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ABSTRACT

Human resource development (HRD) specialists are searching for instructional design models that accommodate e-learning platforms. Van Merrienboer proposed the four-component instructional design model (4C/ID model) for competency-based education. The model's basic message is that well-designed learning environments can always be described in terms of the following interrelated blueprint components: (1) learning tasks (concrete, authentic "whole-task experiences") that are provided to learners; (2) supportive information (information that is supportive to the learning and performance of nonroutine aspects of learning tasks such as reasoning and problem solving); (3) just-in-time information (information that is prerequisite to the learning and performance of routine aspects of learning tasks); and (4) part-task exercise (additional exercises for routine aspects of learning tasks requiring a high level of automaticity). The components of the 4C/ID model can be identified in almost all blueprints of integrated learning, including integrated e-learning, and they are particularly well suited to case-based and project-based approaches to instruction and combinations of the two approaches. Cases can be constructed by carefully analyzing how professionals work as they perform tasks or solve problems. The range of project-centered learning is based on the following dimensions: (1) authenticity of the problem; (2) extent of control; and (3) level of implementation. (MN)

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# A Design Methodology For Complex (E)-Learning

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*Complex cognitive tasks that must be performed by humans because they require flexible problem solving behavior are becoming increasingly important. The basic message of the 4C/ID-model that is introduced is that environments for complex learning can always be described in terms of four interrelated blueprint components. These components are based on the four categories of learning processes that are central to complex learning: learning tasks, supportive information, just-in-time information and part-task practice.*

Keywords: Instructional Design, Competency-bases Learning, Complex Learning

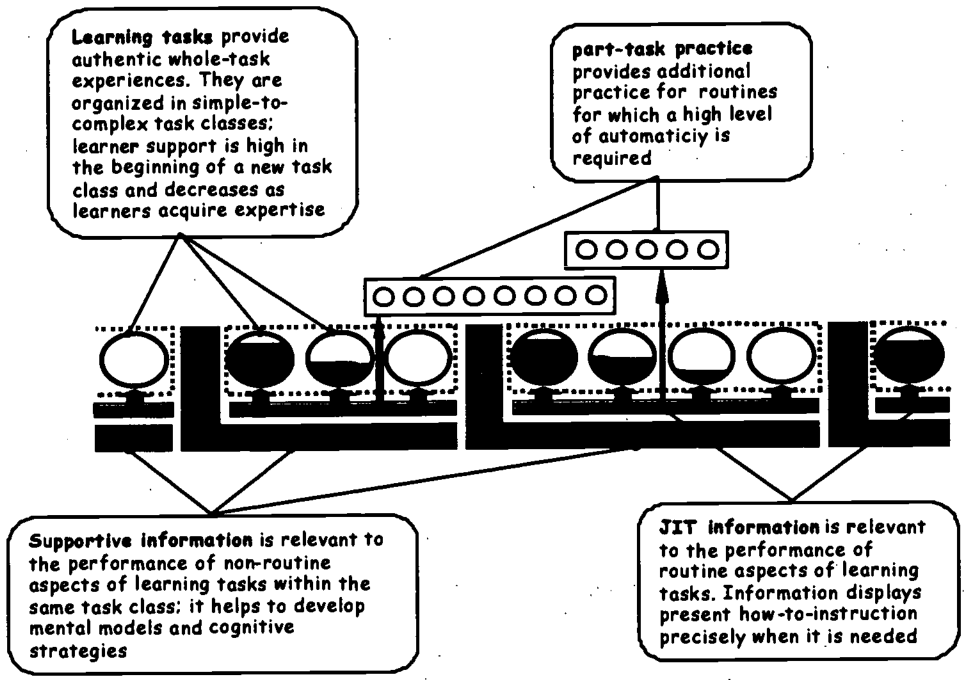
Instructional design is a bit like an aging ocean liner – huge, slow, ponderous and requiring large amounts of energy and a great deal of time to move it even one degree off its traditional track. Despite extraordinary recent advances in research on learning, particularly from the newer cognitive theories, mainstream instructional design models remain largely unchanged.

While most design models have not evolved over time, HRD specialists in business and contemporary educators are searching for models that accommodate novel and complex delivery vehicles such as newer media and Internet/Intranet platforms. The modern context in which design is employed is in constant flux. Business and educational institutions are concerned with the need to proactively accommodate rapid and intricate, systemic changes. Most businesses have recognized the need to capture complex expertise and rapidly transfer it within and between organizations and communities. Current approaches to handling change emphasize the need to identify the knowledge and performance competencies required to close gaps between future social and organizational goals, on the one hand, and the current status of organizational and worker performance, on the other hand. The need for design systems that can be used to close complex, interrelated performance gaps caused by the need for complex, interrelated knowledge structures and strategies, are largely unmet by most current models.

The growing importance of distance learning in business, government and schools also contributes to the urgency of change. The knowledge required to support the continued success of organizations is complex and changing quickly over short periods of time. These changes will continue to place demands on the human resource specialists charged with providing the design systems that support the training, development and performance of workers. Adequate design models must flexibly adjust to advances in our understanding about how to draw on cognitive research on expertise and learning, and incorporate it effectively and efficiently into evolving instructional design theories.

Van Merrienboer (1997) introduced the four-component instructional design model (4C/ID-model), which is a design methodology for competence-based education. The basic message of the model is that well-designed learning environments can always be described in terms of four interrelated blueprint components: (1) *learning tasks*: concrete, authentic "whole-task experiences" that are provided to learners; (2) *supportive information*: information that is supportive to the learning and performance of non-routine aspects of learning tasks, such as reasoning and problem solving; (3) *just-in-time information*: information that is prerequisite to the learning and performance of routine aspects of learning tasks, and (4) *part-task practice*: additional exercises for routine aspects of learning tasks for which a high level of automaticity is required. The interrelationships between the four components are depicted in Figure 1. Each of the four components will be briefly discussed in the following sections.

*Figure 1. The four components of the 4C/ID model*




## Learning Tasks

A sequence of learning tasks is the backbone of every course. The learning tasks are typically performed in a real or simulated task environment and provide "whole-task practice": ideally, they confront the learners with all aspects of the whole complex skill. However, it is clearly impossible to provide highly complex learning tasks right from the start of a course. Therefore, learners will typically start their work on relatively simple learning tasks and progress towards more complex tasks. Task classes are used to define simple-to-complex categories of learning tasks and to steer the process of selection and development of suitable learning tasks. The learning tasks within a particular task class are equivalent in the sense that the tasks can be performed on the basis of the same body of knowledge, but they are different from each other on the dimensions that also vary in the real world (i.e., they show a high variability; see Paas & van Merriënboer, 1994). A more complex task class requires more knowledge or more elaboration of knowledge for effective performance (cf. Elaboration Theory; Reigeluth, 1999). The basic idea is to use a whole-task approach where the first task class refers to the simplest version of whole tasks that experts encounter in the real world. For increasingly more complex task classes the assumptions that simplify task performance are relaxed. The final task class represents all tasks, including the most complex ones that experts encounter in the real world.

While there is no increasing complexity for the learning tasks within one task class, they do differ with regard to the amount of support provided to learners. Much support is given for learning tasks early in a task class, and no support is given for the final learning task in a task class. This process of diminishing support as learners acquire more expertise is called "scaffolding". It is repeated for each subsequent task class, yielding a sawtooth pattern of support throughout the whole course program. Support can take the form of product-oriented or process-oriented support. For product-oriented support, part of the solution is provided to the learners as part of the learning task. For instance, one might ask students to study a case or to complete a partial solution – activities that clearly provide more support than independent problem solving. With process-oriented support, the learners are guided through the problem solving process. For instance, one may require students to successfully complete one problem solving phase before continuing to the next phase, or present them with "process worksheets" – lists of leading questions that guide them through a systematic process.

**Supportive Information**

Obviously, learners need information in order to work fruitfully on non-routine aspects of learning tasks and to genuinely learn from those tasks. This supportive information provides the bridge between what learners already know and their work on the learning tasks. It is the information that teachers typically call "the theory" and which is often presented in study books and lectures. Because the same body of general knowledge underlies all learning tasks in the same task class, and because it is not known beforehand which knowledge is precisely needed to successfully perform a particular learning task, supportive information is not coupled to individual learning tasks but to task classes. The supportive information for each subsequent task class is an addition to or an elaboration of the previous information, allowing the learners to do things that could not be done before.

Supportive information relates to mental models (describing how the world is organized in a particular domain) and cognitive strategies (describing how to effectively approach problems in this domain). The supportive information concerning mental models may contain both general, abstract knowledge and concrete cases that exemplify this knowledge, so that it allows for both abstract and case-based reasoning. Conceptual models (what is this?) focus on how "things" are interrelated and allow for the classification or description of objects, events or activities; structural models (how is this organized?) describe how plans for reaching particular goals are related to each other, and causal models (how does this work?) focus on how principles affect each other and help to interpret processes, give explanations for events and make predictions. Cognitive_strategies also contain general, abstract knowledge and concrete cases that exemplify this knowledge. The general, abstract knowledge typically takes the form of a Systematic Approach to Problem Solving (SAP), describing the successive phases in a problem solving process and the rules-of-thumb or heuristics that may be helpful to successfully complete each of the phases. The concrete cases may refer to an expert who is performing a non-trivial task and simultaneously explaining why he is doing what he is doing (e.g., by thinking-aloud).

**Just-In-Time Information**

Whereas supportive information pertains to the non-routine aspects of a complex skill, just-in-time (JIT) information pertains to the routine aspects, that is, sub skills that are performed after the course program in a highly similar way over different problem situations. JIT information provides learners with the step-by-step knowledge ("how-to-instruction") they need to know in order to perform the routines. They can be in the form of, for example, directions teachers or tutors typically give to their learners during practice, acting as an "assistant looking over your shoulder" (ALOYS) or the procedural steps provided by an Electronic Performance Support System (EPSS). Because the JIT information is identical for many learning tasks, which all require the same routines, it is typically provided during the first learning task for which it is relevant. For subsequent learning tasks, JIT information quickly fades away as the learners gain more expertise (a principle called fading).

JIT information is organized in small units, called information displays. Organization in small units is considered to be essential because only the presentation of relatively small amounts of new information at the same time can prevent processing overload. Information displays include a didactical specification of the procedures that describe correct performance as well as the knowledge that is prerequisite to a correct application of those procedures. For instance, a procedure may state that "in order to start the machine, you must first switch it on" and also indicate that the on/off-switch is located on the back of the machine (i.e., a fact that is prerequisite to a correct application of the procedure). If necessary, the general information may be illustrated by demonstrations of procedures (e.g., a teacher demonstrating how the switch on the machine) and/or instances of concepts (e.g., a photograph of the machine showing the location of the on/off-switch).

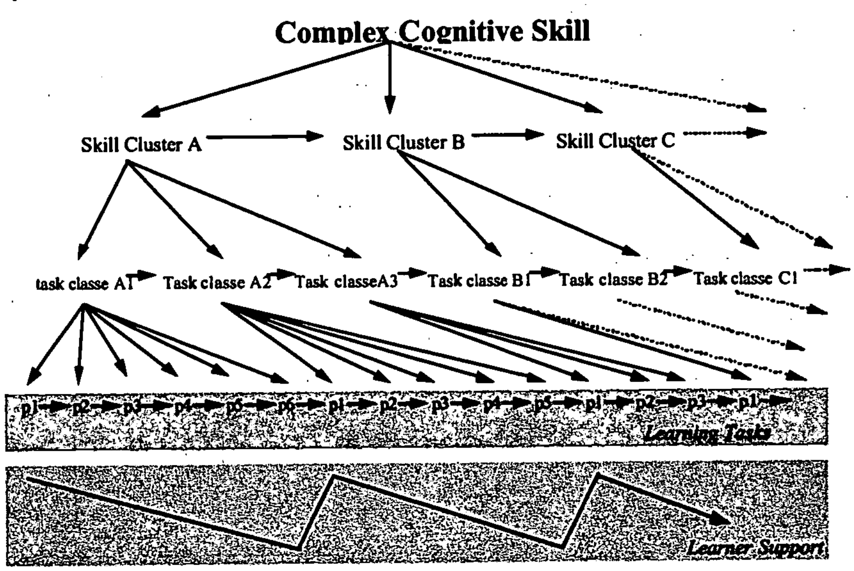
**Part-Task Practice**

Often, learning tasks provide enough opportunity to practice both the non-routine and routine aspects of a to-be-acquired skill. However, if a high level of automaticity of particular routine aspects is required the learning tasks may provide insufficient repetition. Then, it is necessary to include additional part-task practice for those selected routine aspects in the course program. Well-known examples of part-task practice are letting children drill on multiplication tables, playing scales on musical instruments, or training medical students in reanimation techniques. In course design, part-task practice may be applied for routines that (1) are critical in terms of safety, (2) enable the performance of many other skills, or (3) are performed simultaneously to many other skills.

It is critical to start part-task practice within an appropriate "cognitive context" because it has been found to be effective only after exposure to a simple version of the whole complex skill (see van Merrienboer, 1997). One should thus identify the first task class for which performance of the routine aspect is required, and initiate part-task practice during this task class, preferably after learning tasks with ample learner support have already been worked on. This allows learners to identify the activities that are required to integrate the routine aspect in the learning tasks. Extensive amounts of over learning may be necessary to make the routine fully automatic.

Complex learning is always involved with integrated sets of learning goals, or, multiple objectives. It has little to do with reaching separate objectives, but it is foremost dealing with learning to coordinate and integrate objectives in real-life task performance. Thus, in complex learning the whole is clearly more than the sum of its parts because it also includes the ability to coordinate and integrate those parts. The model pays attention to the integration and coordination of constituent skills (skill clusters), and concurrently promotes schema construction for non-recurrent aspects and rule automation for recurrent aspects of the complex target skill (figure 2). By doing so, it aims at transfer of learning – the ability to apply the complex skill in a wide variety of new real-life situations.

*Figure 1. Outline of the 4C/ID model*




### Didactical Models for Integrated (E)-Learning

The four components above can be identified in almost all blueprints of integrated learning, including blueprints for integrated e-learning. The learning tasks are in fact generic and can include for example cases, projects, problems etcetera. In this paper two examples of approaches are presented and the four components are explained in detail. The first example is a case based approach to integrated e-learning, the second approach is a project-centered approach.

### Case-Based Approaches

In case-based approaches of competency based education, cases function as the basic format of learning tasks. A case is defined as a complex real event (from the viewpoint of a professional) in which typical aspects or instances of professional task performance or professional problem solving can be observed. It can be used to offer students opportunities to learn or to get familiar with different faces of professional tasks. A case can be considered as a 'frozen experience', in the first place because students can observe, study, and analyse real problems in their natural context, but without time constraint. Second, learners are allowed to make other decisions, may make mistakes and learn from them: there are no dangerous consequences of mistakes, while at the same time the authenticity of the situation remains completely intact. Case-based learning is a powerful way of learning because it integrates various aspects of tasks in a significant learning context and because it offers excellent opportunities for learners to 'construct' tasks, look at professional problem solving, discuss the value of alternative approaches and solutions.

A case can be constructed by careful analysing how professionals work while carrying out tasks or solving problems. Construction is facilitated by searching for reasons to freeze the event, in time or in complexity. Once that one has found freezing possibilities, all the information that describes the context of the situation till the freezing point or event is documented for students' use. Students can build an idea of the situation. In combination with a clearly defined task students will try to find a solution for the problem or bring the task to an end. From that moment on the way the problem was solved in the case is no longer relevant for the case designer, nor for the student, who indeed has to take over problem solving. The case design enables the teacher-designer to present to the students enough information for sufficient analysis of the professional's problem and a clear learning task will challenge the student to solve the problem. Good case designs support the solving of the problem by providing the students the cognitive strategies and mental models used by professionals in these type of problem solving before they start the task. In the 4C-ID model this is called: 'supportive information'. Any factual information about procedures is during the learning task directly available in the learning environment.

An example of the translation of the four components of the instructional design model in the case- based approach is the following series of cases. The example stems fromthe experience of the Open University of the Netherlands.

Since 1998 the education of senior public administrators consists of a series of cases with which the students learn professional systematic approaches for the design of policy documents and for solving problems of policy making. Each of a series of 12 *learning tasks* is supported by four cases. Examples of these professional tasks, to be learned are analysis and preparation of policy decisions, design of policy documents, collecting documentation and anticipation of expected policy decisions. The learning tasks are made available on the course website. This website also serves as delivery medium for the case descriptions and it encloses a database of available case-sources. The *supportive information* consists of a methods-database, and a database with descriptions of all the theoretical principles, available in the domain. Both databases can be searched thematically or with help of a search engine. The *just-in-time information* consists of descriptions and concepts to be used in the particular case. Students' activities are monitored by tutor/teachers. By e-mail or in the discussion groups tutors give feedback on assignments. This system of competency based e-learning replaces traditional knowledge oriented learning in the faculty of Public Administration. Students evaluate this change as positive and more challenging.

**Project-Centered Approaches**

The project-centered learning approach is based on the 'learning by doing' assumption which means that students are actively involved- and responsible for their own learning process. In this approach students work systematically together on a 'project'. A project is defined as a unknown non routine problem which has to be solved. This problem has to be true to life and embedded in a social context. This is also referred to as authenticity.

The project-centered approach distinguishes several phases. All necessary activities are split up in logical steps and phases. On a certain moment in time students have to make decisions in a phase which have an impact on the following phase and the continuation of the project. Special attention has to be pay to control activities as time, money, quality, information, communication and organisation. The students work relatively independent as a group. The teacher monitors the learning process as a coach. Every phase is completed after an assessment of the process and/or relevant product.

In fact this approach links up with project based working methods which are common practice in business and industry these days.

The range of project centered learning is based on the following 3 dimensions:

- Authenticity of a problem: When a closer look is taken at the problem within the approach it is possible to define a gradation in the authenticity of a problem. Discerned are real problems which are related to existing problems in real life, and so called virtual problems which are a simulation of actual problems.
- Extend of control: The extend of control is based upon self control or external control. Self control means that the project members have a great deal of freedom in their way of working and can make a lot of decisions on their own. External control means for example that the phases are set by the coach and that the freedom to decide is limited to minor problems.

- Level of implementation: The project-centered learning approach is often used as an education model (for the sake of the curriculum), meaning that it is used as a model to integrate all different courses in one. Students work on one set of problems in different disciplines.
It is also possible to use this approach as a didactical model (as a working method in a single course). Students work together on one problem in one discipline.

An example of the translation of the four components of the instructional design model in the project-centered approach is the following: Students in business studies work together in a 'virtual' student company. In this company they have to produce and sale real products and run the comp any on the basis of investors (parents), stocks etc. The formulated problem is 'run the business for half a year, put theory into 'practice' and be as profitable as possible'. In our instructional design model this is *the learning task*. All the students get their own responsibilities formulated as roles. We discern for example a CEO, a financial planner, a marketing and sales man, a chief production and five employees. They can, while running their business, use different suggested readings on management, marketing, production etc. This theoretical knowledge is *supportive information*. During the project they can get for example just-in-time financial information on results on sales, budget, marketing. This is *just-in-time information*. In their roles students sometimes need training and practice in role specific skills like presentation skills for the sales man or calculating for the financial man. These are examples of *part-task practice*. The whole project is centered around a virtual e-learning environment which supports the project with supportive and just-in-time information and different tools to communicate and work together as a group. Computer Supported Collaborative Learning is a key issue when the project-centered learning approach is related to e-learning.

**Mixed Approaches**

When a closer look is taken at the differences and similarities between the two above mentioned approaches we see that it is possible to combine them. For example it is possible to work together in a group systematically on the solution for a virtual problem which happens to be a case. Or it is possible the learn case-based as a project team. We can even make it more complex if we integrate other approaches as competency based learning, dual learning or problem based learning. All approaches have a unique theoretical foundation which in practice is often combined with other approaches. This is very well possible because all approaches try to stimulate the transfer of learning by combining working and learning. All approaches also integrate tasks, learning and information in a specific context. It is not necessary to stick to the specific ground rules of every approach as long as we stick with our (e) learning initiative to the commonalties. The 4C/ID-model provides diverse guidelines and heuristics for the development of training programs for complex (e)-learning. It embodies an integration of theoretical developments and empirical results originating from a large number of research projects involved with the training of complex cognitive skills on a more traditional and electronic way.

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