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ID for Competency−based Learning: New Directions for Design, Delivery and Diagnosis

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Abstract

Currently, there is a clear trend towards competency−based learning. But Instructional Design models provide yet little guidance for the development of such competency−based instructional systems. It is argued that rich, realistic learning tasks are always at the heart of competency−based learning. From this starting point, nine directions for a new paradigm of Instructional Design are presented: Three directions pertain to the design of learning tasks; three directions pertain to the delivery of those tasks and learning resources in multimedia learning environments, and three directions pertain to the diagnosis of learners' progress.

ID for Competency−based Learning: New Directions for Design, Delivery and Diagnosis

Societal and technological developments go faster and faster. Routine tasks are taken over by machines. Knowledge is quickly becoming obsolete. And for those reasons, education has to focus more and more on complex cognition, which is best reflected in the ability to recognize new problems and to find creative solutions for solving them. If people show complex cognition in a particular domain or profession, we often call them competent in that particular domain. According to Keen (1992), competent performance refers to the ability to:

- Deal with non−routine and abstract work processes;
- handle decisions and responsibilities;
- operate in ill−defined and ever−changing environments;
- operate within expanding geographical and time horizons;
- understand dynamic systems, and
- work in groups.

This list is probably not exhaustive. Its elements are important features of so−called competencies − and due to technological and societal developments these things become more and more important in work settings. It should further be clear that these are characteristics of competencies, but not competencies themselves. Competencies are always bound to a particular domain or profession. They are, in fact, a mix of complex cognitive skills, interpersonal skills, and attitudes that allow someone to show competent behavior in a particular domain or profession. Simply said, competency−based learning aims at the development of such competencies. In order to design such education, we should develop a view on how competencies are represented in the human mind.

One perspective is that the ability to exhibit competent behavior in a particular domain depends upon the availability of a highly integrated network of complex cognitive and interpersonal skills, attitudes, and subordinate knowledge structures. Or, to use a popular term, a mental model that allows one to understand problems in a domain from different points of view and to act effectively in that domain according to the most promising perspective. A key aspect of competent behavior is the ability to co−ordinate the constituent skills involved, and to continuously use knowledge in order to recombine skills and attitudes in such a way that they are most helpful to dealing with a new situation. This is in line with Meaning Theory (Bartlett, 1932), in which creativity and problem solving are related to the ability to (mentally) restructure given situations in such a way that solutions can be tried, compared and (sometimes) found through combining the new situation with existing schemata in memory.

This view presents designers of instruction with a serious challenge. Nearly all theories that exist for the design of instruction apply some version of Gagné's Conditions of Learning (4th ed., 1985), stating that the optimal conditions for learning depend on the goal of the learning process. For example, repetition is a good condition for learning a simple motor skill, but not for learning problem solving; and modeling is a good condition for learning strategic approaches to problem solving, but not for learning plain facts. These theories assume that one can describe a subject matter domain in terms of learning goals, and can then develop instruction for each of the learning goals − taking the optimal conditions of learning for each goal into account. This may work well for a domain that is characterized by independent learning goals, but certainly not for developing competencies that are characterized by highly integrated, complex sets of learning goals.

Thus, we need a new paradigm for the design of instruction! We should acknowledge that lists of independent learning goals could never form the basis for competency−based learning. It might not even be a good idea to provide specific learning goals to students, because they will then focus on attaining each of the distinct learning goals and not on the co−ordination and integration of skills, knowledge and attitudes involved. Instead, the starting point for competency−based learning must on the one hand be a highly integrated network of learning goals that stresses the relationships between those goals, and on the other hand learner activities must be designed in such a way that they stimulate the construction of such a network. How to reach this?

The most promising model assumes that learners develop competencies on the basis of interacting with a series of different real events or, in educational settings, simulations of those real events. In competency−based learning, the learning tasks that are performed by the students can be situated in such a simulated task environment and provide the necessary (vicarious) experience. The design of learning tasks is thus at the heart of competency−based learning or a competency−based curriculum. Second, the learning tasks will be performed more and more in technology−enhanced learning environments, posing new requirements to delivery in multimedia environments. And finally, when realistic, rich tasks are the kernel of competency−based learning such tasks must also be used for testing and assessment, asking for new approaches to diagnosing learner progress.

To summarize this Introduction, future students will develop competencies in their domain of study by working on rich learning tasks in multimedia learning environments where assessments will be based on their complex performances (see also Kirschner, van Vilsteren, Hummel, & Wigman, 1996). The next three sections discuss the main instructional design questions that must be answered in order to be able to develop such environments: (1) how to design realistic learning tasks for complex learning to occur?, (2) how to deliver such tasks and resources in multimedia environments?, and (3) how to diagnose learners' progress on the basis of their complex task performances?

Design of Tasks for Complex Learning

Learning tasks that aim at the development of competencies involve complex learning. They must allow that the acquisition of cognitive and interpersonal skills and constituent skills, the construction of subordinate knowledge, and the formation of attitudes and values take place in a simultaneous, integrated process. It is precisely the integration and co−ordination of all aspects that characterize a competency which allows for transfer to new problems and new situations and for lifelong retention. Learning tasks may, for instance, refer to the analysis of case studies (as in the Harvard case−method); to working on problems in a particular domain (as in the Maastricht model of problem−based learning); to the design of some product or process (as in the Aalborg model of project−oriented learning), and so further. There are thus many types of learning tasks that may play a role in a competency−based curriculum. In the following subsections, three directions or challenges with regard to the design of learning tasks will be formulated (see top of Table 1). These are viewed as urgent goals that must be attained if it comes to the development of competency−based education:

- Unite the World of Knowledge and the World of Work in Learning
- Build Learner Support that Works
- Promote the Development of Higher−order Skills

Designing learning tasks for competency−based learning
1. Unite the World of Knowledge and the World of Work in Learning
2. Build Learner Support that Works
3. Promote the Development of Higher Order Skills
Delivering learning tasks and resources in multimedia learning environments
1. Develop Web−based Instruction that Makes a Difference
2. Defeat the Transfer Paradox
3. Make Students Work Together
Diagnosing learner progress incompetency−based learning systems
1. Provide Meaningful Feedback
2. Use Tests for Complex Performances
3. Assure the Quality of Competency−based Learning

1st Direction: Unite The World of Knowledge and the World of Work in Learning

The traditional approach to the design of learning tasks is pretty straightforward and familiar to most of us. It takes the World of Knowledge as a starting point (van Merriënboer & Kirschner, in press). A particular discipline or subject matter domain is analyzed and ordered. Methods for domain analysis, subject matter analysis and task analysis are used to make this process more efficient. The main output of the process is a highly structured description of the domain, or, simply said a study book. Learning is primarily active reading and understanding these study books. The presentation of subject matter is typically used as the skeleton for further instruction: Learning tasks have the form of assignments or practice items that are added to this skeleton for us during reading. Or, it is the exercises that you usually find at the end of each chapter in the study book to evaluate learning.

This approach has its charms. It is neat, elegant, conveniently arranged and familiar. But it also has its drawbacks. Constructivist approaches to learning correctly stress that knowledge is not something that can simply be described in a study book and then be transmitted to learners. Instead, knowledge must be constructed by the learners − and learning tasks or meaningful problem solving can help them to do so. Indeed, one may wonder if reading a study book is the best learning task for reaching this goal. Moreover, it may be argued that constructivist learning environments, defined as environments in which learners work on relatively complex, meaningful learning tasks, yield instruction that is less fragmented, offers more opportunities for an interdisciplinary approach, and provides better opportunities for transfer of what is learned to new problem situations. But where do these learning tasks come from? A popular approach is to replace the World of Knowledge by the World of Experience, or, in the field of professional education, by the <u>World of Work</u>. It is no longer the discipline or subject matter domain that is analyzed, but the jobs performed by professionals in the domain of study. Job profiles become the basis of a curriculum, and the learning tasks more or less mimic the tasks that students will encounter in their professional, post−academic life. These are then said to be "authentic" learning tasks.

It may be argued that the replacement of the World of Knowledge by the World of Work will not solve, but merely replace old problems with new ones. Three of them will be briefly mentioned. The first problem relates to the <u>least effort principle</u>. Students tend to consult a minimum of study materials in order to complete their tasks. Thus, the knowledge that students gain for working on particular learning tasks often lacks a broader structure, making it impossible to develop a historical overview of the discipline or to develop a deeper understanding of the theoretical relationships in the field of study. And it is precisely this type of knowledge that may be necessary for transfer to occur.

The second problem is the <u>supportive knowledge problem</u>. Supportive knowledge is all knowledge that may be helpful to solve particular problems in a domain. It is often not known which knowledge underlies effective performance on complex tasks that involve problem solving. So, it is impossible to determine which information students must have available for their work on one particular learning task. Real professionals act opportunistic: They try a particular approach and quickly switch to a new approach if the current approach does not work. And they can only do this because they know a lot about the domain, or, because they have the overview that students lack and cannot develop by only working on learning tasks.

And third, there is the <u>professional mobility problem</u>. Employees quickly change their jobs nowadays, which makes it less useful to take job profiles as the basis for a curriculum. To a lesser degree, this problem also occurs in the World of Knowledge, because knowledge is nowadays also liable to fast changes. One may seriously wonder how to deal with the relationship between labor market demands and the design of competency−based curricula.

A first major challenge is to develop procedures that help us to combine and integrate the World of Knowledge and the World of Work in teaching. One approach may be to take competencies as a starting point, and analyze these competencies in order to develop <u>task classes</u> (also called "case types", van Merriënboer, 1997) that give an abstract, general description of a broad category of learning tasks. On the one hand, such task classes allow one to identify the knowledge that may be helpful in solving a particular <u>category</u> of problems in the domain of study. It allows for the teaching of larger, integrated bodies of knowledge, as we used to do in the World of Knowledge. On the other hand, task classes might also be used for helping content experts to identify professional tasks that are really useful as learning tasks − and so bring in the World of Work. Each learning task should nicely fit the task class it exemplifies, and the complete set of learning tasks for a particular task class should provide a good mapping of all the skills and knowledge required for solving the problems in this class. This approach has been successful in training for complex skills (see Clark & Estes, 1999).

2nd direction: Build Learner Support that Works

If ID succeeds in integrating the World of Knowledge and the World of Work, the learning tasks that are given to students will still be much more complex and time−consuming than the assignments or practice items that can be found in a typical study book. In order to fruitfully work on the tasks, learners need <u>support</u> − and we clearly need to build support that works. We cannot leave the task of supporting students to the teachers, many of whom are already swamped with work. When students work on more complex tasks this will only become worse. Over the last decade, quite a lot of research has studied the effectiveness of support given by electronic performance support systems (EPSS, e.g. Bastiaens, Nijhof, Streumer, & Abma, 1997), cognitive tools, help systems, learning aids, and other "...things that [are supposed to] make

us smart" (Norman, 1993).
The results of research on the use and effectiveness of support systems are often disappointing. The most salient finding is possibly that those learners who need the most support are least inclined to use it. They act as typical computer users who encounter software problems: "Only when everything else fails, consult the documentation (or, the available support)". This finding can easily be explained by Cognitive Load Theory (Sweller, 1988; Sweller, van Merriënboer, & Paas, 1998). When students encounter problems while working on a learning task, the last thing they are inclined to do is further increase their cognitive load by adding additional information−from the support system−to their working memory. For this reason, support systems that are "add−ons" to the learning environment may increase the gap between weak and strong learners.
If traditional support fails, what must support look like to succeed? It seems likely that support must be fully embedded in the learning task or learning environment in order to be effective (Martens & Valcke, 1995). In the field of constructivism, providing embedded support is often called "scaffolding", and the term performance constraint is then probably more appropriate than the term performance support. We are all familiar with the training wheels on children's' bikes, which is a performance constraint that prevents them from falling over (see Carroll & Carrithers, 1984). These training wheels are clearly more effective than add−on performance support, like the parent who is running alongside and shouting "Keep your handlebars straight!" What we need to do is define the training wheels that promote learning from complex tasks. Three of them will be discussed.
A first training wheel is to divide a complex learning task in subtasks. For instance, if law students have to prepare a plea to be presented in court, they can be simply instructed to prepare a plea. Or they can be provided with a "systematic approach to problem solving" for preparing a plea by instructing them to (1) study the files and determine their strategy for pleading, (2) translate the strategy for pleading to an outline for the plea, and (3) write the plea. So, embedded support is given by decomposing the learning task in phases.
A second training wheel is known as sequencing. Sequencing learning tasks from simple to complex is sometimes associated with old−fashioned instructional design, but in the field of constructivism authors also stress its utmost importance. For instance, Collins, Brown, and Newman (1987) correctly argued in an influential article that "...the ability to produce a coherent and appropriate sequence of case studies and problems [i.e., learning tasks] is a key feature in the design of constructivist learning environments". This is not to say that we should only adhere to traditional simple−to−complex orderings of learning tasks. For example, the work of Gropper (1983) or Krammer and myself (van Merriënboer & Krammer, 1987) indicated the usefulness of backward chaining approaches to sequencing for complex learning. Learning tasks are then ordered in the reverse order of how an expert would encounter them. For instance, in learning instructional design, student would start with the evaluation and revision of existing instructional materials. Such sequencing techniques are very effective because they quickly provide useful models to the learners and because they offer meaningful, relatively complex learning tasks from the start.
A third training wheel can be embedded in the nature of the learning task itself. For instance, studying a case which provides a real−world solution for a given problem provides more support than a conventional problem, in which students are asked to come up with a solution for the same given problem themselves. There is ample evidence that students who are novices in a domain learn more from the case or worked−out example than from the conventional problem (e.g., Paas, 1992; Paas & van Merriënboer, 1994). As another example, completing or extending a given design for some product or process in project−oriented learning provides more support than a conventional project for which students have to design the product or process from scratch. And again, there is ample evidence that novice students learn most from the completion problems (e.g., van Merriënboer, 1990; van Merriënboer & de Croock, 1992).

3rd Direction: Promote the Development of Higher−order Skills

So far, an educational system was sketched in which meaningful work on relatively complex tasks forms the kernel of a curriculum. And from an instructional point of view, scaffolding learners is critical in such a system. If we do not embed enough support in the learning environment in a clever way, teachers will be overburdened because learners will typically need more support than in a traditional educational system. But the training wheels will be mounted higher and higher, that is, support diminishes, as students become more proficient in performing particular tasks (belonging to a particular "task class"). It is thus important not to focus only on instructional support, but also on the question of what is required from students in such a new, competency−based curriculum. There are many answers to this question: Students must learn−how−to−learn, students must regulate their own learning processes, students must monitor and assess their own performance as well as the performance of others, students must develop better study skills, metacognitive skills, learning strategies and even general problem solving skills, and so forth. Obviously, there is a delicate trade−off between the necessity for learner support and the desire to develop independent learners.

For the purpose of this article, the many useful distinctions made in the literature with regard to independent learning will be discarded and all referred to as higher−order skills. While first−order skills are bound to a particular learning domain, these higher−order skills seem−incorrectly−to be independent of any domain. If you have learned to learn in domain A, you will also be able to learn in domain B; and if you can regulate your own learning in domain X, you will also be able to regulate your own learning in domain Y. These higher−order skills are indeed the key for effective learning to occur. Students who lack these higher−order skills will simply not be able to learn in such a way that acquired cognitive schemata are useful beyond the educational context. But at the same time, it is often surprising how the discussion on higher−order skills takes place in the literature and in the educational field. Three comments relate to (1) the importance of training, (2) the assumed domain−independence, and (3) the claim that domain knowledge is becoming less important.

To start with the first issue: Higher−order skills are still skills. And more in particular, they are highly complex skills. A first−order complex cognitive skill (e.g., diagnosing cardio−vascular diseases, performing psychological research) typically takes hundreds or even thousands of hours to develop. It thus seems fair to state that the development of a complex higher−order skill will also take at least hundreds of hours of experience, preferably distributed over many years. We should provide opportunities for the development of higher−order skills from primary school on − and not limit this to secondary and tertiary education. And it should also be acknowledged that explicit training in such higher order skills is often necessary. It is naive to withhold support from students during their work on complex learning tasks and then expect them to spontaneously show independent learning behaviors. There are no "hocus−pocus" higher order skills! Yet, this is what can be observed nowadays in some research, reform and development projects. This way, efforts directed at independent learning will seriously jeopardize the quality of education.

This brings us to a second issue: The design of training for higher−order skills. These skills can be trained − but is it also possible to train them outside a particular learning domain? This parallels the old discussion on the possibility to teach general, domain−independent problem solving skills. What seems to be critical in this discussion is that both general problem solving skills and other higher−order skills mainly indicate "strategic knowledge", that is, knowledge about which rules−of−thumb and systematic approaches are effective to approach a learning task or problem. As argued elsewhere (van Merriënboer, 1997), there is always a bi−directional relationship between strategic knowledge and supportive knowledge. The better a learner's knowledge about a particular domain is organized, the more likely it is that strategic knowledge can help to operate in this domain. And the reverse is also true. A rich knowledge base is only useful if learners possess the strategic knowledge enabling them to make effective use of it. The bi−directional relationship between supportive and strategic knowledge simply indicates that both are cognitively represented in an integrated fashion and that one is of little use without the other. If this is true, higher order skills can only be trained in a particular domain. And if we want the strategic component of higher−order skills to transfer between domains, they should be trained in as many domains (or, courses) as possible and it should be made explicit to students that a higher−order skill that works in one domain may also work, or may not work, in another domain.

Third, this analysis leads to questioning a claim that is becoming more and more popular in the field of education. What you hear is that a highly technological society such as ours is requiring more and more employees who have developed competencies and who exhibit higher−order skills, and that domain knowledge is [thus] becoming less important. The first part of this statement is certainly true, but the second part is a very dangerous misunderstanding. There is no such thing as complex cognition outside a domain, and we will never be able to develop complex cognition, including higher−order skills, outside domains. The human cognitive architecture is bound to domain−knowledge (see Sweller, van Merriënboer & Paas, 1998).

This section discussed the direction to fruitfully combine the World of Knowledge and the World of Work in a competency−based curriculum that is based on learning tasks; the direction to support or scaffold students who work on the tasks in such a way that learning is improved, and, finally, the direction to develop higher−order skills in such a curriculum − taking the delicate balance between required learner support and desired independent learning into account. The next section will turn to a second aspect of future competency−based learning, namely that it will more and more take place in Web−based multimedia learning environments.

Delivery in Multimedia Learning Environments

Multimedia learning environments evolved from programmed tutorials, drill−and−practice computer−based training, hypertext systems, and intelligent tutoring systems towards simulation−based learning environments and all kinds of combinations of these. And nowadays, Web−based instruction is in the center of interest because it facilitates distributed distance delivery and combines presentation and communication facilities. We must answer the question if these technologies can be used to support competency−based learning − and if so, how? Three new directions will be formulated, now with regard to the delivery of learning tasks in multimedia learning environments, including the Web (see middle part of Table 1). Again, these are viewed as urgent goals that must be attained for making multimedia instruction more effective, efficient and appealing:

- Develop Web−based Instruction that Makes a Difference
- Defeat the Transfer Paradox
- Make Students Work Together

4th Direction: Develop Web−based Instruction that Makes a Difference

Web−based instruction is hot! It is easily accessible from the whole world, it offers integrated presentation and communication facilities, it provides better opportunities for updating and re−using learning materials, and so forth. This is all true, which is why some authors argue that it provides a "technology push" for improving the quality of education. But media will never influence learning (Clark, 1994). Only instructional methods may improve the quality of education, and it is an open question if current Web technology supports the use of instructional methods that are necessary for complex learning to occur.

If we seriously study what is really going on at the moment, Web technology yields a <u>backward−push</u> instead of a forward−push. The key concept with regard to Web−based instruction seems to be <u>content</u>, as it was in the World of Knowledge, and so−called "content−providers" (publishers, universities) are expected to supply ready−made content that can be delivered over the Internet. Most Web−based instruction that you find on the Internet takes us back to the early days of programmed tutorials and electronic books, where learner activities mainly consist of reading from the screen and filling in boxes. This is in clear contrast with the constructivist ideas that emerged in the 80's, stressing the importance of active work on meaningful learning tasks for knowledge construction and skill acquisition to take place.

This development threatens to lower the quality of education instead of improving it. In order to promote the development of competencies or complex cognitive skills, the kernel of Web−based instruction should not consist of content, but of rich learning tasks that are presented in a meaningful (simulated) task environment. For a limited number of tasks, the Web already provides the necessary functionalities. For instance, the Virtual Company Project (Westera & Sloep, 1998) offers a collaborative, distributed learning environment in which students work on rich learning tasks in a simulated company. But for many other tasks, like pleading in court, controlling aircraft, or conducting psychological experiments, Web−based instruction currently lacks the necessary functionalities (e.g., input−output facilities, simulation models that can run on the background, etc.). Of course, things will be better in the future, with Giganet ports and broadband Internet connections, but for now we should simply acknowledge that the Web often lacks the functionalities that are necessary for implementing instructional methods that promote complex learning.

And what about the content? In competency−based learning, content or information to be presented to learners is always subordinate to, although harmonized with the learning tasks. Part of this content is best presented when students actually need it, that is, while they are working on the learning tasks. This type of content can best be characterized as just−in−time (JIT) information. It is mainly the information that is relevant to the recurrent aspects of effective task performance, that is, those aspects that are the same from problem situation to problem situation (van Merriënboer, 1997). JIT information presentation then best allows this information to be restrictedly encoded in the cognitive rules or schemata that represent these particular aspects of task performance. Computer−based instruction, including Web−based instruction, offers excellent opportunities for the just−in−time presentation of information. For instance, this content can easily be hyperlinked to the parts of the learning task for which it is relevant.

Another part of the content cannot easily be connected to particular learning tasks. It is the content which represents the knowledge that supports performing non−recurrent, problem−solving intensive aspects of the learning task. It encompasses the "integrated bodies of domain knowledge" that may help to solve problems in the domain of interest − but you can never be sure for which specific problem they are helpful. This information is best made available to students before they start to work on a particular category of learning tasks (which were called "task classes" before), and should remain available during their work on those tasks. This will best allow them to elaborate on the information, that is, to integrate it with their existing prior knowledge. Printed materials are still the best medium for delivering this type of information. They can easily be consulted (in bed, in the train, or on the beach), specific information is relatively easy to search for, it is easy to take notes and make annotations, and reading from a book is easier than reading from a monitor.

Nonetheless, the Internet may be preferred over printed materials for the presentation of supportive information, or be used in addition to printed materials, simply because it contains so much useful information. This view is popular in the field of Resource−based Learning (e.g., Rakes, 1996). Here, we should acknowledge the fact that the Internet contains useful information, but also a multitude of information that is not useful. This brings us back to the discussion on learner support versus higher−order skills. On the one hand, we might structure the information in such a way that learners can find what they are looking for. This helps us in fighting the Butterfly Defect (Salomon, 1998): "... touch, but don't touch, and just move on to make something out of it". On the other hand, we might focus on the development of search literacy skills. The development of search literacy skills is indeed important, but one should be extremely careful that searching for information does not interfere with learning in the primary domain.

5th Direction: Defeat the Transfer Paradox

Instruction that yields higher transfer to new situations, or yields better transfer from the educational setting to future job performance, usually takes more time than traditional instruction and/or poses higher requirements to the cognitive involvement of the learners (van Merriënboer, de Croock, & Jelsma, 1997). Thus, whether we like it or not, learners have to pay a price for learning in such a way that what is learned becomes useful in a broader context. This is due to the fact that transfer depends on the richness and interconnectedness of the cognitive schemata that learners are required to develop when they are working on the learning tasks. The construction of schemata in such a way is a highly effort−demanding and time−consuming process. There is no simple solution to this paradox. But, especially in multimedia learning environments, much can be gained by lowering the extraneous cognitive load that is imposed on learners and, at the same time, explicitly helping them to focus their attention on those activities that promote deeper cognitive processing. This process is also known as "redirecting attention" (van Merriënboer, Schuurman, de Croock & Paas, in press), from learner activities that are not relevant for learning to learner activities that are relevant for learning.

Essential in alleviating or at least reducing the paradox is effective and efficient use of cognitive resources and thus elimination or reduction of extraneous cognitive load. In many multimedia learning environments learners are overwhelmed and confused by the amount of available options for navigation, by the amount of available information, or nowadays even by the amount of advertisements! Students have to find out how the interface works, which information is useful and which is not, which parts of the screen belong to each other, and many other things that have little to do with learning. Of course, usability engineering is important for all software products − but it is critical for multimedia learning environments. If usability is low, no learning will occur. And given the transfer paradox, a trade−off can be expected between the usability of a multimedia learning environment and the transfer of learning. Simplicity of the interface is a key issue in learning that is too often underestimated.

In addition to simplicity, an optimal use of modalities may also help in making multimedia environments more suitable for learning. In general, little is known about the optimal combination of audio or speech, screen texts, and illustrations in pictures or video. But as argued by Mayer (1997), effective working memory capacity can be increased by a good combination of audio, text and pictorial information.

Only when multimedia learning environments are characterized by simplicity and an optimal use of modalities, it makes sense to focus the attention of the learners on activities that promote intentional deeper processing of the materials, or, increase their so−called "germane" cognitive load devoted to the construction of cognitive schemata. One way to reach this goal is to increase the variability in a set of learning tasks that belong to the same task class (Paas & van Merriënboer, 1994; de Croock, van Merriënboer, & Paas, 1998). Or, alternatively, learning tasks might be interspersed with questions that make the tasks into epistemic tasks (Ohlsson, 1996). Collins and Ferguson (1994) and Goodyear (1998) go one step further and claim that multimedia learning environments should mainly engage students in playing "epistemic games" that provoke deep cognitive processing and promote understanding.

To conclude, dealing with the transfer paradox is even more difficult because there are large inter−individual differences between students. A learning task that yields high extraneous cognitive load, and thus leaves little cognitive capacity for genuine learning for one student, may be a good learning task for another student. For this reason, adaptive interfaces in multimedia learning environments could give less functionalities to students who experience high cognitive load and more functionalities to students who experience low cognitive load. This is a clear application of the training wheels approach to interface design.

6th Direction: Make Students Work Together

According to my 4th direction, Web−based instruction should be developed that makes a difference. The presentation facilities of the Web are yet far from perfect. In its current form, it certainly does not always allow for the use of instructional methods that may be necessary for complex learning to occur. But Web−based instruction provides another feature which importance cannot be overestimated: communication facilities. This refers both to asynchronous types of communication, such as E−mail and discussion lists, and to synchronous types of communication, such as chat boxes and video−conferences. While the use of these means of communication is becoming increasingly popular in Western society, experiences in education are mixed. Sometimes students do not use them at all; sometimes they use them to discuss all kind of things (football, music etc.) that are not related to learning, and sometimes they use them to sustain learning. We should find out under which conditions the last option is true. Three possible approaches will be discussed.

First, it should not be expected from students that they work together if there is no clear need to do so. Social factors play a role but it is also related to the least effort principle. When you are working on an individual task, you will only start to communicate about this task when things go seriously wrong. People are only inclined to learn and work together if it has a clear added value. Fortunately, competency−based learning provides excellent opportunities for proving this added value. Many competencies include interpersonal skills, so that there will no doubt be learning tasks that require students to practice such skills in a simulated task environment. In short, some learning tasks will be distributed team tasks, that is, tasks with a co−operative goal structure (Johnson, Maruyama, Johnson, Nelson, & Skon, 1981) which makes working together into a strict condition for completing the task.

Second, Web−based communication technology is likely to experience the same problem as learner support systems. When things get tough, students are least inclined to use support systems and probably also least inclined to use communication facilities. Like support systems, communication systems must probably be fully embedded in the learning environment before they are optimally used. Add−on communication facilities, like commercial programs for e−mail, discussion lists, and chats may hamper learning because learners suffer from the so−called "split−attention effect" (Sweller, van Merriënboer & Paas, 1998).

My third point with regard to computer−mediated communication is that we should not only take the transfer paradox into account for instructional on−screen messages (remember the 5th direction!), but also for student−generated messages. Have you ever been involved in a collaborative problem solving effort, in which you were confronted with twenty e−mail messages from peers that all gave different directions for solving a particular subproblem − and in which it was your role to make sense out of all the e−mail

messages and come to a substantiated solution? I have been, and I can assure you that the only thing you want to do in such an "epistemic game" is to forget about the e−mails and present your own solution (or switch off the computer). If we want these types of learning to be successful (and they can be!), we need simpler ways of organizing and representing the available information.
This section on delivery in multimedia learning environments discussed the direction to develop Web−based environments for competency−based, complex learning; the direction to defeat the transfer paradox by using instructional methods that promote deeper cognitive processing balanced out by methods that decrease extraneous cognitive load; and, finally, the direction to make students work and learn together on distributed team learning tasks. The next section will turn to the third and last aspect of future competency−based learning, namely that it poses new challenges to the diagnosis of learner progress.

Diagnosis of Learner Progress

Learning cannot take place without feedback. For basic learning processes, Knowledge of Results (KR) may be sufficient. You simply see the outcomes of what you do. But for complex learning to occur, the feedback that students receive should generally be more informative. In order to give such feedback, judgments of the quality of complex performances are necessary. And such judgments are not only necessary to improve the quality of learning, but also to certify learners, to make pass/fail decisions, or to make placement decisions. Again, three new directions will be formulated, now with regard to the diagnosis of learner progress (see bottom of Table 1). In fact, the last direction concerns the interface between diagnosing learners ("student evaluation") and diagnosing educational systems ("system evaluation"). All three of them should be viewed as challenges that must be attained in successful, competency−based learning:

- Provide Meaningful Feedback
- Use Tests for Complex Performances
- Assure the Quality of Competency−based Learning

7th Direction: Provide Meaningful Feedback
Quite a lot is known about providing effective feedback to learners. At least, if it comes to learning declarative knowledge or learning procedural skills. For instance, it is known that feedback is then most effective when it is provided immediately after performance. And in case of incorrect performance, feedback should explain why there was an error and give hints for how to reach the correct goal. Nevertheless, providing feedback to students is a major problem in traditional education − probably because it requires that teachers closely monitor the performance of their individual students. This may be possible in one−to−one tutoring, but not in a group−based educational system. We all know that there are still too many courses for which the only feedback that students get is a final grade, which is not very informative if it comes to improving learning.
There is bad news. These problems can become even worse in a competency−based curriculum. One reason for this is that performance on a rich learning task is never right or wrong, it is merely more or less effective, efficient or satisfactory. The best students can do is apply a systematic approach to problem solving, and try out the heuristics that can be helpful to reaching success. Another reason is that many different aspects can be judged for complex performances. It should be clear that only one or a few judgments on the quality of performance provide learners with little detail about how to improve performance; feedback should ideally be given on the many different performance aspects that can be distinguished for the learning task.
Such feedback is critical to learning complex cognitive skills − but to date, little is known about the characteristics of optimal feedback for complex performances. It is clear that students must be allowed to discover the advantages and disadvantages of applying particular approaches and heuristics and to make mistakes. Feedback can only be given retrospectively. It should discuss the similarities and dissimilarities between the approach that has been taken by the students and expert approaches, the application and misapplication of particular rules−of−thumb, the qualities of the solution in comparison to other possible

solutions, and so on.
Butler and Winne (1995) presented an interesting model for providing so−called cognitive feedback to students, in such a way that it promotes self−regulated learning from rich learning tasks. The central idea is that feedback should provide students with information that allows them to link particular "cues" to the quality of their performance. Cues may, for instance, concern features of the task, the learning activities, or the cognitive processes the learners were engaged in. The cues should enable students to reflect on the quality of found solutions, on the quality of problem solving processes, and on the quality of learning itself. So, cues that promote reflection become a central element of feedback to students, like it is a central element for (reflective) practitioners and life−long learners.
But even if we succeed in identifying the characteristics of effective feedback for complex learning, providing this type of feedback will remain a heavy burden for teachers. While some progress in the field of Artificial Intelligence is made (e.g., the use of Latent Semantic Analysis for providing feedback on papers; see Landauer, Foltz, & Laham, 1998), computers are still far away from taking over this task from teachers. The most feasible approach, both from a practical viewpoint and from the viewpoint of the development of higher order skills, is to delegate an important part of the work to students themselves. Debriefing sessions, group discussions, and peer and self−assessments can offer a valuable approach to providing meaningful feedback (Sluijsmans, Dochy, & Moerkerke, 1999).

8th Direction: Use Tests for Complex Performances
If we find solutions for the seven challenges discussed above, we begin to see an ideal, future environment for complex learning: 1. Students work on rich learning tasks that combine the World of Knowledge with the World of Work. 2. They receive enough, embedded support to ensure learning. 3. They are assisted in developing higher order skills. 4. They will often work on their tasks in a simulated (Web−based) task environment, where the information that is prerequisite to task performance is presented just−in−time and the information that supports the work on broader classes of tasks is available in books or in highly accessible electronic repositories. 5. They are elicited by the environment to redirect their attention from irrelevant processes towards processes that are important for genuine learning. 6. They have optimal facilities for performing team learning tasks through communication with peers and tutors. 7. And finally, they receive meaningful feedback from peers and tutors on the quality of their complex performances.
But there is still one thing that may destroy this dream: Examinations! Frederiksen (1984) convincingly described the "real test bias", that is, the tendency of teachers and students to focus their teaching and learning on that which is tested. We can put a lot of effort in the design and development of powerful environments for complex learning, but if we subsequently test students on their factual knowledge and procedural skills it will certainly be a waste of time and effort. As argued before, we have to deal with the least effort principle. Like all of us, students act as "calculating citizens" and will only learn what they are required to learn with a minimum of time and effort devoted to it. And we cannot blame them for that. There is only one solution. We should test how we teach. Tasks for testing must mimic the rich learning tasks used for learning, and students must be judged on their complex performances.
Several authors plead for such an integration of teaching and testing (Frederiksen, 1994). And from the viewpoint of cognitive psychology, the problem of performance−based testing is largely solved together with the problem of providing meaningful feedback on complex performances (the 7th direction). Both problems concern judgments of the quality of performance on rich tasks, and the only difference seems to be in their purpose. For feedback, the purpose is to improve learning; for testing, the purpose is to make pass/fail decisions or to certify learners.
However, these different purposes have some important implications. Two of them will be briefly discussed. First, if the purpose is to improve learning, written or verbal interpretive summaries, giving judgments on the quality of all relevant aspects of complex performance, are most useful. Much more information is conveyed in such summaries than in numerical ratings. While some authors seem to argue that these qualitative judgments are the only way to judge complex performances (e.g., Delandshere & Petrosky, 1998), we nevertheless need numerical ratings for the purpose of certification. At least and most simply, a judgment on a numerical 0−1 scale (0 = fail / do not certify; 1 = pass / certify) is necessary. It is thus important to develop scoring and judging procedures for complex performances and to support teachers in their use of such procedures.
Second, in a traditional curriculum certification usually takes place course−by−course. Students simply get

their diploma after they passed all examinations. This is not possible in a competency−based curriculum that uses performance assessments, because competencies are not linked to particular courses, but are expected to develop throughout the whole curriculum. This necessitates some form of progress testing (cf., van der Vleuten, 1996), yielding information on the quality of different aspects of complex performances with regard to the end objectives of the curriculum. Student dossiers can thus no longer be a simple file with pass/fail results for each course, but must keep track of student progress in a much more detailed fashion.

9th Direction: Assure the Quality of Competency−based Learning

Learner diagnosis for giving meaningful feedback and improving learning was discussed, which is mainly related to the process of learning ("throughput"); and for certification or making pass/fail decisions, which is mainly related to the output of learning. This leaves us with the input: Learner diagnosis with the purpose of making placement decisions (or, in some contexts, selection). This type of learner diagnosis is especially important for institutes for Open Learning, which serve a highly heterogeneous group of students.

One obvious requirement for intake procedures is that they should be representative for the system of competency−based learning and performance−based assessment that underlies the whole educational system. Only knowledge testing is not enough! In addition, institutes for Open Learning are too often characterized by a high drop−out rate. Representative, performance−based assessment procedures may better help students to determine their suitability for a (particular) study and so increase the success rate of study programs.

Making placement decisions in order to increase success rates of academic programs marks the transition between student evaluation and system evaluation (i.e., diagnosing the quality of the educational system). In this article, so far a rough sketch was given of a future educational system, in which students work on rich (team) learning tasks in multimedia learning environments and are assessed on their complex performances. There is no doubt that the methods, techniques and instruments needed for evaluating and assuring the quality of such a system will be different from the ones that are currently available. For this reason, it needs to become clear what the implications of this new approach to learning are for system evaluation and quality assurance.

Conclusion

In this article, nine new directions for Instructional Design for competency−based learning were presented and discussed. Together, they define a new paradigm for Instructional Design. However, presenting the directions is easier than applying them in practice. ID projects are, by definition, bound to a highly particular educational context. Reigeluth (1983) describes the process of ID and makes a distinction between conditions or context variables, methods and outcomes. For ID projects, the conditions cannot easily be manipulated and include, for instance, size and grouping of the target learners, available technological and physical infrastructure (computer and network facilities, rooms), organizational characteristics, lesson schedules, available expertise among parties involved, and so forth. Within these limitations, it is up to the professionalism, expertise and creativity of the designer or design team to specify the instructional methods that are appropriate for reaching the desired outcomes, that is, to specify a learning environment that is as effective, efficient and appealing as possible. But in addition, a process of organizational change and deep innovation is needed to create fruitful conditions for application of the directions presented in this article.

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