A MODEL&SUPPORT TOOL FOR MODELING THE COMPUTER-BASED/e-INSTRUCTIONAL PROCESS

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ABSTRACT
While in psychology instruction appears as a binder and an intersection between conscience, activity and personality structures, in didactics, at individual level, instruction is conceived as a bi-dimensional activity that involves both teaching and learning. The internal dichotomy of this activity has lead during history to learning theories (in psychological plan, concerning the learner) and to teaching techniques, models and methods - as embryos of instructional theories (in didactics plan, one considers ab initio that here both teaching and learning are concerned). This unity between teaching and learning is axiomatic in didactics. In this paper, we present both a model and a correspondent support tool that offers support for the actors involved in each stage of the instructional process in a Computer-Based Instructional (CBI) environment. It provides for the pre-requisites settling, for definition of the instruction objectives that correspond to a given syllabus, for analysis of the factors that influence the instruction process, for design of an appropriate didactic strategy, and finally for evaluation of the characteristics and results of this process. Some capabilities of this integrated tool can provide (semi-) automated support for some parts of the traditional instructional process.

KEYWORDS
Instructional process, instruction objectives, instruction variables, didactic strategy, instruction evaluation, design of computer-based/e-instructional process, instructional system.

INTRODUCTION

Education seems to be one of the most effervescent domains of social activity during the last decades all over the world. There is an impressive fan of endeavors, projects, ideas and solutions to organize education, having in one extreme a strict Skinnerian conditioning and in the other a society without an institutionalized education. Computer-based/online (CBI/e-) instruction emerges as a more and more important part of the educational process, no matter if it is self-made or within a (virtual) classroom. It provides for the construction of educational systems organically integrated in global social systems in the Information Society.

We present here a model and a support tool (called DIP) that offers support for the actors involved in each stage of the instructional process (IP) in a CBI/e- environment. It provides for pre-requisites settling, for definition of the instruction objectives that correspond to a given syllabus, for analysis of the factors that influence IP, for design of an appropriate didactic strategy, and finally for evaluation of the characteristics and results of this process. Some capabilities of this integrated tool can provide (semi-)automated support for some parts of the traditional IP. DIP implements an extended instruction design model. The extension concerns the part related to the CBI and online instruction issues.

DESIGN OF INSTRUCTION IS A DIFFICULT TASK

When the teacher is supposed to design a segment of the instructional process, as a lesson or a lessons' system, he or she has to solve a big dilemma. Despite de fact that the syllabus indicates the content of the discipline to be taught and that one can use some materials about teaching methods, design of instruction is still quite a hard task (Noveanu et al., 1983). On the one hand, design of instruction is more than being aware of the teaching methods. It is concerned also with learning theories, problematic of objectives, of evaluation, of socio-pedagogic aspects of instruction and so on. When designing from a behaviorist/cognitivist stance, the designer analyzes the situation and sets a goal. Individual tasks are broken down and learning objectives are developed. Evaluation consists of determining whether the criteria for the objectives have been met. In this approach, the designer decides what is important for the learner to know and attempts to transfer that knowledge to the learner. The learning package is somewhat of a closed system, since although it may allow for some branching and remediation, the learner is still confined to the designer's world. To design from a constructivist approach requires that the designer produce a teaching and learning product that is much more facilitative in nature than prescriptive. The content is not pre-specified, the learner determines the studying direction and assessment is much more subjective because it does not depend on specific quantitative/qualitative criteria, but rather the process and self-evaluation of the learner himself/herself (Newmann, 2001).

On the other hand, the lack of precision of some of the actual syllabuses induces various interpretations and, as a consequence, different positions against the expected results of instruction. As a result, if we consider different objectives, the adopted strategy will be different too. If we would ask to 10 mathematics teachers to describe what their aims is when they teach the Real Numbers module, we would probably get about 10 different answers, despite the fact that they are supposed to follow the same syllabus indications. These are only few arguments for the need to use tools that can guide and help teachers to better define and build their lesson plans inside of an open CBI/e- environment.

INSTRUCTIONAL THEORIES AND DESIGN MODELS

Knowledge is a fabric of relations in which one individual is fundamentally entwined with all others in a collective discourse. Models help us to better understand and make sense of our world. They provide their users means to comprehend an otherwise incomprehensible problem. An Instructional Design (ID) model gives structure and meaning to an instructional problem, enabling the would-be designer to negotiate her/his design task with a semblance of conscious understanding. Models help us in this case also to visualize the problem, to break it down into discrete, manageable units (Vladoiu et al., 1997, Ryder 2002).

Instruction is dichotomous in pedagogic plan: first, it can be seen as investigation object, and secondly as design object. In the former case, the outcome of our action is a descriptive model for instruction, as this can be done because of observing the real phenomenon. In the latter one, the outcome is a model built in accordance with some parameters that can be starting point to realization of instruction designs on various hierarchical levels. Despite the fact that the dichotomy is obvious, here appears the principle problem with most methodological implications. Instruction can be the object of study for many sciences, sociology, psychology, cybernetics, linguistics etc., each one of these having its own conceptual structure and methodology. This means that the achieved results in instruction investigation, from the point of view of each of these sciences, will be expressed in concepts proper to that particular science and not for didactics. Thus it becomes clear the need that the whole ensemble of concepts, both for instruction as an investigation object and for it seen as a design object, to be in the same reference framework, the one of didactics.

The internal dichotomy of instructional activity, teaching on the one hand and learning on the other, has led during history to theories *of learning* in psychological plan, for the processes that take place in learner's mind, and to *theories of instruction* in didactic plan, considering ab initio that here both teaching and learning are concerned (Noveanu et al., 1983). Therefore, one can say that unity between teaching and learning is axiomatic in didactics. Specialists in learning psychology stress out also that this unity is necessary.

Instructional Design is a part of the development of a larger Instructional System (IS). Design typically forms the first step when developing a complete instructional system. It also represents the first step in any subsequent re-design of a system. Instructional Design results in a "blueprint" for an educational application (EA), ready for development into a completed package. The "blueprint" consists of the named EA, lists of content resources, assumptions that limit the range/scope of the EA, knowledge and skills to be taught, the set of pinpointed behaviors necessary and relevant to the knowledge and skills to be taught, and the set of named units and modules, with each module containing a set of one or more behavioral objectives, each objective tagged and classified by learning category (Eshlemann, 2000).

There is a lot of literature on ID models. A simple keyword search using <google> search engine produces a 20 pages document that contains sites that refer to this subject. A similar search in a classic library produces tens of similar references. We find similar results searching for theories of learning and instruction: there are around 50 such theories (Hoffman, 2003). ID models try to provide a link between learning theories and the practice of building ISs (Gros, 1997). There are two classes of ID models: prescriptive (objective, behaviorist, and modern) and phenomenological (cognitivist, constructivist, postmodern). First ones are based on observable and measurable changes in behavior, while the latter ones are user-centered, i.e. they deal with user mental models and his/her own (constructed) perspective of the world. Prescriptive models are easier to be “implemented” in instructional systems both in classical and electronic form, still CBI/e- environments provide for the construction of real phenomenological instructional systems.

While in learning psychology, the unity connects teaching and learning at individual level, didactics, especially in CBI/e- environments, is concerned with both social dimensions of teaching and learning process: individual and group level. This unity vision leads to the next methodological position: diverse factors influence learning according to it. The factors that influence instruction processes can be grouped as follows (Noveanu et al., 1983):

M (environment)	**E** (learner)	**Pr** (program)	**P** (teacher)	**I** (interaction)	**R** (results)
socio-economic	age, sex	objective	age, sex		progress
Geographic	level	methods	education	learner – learning situation	capabilities
ethno-linguistic	motivation	means	experience		evolution
…	familial	specificity	personality		personality
	…	…	…	…	…

For computer-based instruction, we could add aspects related to the e-environment as:
hardware/software basic resources, multimedia classrooms, distribution channels, computer user profile, CBI/e- packages, instructional approach (presentation, tutorial, simulation, quizzes, net conferencing, virtual reality etc.) and so on.

The above variables (M, E, Pr, P, I, C) influence the group R variables,
inter-connect and inter-condition one to another, and generate variable and complex interaction moments (Loveless, 2001). The way in which variables (that fusion in program progress specific interaction) concretize here, demonstrate the built-in unity between teaching and learning. That is why this interaction is a core idea for instruction theories, regardless they are classical or computer-based oriented.

OBJECTIVES OF INSTRUCTION

There are some prerequisites for the correct operationalization of the instruction objectives. The teacher must have deep knowledge about educational objective taxonomies in order to attach the types of behavior to the corresponding content elements. He or she has to deal also with hierarchical levels of educational objectives to understand the way objectives derive and subordinate to each other. Defining objectives represents the heart of the ID process. If we define the right objectives, and write them properly, subsequent design and development will proceed smoothly. Otherwise, development may encounter various delays (Eshlemann, 2000).

1. Levels of objective formulation

First, let us compare three objectives: a multilateral education for better integration in Information Society, achievement of basic scientific, technical and cultural knowledge in main domains of human knowledge, by systematically studying of the correspondent discipline and the indication of selection control structures in Java programming language. One quick look is enough to see that first objective is on the highest level of generality, as opposed to the last one, which is very concrete. That shows what levels of objective formulation is concerned with. We present here an operational scheme of objective derivation in Romanian Education that is a part of a complex analysis of this education [Fig. 1] (Radu, 1991).

2. Classification of objectives

After the study of a certain chapter from a discipline, as we are supposed to develop the assessment test, we can use different items: knowledge (retrieval of memorized information) items, comprehension items, application items etc. That means that for the same content segment we can formulate as expected results of instruction, therefore as objectives, different behaviors. As pedagogical thinking has evolved, it has emerged the need for classifying the set of the specific objectives from the last level. Taxonomies of educational objectives, starting with Bloom's, have constituted a starting point for classification of objectives, either they are cognitive, affective or psychomotor. Taxonomical movment has influenced also the design of instruction guided by objectives. Nowadays pedagogy by objectives seems to be a system in which the analysis of objectives determinate the ensemble of functions that constitute the core of the pedagogical action.

Below we can see a bi-dimensional synthesis of objective classification: horizontally we have the domains of human personality (cognitive, affective, psychomotor) and vertically the hierarchy of human capabilities involved in each domain. For developing this pyramid, authors used the most complete (extendable as needed) taxonomical systems: Bloom for cognitive domain, Krathwohl for affective domain, and Simpson for psychomotor domain [Fig. 2].

3. Operationalization of objectives

In didactic practice, we need to know how to achieve operational objectives, i.e. objectives that describe observable behaviors that can be measured. In the current stage of pedagogical theory and practice evolution, the teacher cannot use a set of tools that provide operational definitions for the objectives of the discipline to be taught, despite the fact that syllabuses already contain some first level objectives. The teacher can use though, for the types of behaviors that will be attached to content elements, the general objectives and methodical indications for instruction design from the syllabus.

Classification of objectives and, in particular, operationalization of objectives generates several advantages for the evaluation and instruction (Noveanu et al., 1983):

- Level definition of objectives provide for a more clearer image of expected results, both horizontally and vertically;
- From this multi-level image, one can see easier the relations between different levels, or inside of the same level. This can reveal perfectible parts from syllabi and curricula;
- Operational objectives eliminate ambiguities and constitute valuable indications for ID;
- Operational objectives can be the starting point to elaborate assessment tools and they can be seen as an evaluation criterion for the achieved results.

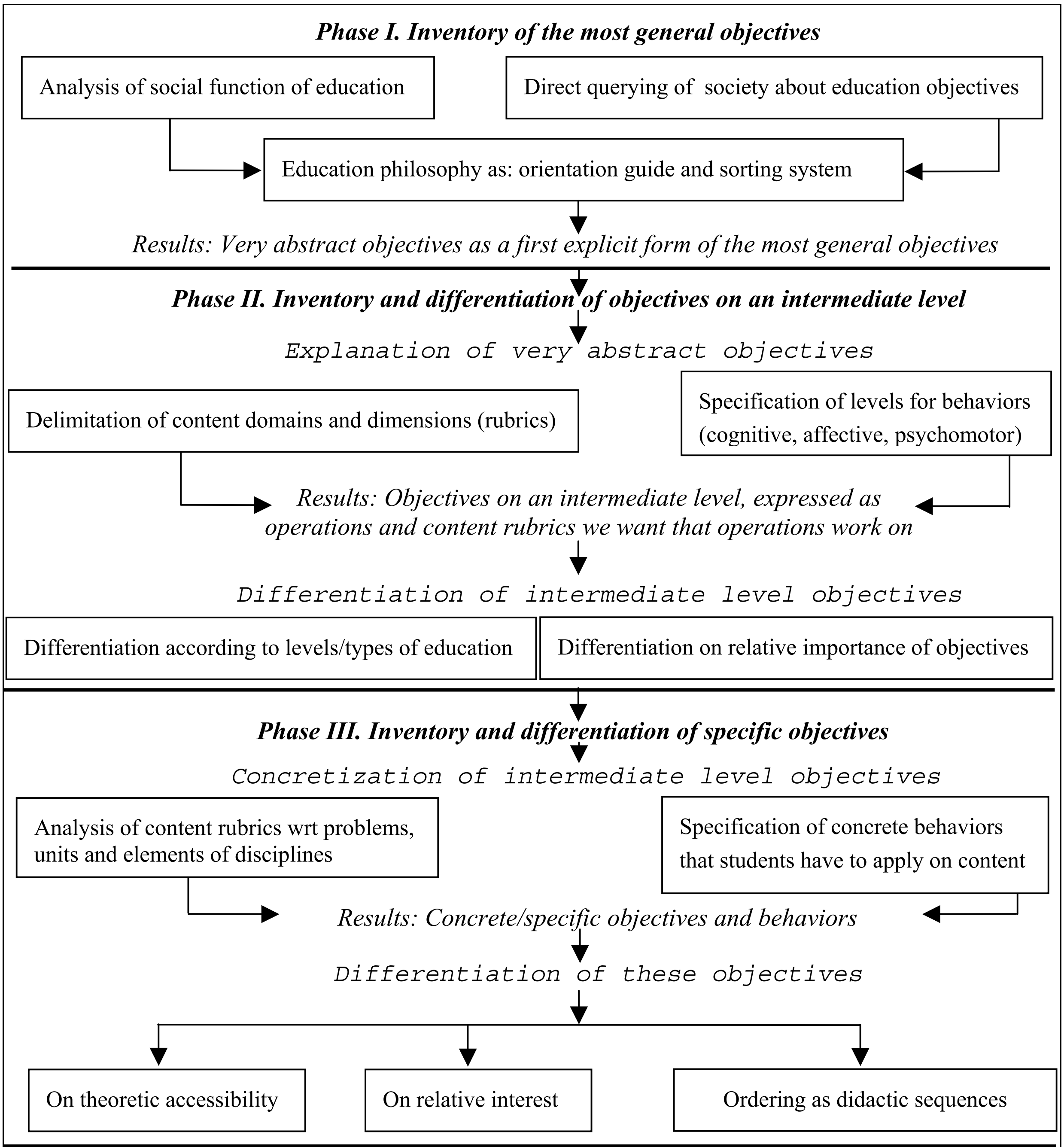

Figure 1. Objectives' derivation scheme

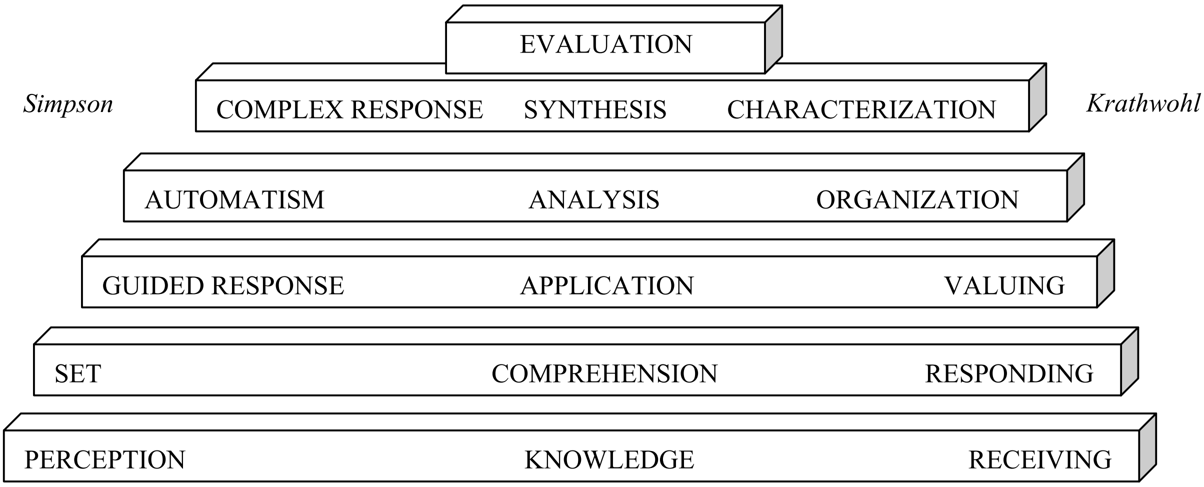

Figure 2. Synthesis of objectives' classification scheme

4. Some conceptual and methodological remarks

Although the educational process influences the overall development of students, the results they achieve while they try to reach objectives specified in syllabuses, represent a valuable indicator that can be used to appreciate the efficacy of this process. Of course, we must be aware of the following restrictions (Noveanu et al., 1983):

- There are objectives that cannot be operationalized or measured (e.g. human values);
- Causes of a particular performance are complex and cannot be assumed to be the result of only one study discipline;
- Most of the effects of the instructional-educational process are complex and they cannot be reduced to isolated performances.

Secondly, there is no consensus yet with respect to operationalization of objectives. Many specialists prefer observable and measurable behaviors as performance indicators, but there are some who consider competency as indicator of "potential performance" (Noveanu et al., 1983). In order to understand the pedagogic implications of these two positions, not only in assessment area, there is necessary a return to fundamental concepts, namely to rapports between finalities, goals, and objectives. Authors call finalities the main orientations of an education system (for instance, to have more IT specialists), goals define the type of person/society that is aimed (on education system level, they concretize in graduate profile), and by pedagogic objectives they express explicit formulations of expected modifications of students, because of their participation to the instruction process.

STEPS IN COMPUTER-BASED INSTRUCTIONAL DESIGN

Instructional design represents the first step in construction of ISs. Of course, the development of an IS assumes that some need for instruction has been determined. The principal inputs to the design phase include either a contract agreed upon with a client for whom the system will be produced, an assignment or work order, or a decision to create an EA "on spec." Without any of these decisions being made, little reason would exist to begin designing and developing EAs. Note that an EA developed "on spec" typically means one developed for potential general use. In that case, the end-product becomes available "off the shelf" (Eshlemann, 2000).

Main steps in design of CBI/e- process that we propose are establishment of pre-requisites, syllabus development, definition of instruction objectives, analysis of instruction variables, design of didactic strategy, and, finally, evaluation of IP [Fig. 3].

Establishment of pre-requisites: Naming an EA "gets matters up and going" (Eshlemann, 2000). Along with stating an appropriate name (according to the topic) for an EA, a designer should also assign a version number to it, and the starting date. At approximately the same time as a decision has been made to proceed with designing a system, the designer should obtain or specify some figure, or range of figures, pertaining to how much financial resources are available. One needs to cover costs and to stay within budget during development. The financial resources available will determine the size, range, scope, and complexity of the EA to be designed. The financial resources will also affect decisions about adding various special features to the EA, such as graphics, animations, videos, computer-based modules, and so on. Thus, at this stage, the designer should have in hand a financial statement or estimate.

Determining content resources, references, and available human expertise represents also a research step in ID. A designer may or may not be a content expert. If not, then one needs to begin research into the topic area(s) designated in the naming step. The content of an EA represents the "raw material" for use in both design and development. In this step, the designer should amass all necessary and appropriate books, articles, documents, manuals, photographs, drawings, flowcharts, graphs, computer files, website URLs, and so on (Ryder, 2002). One may wish to conduct library research, as well. This may reveal additional materials that could be put to use. The designer should also draft a list of references. Finally, a designer should either have in hand, or write up, a list of names of people who can be contacted as content experts. The output of this step includes: assemblage and storage of content resource materials, a references list or bibliography, and a list of names of people who are available as content experts (Eshlemann, 2000).

Further on the designer should identify knowledge topics and skills to be taught. Note that this identification process represents an ongoing task all throughout the design process. It may even continue into the development phase, if necessary. To reduce costs, one should focus effort and attention on precisely identifying the pertinent knowledge and skills. The end product of this phase consists of a list or outline of knowledge topics and relevant skills. One should probably tag the listed topics and skills as verbal or nonverbal behaviors, or a combination of both (one can use a simple coding system for doing this (Eshlemann, 2000)).

At the same time or immediately after the previous step, a designer should specify two sets of assumptions: about the people in the target audience for the EA, and about prerequisite knowledge and skills that most, if not all, learners should be expected to have upon encountering the EA. Clearly defining these assumptions will help place needed limits on the EA, and thus on the plan, range, and scope of subsequent EA development.

After the designer clarifies all the aspects that concern resources, knowledge and audience, one is able to determine which is the right content for the EA that is under development. He or she can also determine some future evolutions of the content in order to keep it up-to-date.

Pinpointing represents a process of identifying and stating active verbs that describe behavior and performance, and which pass Lindsley's "Dead Man's Test"(Eshlemann, 2000). Pinpointing relevant behaviors that demonstrate skilled performance marks the last step before defining objectives. In the pinpointing step, one should observe actual learners and consider context and conditions under which the behavior occurs along with measuring behavior. Focus must be on pinpointing behavior, using active behavior verbs. For instance, instead of noting that a learner can "state" something, note whether the learner "says" something, or "writes" something, or "points to" something, and so on. The more active and specific the action verb you select, the better the pinpointing becomes. The output of this sub-step is a list with the identified skills and their associated (sequence of) behavior(s) verbs. In the same context the behaviour/learning input/output channels issue should be considered. The "inputs" typically involve the five senses, which can be described behaviorally. These are seeing, hearing, touching, sniffing, and tasting. In some cases the "input" may have no particular sense and have the freedom to occur at any rate of response (Ryder, 2002). In those cases the "inputs" are "free." The "outputs" are the pinpoint verbs that have been selected in the previous step.

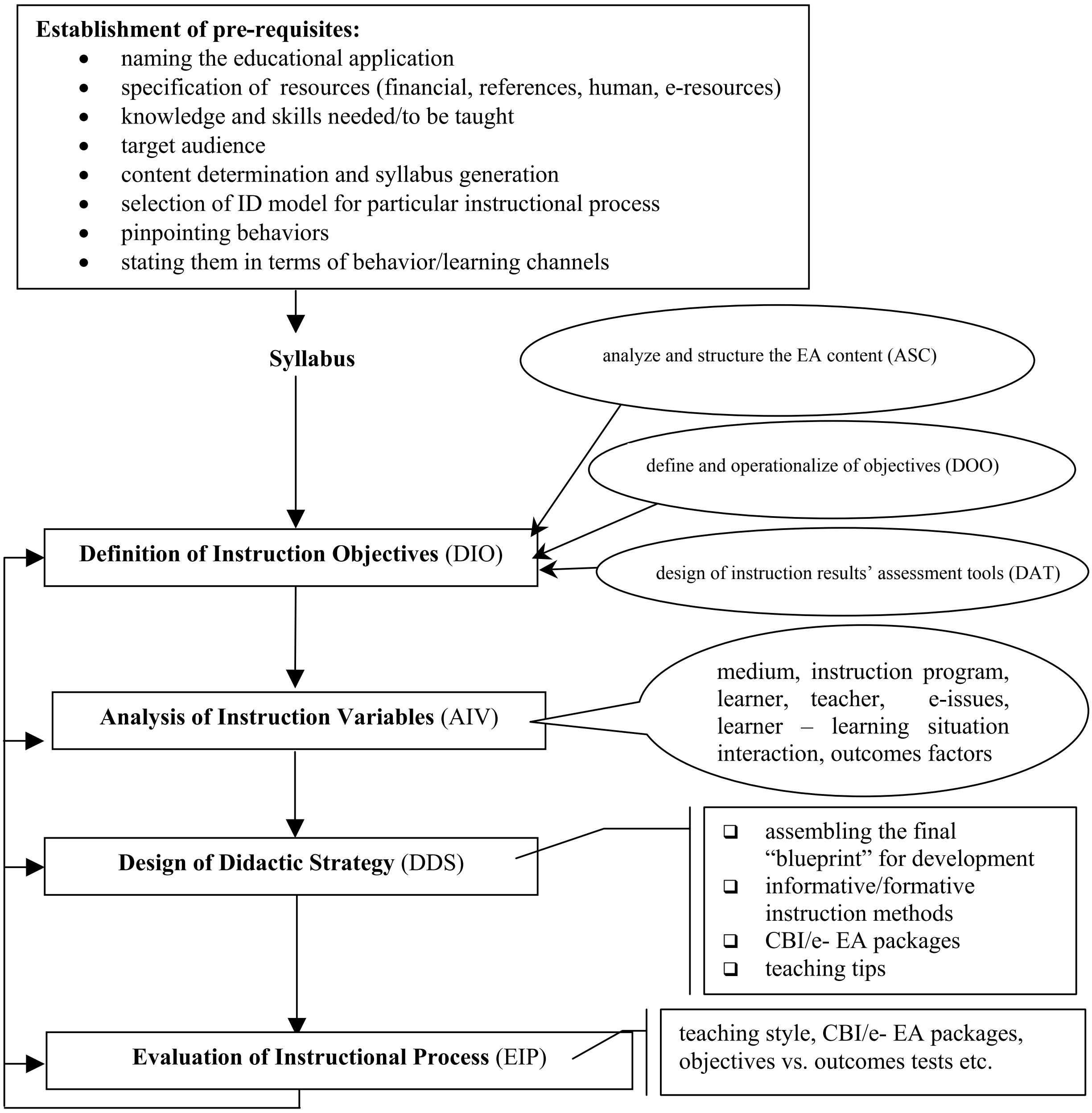

Figure 3. Design of CBI/e- Instructional Process

In the same step, the designer must choose the right ID model according to the particular IP and to generate the appropriate *syllabus*. Next, it comes the first major phase of the instructional process: definition of instruction objectives. This stage deals with analysing and structuring the content of EA, with defining and operationalizing the objectives (along with their grouping in modules of instruction) and with the design of ID results assessment tools (e.g. for presumed effects, products and efficiency etc.).

The *definition and operationalization of objectives* represents the heart of the ID process. If we define them properly, subsequent design and development will proceed smoothly.
The designer must not use a specific taxonomy. One should be able to differentiate between information

and modalities to operate with achieved information (intellectual capabilities). The designer is also supposed to be able to discriminate various such modalities.

The starting point for design of evaluation tools for instruction results is the content of the discipline along with the operational objectives. The designer must keep in mind that the behaviors' ensemble checked by a test must reflect the objective structure. One can use a bi-dimensional specification table that has two components: content units and behaviour classes. These are weighted according to their relative importance within objectives' ensemble. Before designing any instructional strategy, the designer must analyse the concrete situation (factors, conditions) in which the IP will take place, as described by the *instruction variables* presented in a previous paragraph. Sometime, when a factor differs very much from its "normal" range, there are necessary rectifications of content and objectives.

Didactic strategy can be seen as an ensemble of decisions concerning the education-instruction process that must be made in order to reach the proposed objectives under the concrete conditions. The same strategy can lead to different instruction models and one such model can be implemented differently by one teacher or another. Confronted with the set of elements to be considered in designing a strategy, the designer has to settle some milestones: assembling the final "blueprint" for instruction development, what types of objectives must be achieved and what is relevant in learning psychology for these. The difference between achieving information and operate with it leads to different ways (methods) to learn them. There are two classes of such methods: informative (lecture, observation, excursion, visit, conversation, demonstration, dialogue, explanation, narration) and formative (learning through discovery, problem solving, experimenting, programmed instruction, algorithmization).

For CBI/e- environments one should decide also what is the correspondent CBI/e- method (presentation, tutorial, simulation, quizzes, virtual reality etc.) taking into consideration that in such environments we have enhanced opportunities. After choosing one method or another (and the related instructional materials) the designer must plan the instruction events, specifying the activities (along with their correspondent mental operations) to be carried on and the moment for testing activities. *Evaluation of the instructional process* (didactic action) is concerned with aspects as teaching behaviour analysis, CBI/e- packages issues, quality and relevance of tests and so on. The teaching style can be analysed using several systems from Flanders' Interaction Analysis System for verbal interaction [Noveanu et al., 1983, Eshlemann, 2000] to polyvalent tools that try to capture the complexity of educational phenomenon on different levels (communicational, pedagogic behaviors, and cognitive content). Different kinds of teachers can be revealed: pro-active, reactive or ultra-reactive.

DIP: A TOOL FOR MODELING THE COMPUTER-BASED INSTRUCTIONAL PROCESS

DIP offers support for the actors involved in each stage of the CBI/e- process according to the model and methodology presented in the previous section. It provides for the pre-requisites establishment, definition of the behavior objectives that correspond to a given syllabus, analysis of the factors that influence the CBI/e- process, design of an appropriate didactic strategy, and finally for evaluation of the characteristics and results of this process (various evaluation tests). Some capabilities of this integrated tool can provide (semi-)automated support for some parts of the traditional instructional process. DIP implements an extended prescriptive ID model. The extension concerns the part related to the computer-based and online instruction issues.

The software package that implements DIP in Java 2 (SUN), under JBuilder5 from Borland, is quite simple and small sized. It has a main project <DIP.jpr> and several sub-projects: <Pre.jpr>, <Syllabus.jpr>, <DIO_ASC.jpr>, <DIO_DOO.jpr>, etc. They correspond to, respectively, settling of pre-requisites for CBI/e- process, to preparation of the syllabus, to analysis and structuring of course content, to definition and operationalization of instruction objectives and so on. The graphical interface is simple and suggestive.

We present below some sample screens from DIP. In the former (Fig. 4), the designer can choose the appropriate words (subject, active verbs, direct object etc.) along with verb learning channel and classifying tags (Eshlemann, 2000) to build an appropriate instruction objective. In the latter, we exemplify the specification table for evaluation of objectives versus outcomes with an example from physics (Noveanu et al., 1983) because when one studies this discipline one can follow and get a big diversity of learning results. The two complementary tendencies of physics development as science, experiment and mathematical approaches, must reflect on didactic plan as well. The presented example has as the teaching and learning subject: *specific heat and calorimetry*. In the later table (Fig. 5), we have in the first column the content units and in the header the behavior classes. On the rows, there are presented the number of objectives that correspond to one specific content unit and to one behavior class. In the last row and column, respectively, there are inserted the weights for the units and classes, according to their relative importance in the ensemble of the objectives. The sum of the item values on each row/column, in rapport with the total number of items, must be approximately equal with the correspondent percent.

CONCLUSIONS

In this paper, we presented a model for the design of the CBI/e- instructional process. The model proposed here is behaviorist and cognitive at the same time. When designing from a behaviorist/cognitivist stance, the designer analyzes the situation and sets a goal. Individual tasks are broken down and learning objectives are developed. Evaluation consists of determining whether the criteria for the objectives have been met. In this approach, the designer decides what is important for the learner to know and attempts to transfer that knowledge to the learner. The learning package is somewhat of a closed system, since although it may allow for some branching and remediation, the learner is still confined to the designer's "world"(Newmann, 2001).

The principal output of the instructional design process, as described here, is a "blueprint" for subsequent development of the course. The "blueprint" consists of all of the outputs and materials produced and assembled in this phase, as listed above. An instructional systems "blueprint" should be as precise as possible. It should express and match the learning needs of the organization or group for whom it was designed. It should consist of behavioral pinpoints specified to the most appropriate, relevant, and useful level. It should have behavioral objectives written using both the specified pinpoints and the learning channels matrix. In addition, it should have a precise, discrete nomination of modules, units, and course(s) (Eshlemann, 2000). With an effective and useful "blueprint" at hand, one can proceed to the next major phase of the instructional process: development of an instructional system.

To design from a constructivist approach requires that the designer produces a product that is much more facilitative in nature than prescriptive. The content is not pre-specified, direction is determined by the learner and assessment is much more subjective because it does not depend on specific quantitative criteria, but rather the process and self-evaluation of the learner. The standard pencil-and-paper tests of mastery learning are not used in constructive design; instead, evaluation is based on notes, early drafts, final products and journals.

The proposed model takes into consideration partially the characteristics of the CBI/e- environment. In order to benefit more from this enhanced environment (hypermedia, virtual reality), in the future we intend to add more constructivist elements to it. Constructivism promotes a more open-ended learning experience where the methods and results of learning are not easily measured and can be personalized. Cognitivism may act as a bridge between behaviorist and constructivist aspects of CBI/e- process. It can also provide for enhancing ID with reflective learning elements.

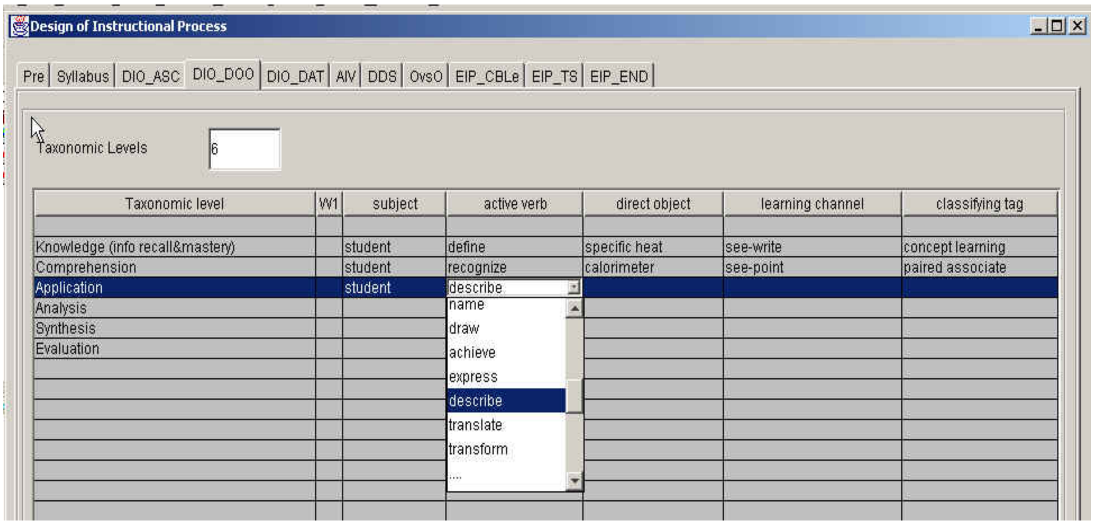

Figure 4. Definition and operationalization of instruction objectives

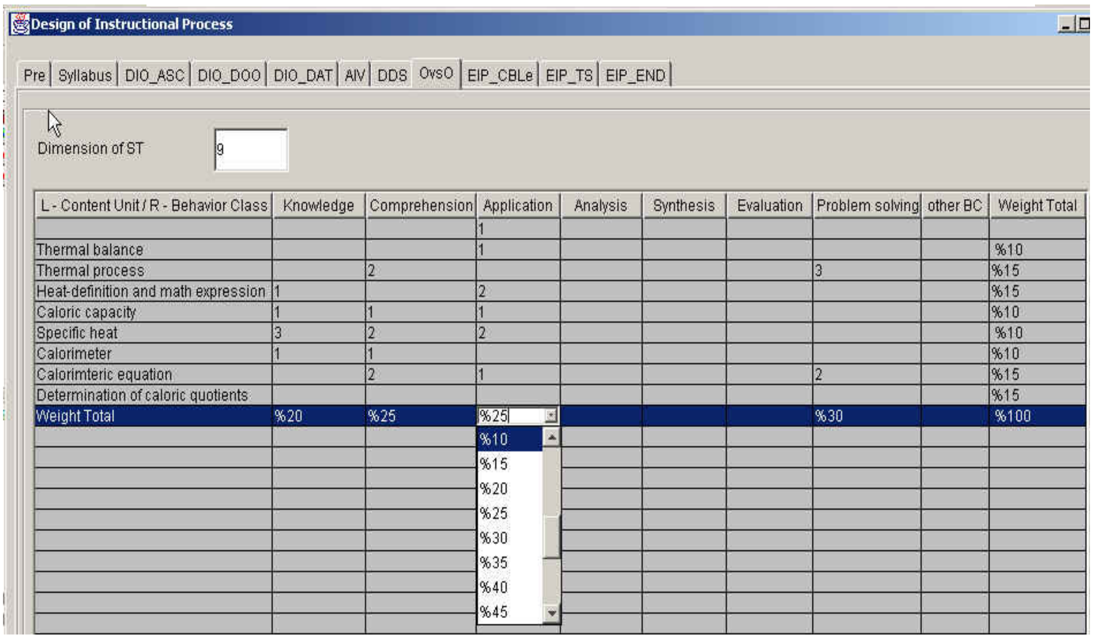

Figure 5. Specification table for evaluation of objectives vs. outcomes

Besides adding constructivist features to the proposed model, other future work directions will be improving and enhancing it by adding methods for information management.

The information can be modeled as digital learning objects that can be embedded in educational archives that reside in a global worldwide digital library. A prototype tool, called DIP has been developed in order to demonstrate that the proposed model is easy to use. The goal of this tool is to provide support for all the features of the model and its future extensions. For the time being, this prototype tool concentrates strictly on functionality. This is ongoing work, so more features will be added to DIP along with the evolution of the built-in model. Equally, we think to improve the functionality and the user friendliness of the features that have been already implemented. As a conclusion, we would like to point out that despite the fact that we can consider instruction (education) as being a science, it has an important creative part that cannot be modeled or automatized. Support tools can only help teachers to improve their activity on the never-ending way to knowledge.

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