical approaches allowing designers to navigate in the tool according to their internal process of creativity. However, the tool should offer best practices to guide them.

4.1.3 Personalization

Gustafson [21] notes that it is important that the tool could be configured to be adapted to user needs. The acceptance of a tool is correlated to its usability, which depends from the fact that we are taking the user's profile and practices into consideration.

The tool will offer the ability to adapt to different design approaches.

4.1.4 Assistance modalities

The evaluation showed that designers appreciate to interact with the evaluator to solve their instructional problem. This interaction has fostered the understanding of their problem and has favored their creativity. The aim is not to develop an authoring tool or an expert system but to produce good advices thanks to relevant questioning**.**

We want to develop a tool that offers mechanisms to foster the creativity of designers. The tool must ask relevant questions and offer advices in accordance with their problem.

4.1.5 Instructional problem

GRASP has been built according to the constructive alignment theory [22]. This theory favors in-depth approaches in which pedagogy should focus on critical thought, dialogue and discussion. Thus, the training situation should suggest questions to students, who, by finding the responses, acquire additional experience and new skills. Teachers must create situations that force them to carry out a task, produce something or solve a problem. Some instructional methods can be found in [1,23].*We will favor social constructivist theories but other theories are acceptable.*

4.2 Design phase

4.2.1 Mock-ups realization

The design phase started with the realization of mock-ups respecting the requirement identified in the analysis phase. They are designed in a real will to respect each teacher's design process.

Some mock-ups (figure 4) illustrate the philosophy, notably the free navigation in the tool. The homepage has been designed in order to allow a free navigation. Designers can navigate between the different activities according to their preferences and even refine their choices.

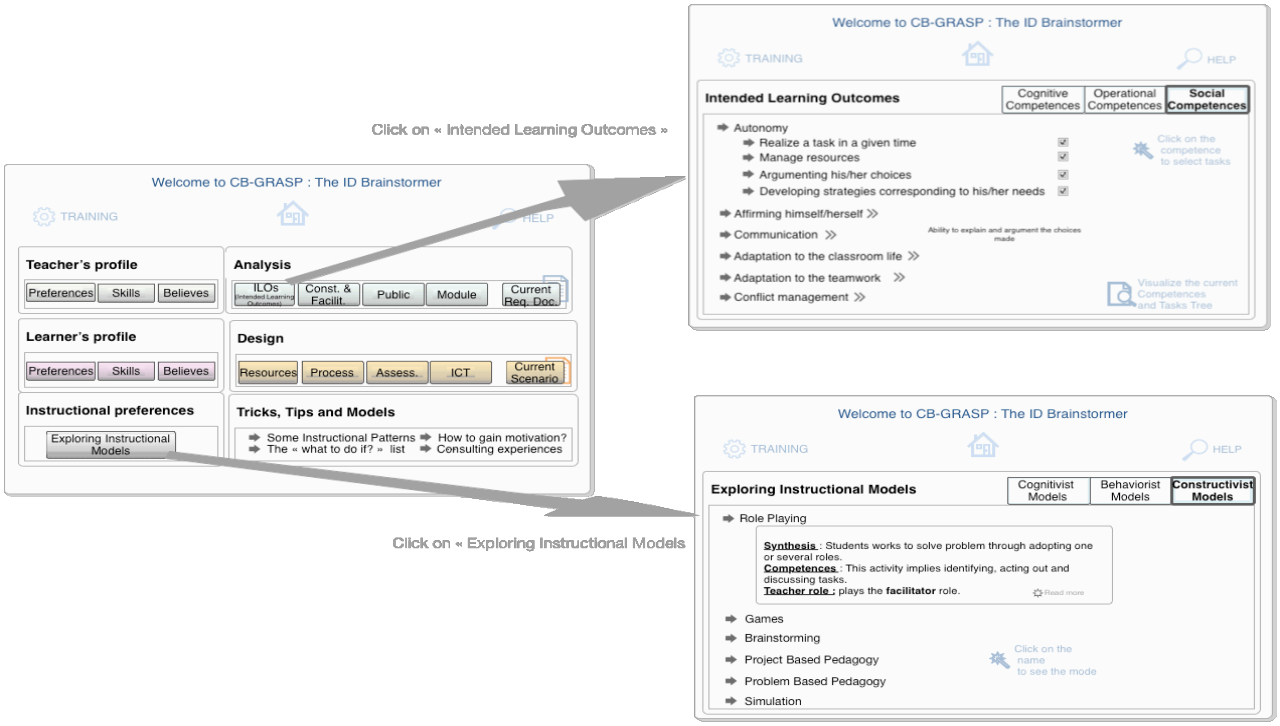


Fig. 4. Some CB-GRASP Mock-ups

On the main page, the "Help" button offers information on the tool functionalities. The "Training" button gives access to a page that offers explanations about the design approach and the tool. It describes each button and the navigation modalities in each window. The "ILOs" button leads to a page that offers three tabs: each tab corresponds to a type of know-how (operational, cognitive and social know-how). In each tab, teachers can navigate in a competences model. They can select specific know-hows they want to develop. Each competence is linked to a set of tasks that are likely to develop this competence. Teachers can input know-hows that are not provided in the tool. This may be the case of operational know-hows that are specific to the instructional field.

All selections and data entering are stored. The teachers can click on the current requirement document or the current scenario to download a document that synthetizes all elements that have been already informed.

The teacher's profile and learner's profile definitions help to structure the learning context. Each button of these profile definitions leads to a page where designers navigate in trees and select elements.

The "Tricks, tips and models" space allows the elaboration of solutions after an exploration of these elements. The "Exploring instructional models" page helps teachers to imagine and build the instructional system. During the exploration, designers can select items and visualize their specificities.

4.2.2 Mock-ups evaluation

The current phase of work concerns the evaluation of the mocks-ups in order to improve the effectiveness of their design. There is a strong desire that the evaluation begins in the early stages of the tool production. An iterative design model is preferred through a practice of a user-centered design. The approach emphasizes analysis of teachers' tasks and activities in order to reflect how they actually work. So, all actions and comments made by the teachers about mock-ups will be observed and analyzed.

In order to validate acceptation by teachers, a focus will be made on the concept of usability. The ability of the tool to really assist the teacher during the implementation of an instructional environment will be evaluated. The main question is 'is it relevant for teachers to easily achieve their objectives?'. The evaluation must so insist on the quality of interface (ergonomics): structuring, information presentation, etc. The questions are: 'Is the design environment easy to use?', 'Is it easy to learn?', 'Is it comfortable?', 'Is it flexible?', 'Is it error-free?'.

In order not to miss any functionalities of the system, a focus will be made on the concept of utility. The assessment should

ensure that the tool really checks the specifications described in section 4.1.

In order to improve the ergonomics of the tool, we will implement an already tried and tested method. It was practiced by one of the authors who is specialized in software ergonomics for the modernization of a control room and has involved field operators. The aim of this method is to exploit users' needs to correct and build the final mock-ups. This method will concern teachers (the same teachers as those who were implied in the evaluation of GRASP 2.0). These 15 teachers will define, according to a specific process, the layout of the tool that would help them to develop an IT-supported learning environment. The activity that will be asked to them will be: "*imagine and draw the tool that should facilitate your design work*". Designers will have access to the GRASP grid version. They will also have access to models of mock-ups (of unrelated fields). Production time will be limited to one hour. There will be two groups of teachers. A group will work after a pre-visualization of the designed mock-ups (figure 4). Another group will work without this support. We will compare the results and will cross them with questionnaires filled in by the designers before and after the work on mock-ups.

The results of this work will be merged in order to produce the second version of mock-ups. Then, a second human-centered evaluation will be done before to undertake the production of the operational tool. During the implementation of the tool, traditional methods of quality control will be implemented and then, before the distribution of CB-GRASP, user satisfaction studies and critical incident detection will be performed.

5 Conclusion and Perspectives

In this paper, we have presented the instructional design domain and the GRASP tool. We propose to produce a computer-supported tool to better help teachers to design pedagogical environments adapted to their context. For this purpose, we have defined the requirements and elaborated mock-ups to highlight the principles of CB-GRASP, a computerized version of GRASP. The current phase is the mock-ups evaluation phase. 15 teachers are implicated in the evaluation-design cycle of suited mock-ups. The next phases of our work will be the architecture definition and the iterative development of the computerized tool; they will be described in other papers.

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