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Training Higher Education Teachers for Instructional Design of Competency-based Education: Product-oriented versus Process-oriented Worked Examples

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Abstract

Teachers involved in the development of competency-based higher education (CBE) are expected to fulfil a new role of instructional designer. As a consequence, they are confronted with the problem to translate abstract new curriculum principles into concrete learning tasks. Recent studies have shown that teachers can be trained to apply an instructional systems design methodology (ISD: Hoogveld et al., 2001, 2002). After this training the teachers were able to design better learning tasks for CBE in comparison with their experienced-based design efforts. In order to optimize the training, this study compares an experimental condition with process-oriented worked examples with a conventional training condition with emphasis on product-oriented worked examples. After the training, the participants - 25 higher education teachers - had to apply the ISD methodology to two design problems. The quality of the resulting design materials, as rated by experts, was higher in the product-oriented worked examples condition than in the process-oriented worked examples condition. The significance of this finding for training approaches to design methodology for CBE is discussed.

Training Higher Education Teachers for Instructional Design of Competency-based Education:

Product-Oriented versus Process-Oriented Worked Examples

In the last decade, a trend can be observed in the field of higher education from knowledge-oriented to competency-based education (CBE) (Achtenhagen, 2001; Arguelles & Gonczi, 2000; Barnett, 1994; Levesque, Lauen, Teitelbaum, Librera, & MPR Associates, 2000; Samuelowicz, 2001; Vermunt & Verloop, 1999). CBE is aimed at providing students with the knowledge, skills, and attitudes to enable them to recognize and solve complex problems in their domain of study or future work, i.e., authentic tasks (Keen, 1992). Whereas knowledge-oriented education focused on the question of what needs to be taught and learned in terms of concepts and conceptual structures, within CBE the questions of why something has to be learned and how it can be used in solving a complex problem are considered important. Knowledge application, problem solving and heuristics are key topics of CBE.

The successful realization of CBE heavily relies on the teachers, who are expected to give up their role as 'knowledge transmitter' and adopt the new roles of 'coach' (Enkenberg, 2001; Kerr, 1996; Pratt, 1998; Samuelowicz, 2001), and 'instructional designer' (Tennyson, 2001). Particularly, in the new role of instructional designer, teachers are confronted with the difficult task to translate abstract new curriculum principles into a meaningful sequence of authentic learning tasks. The creation of this type of learning tasks and its prerequisite competency analysis has been identified as the teachers' major design challenge of the transition process from knowledge- to competency-based higher education (Hoogveld et al., 2001). In general, teachers are not well equipped with the appropriate skills for this complex design task. Hoogveld et al. (2001) have shown that in the intuitive, experienced-based design approach of teachers only little attention is paid to the phases of analysis and evaluation. Since, the analysis of the competency is considered crucial for effective instructional design for CBE, they argued that an Instructional Systems Design (ISD) approach with an emphasis on task analysis could offer a solution to the problem. In line with this argument, Tennyson (2001) has stated that competency

in ISD methodology can be considered as one of the three basic core knowledge areas that need to be mastered by teachers to cope with the learning-process oriented teaching principles in designing CBE. Hoogveld, Paas, Jochems and van Merriënboer (2001) compared the effects on higher education teachers' design performance of a training in the Four-Component Instructional Systems Design methodology (4C-ID: Van Merriënboer, 1997) with a training optimizing the teachers' experience-based design approach. They found that the teachers that were trained in the 4C-ID methodology were better able to cope with the instructional design requirements of CBE than the teachers that were trained to optimize their intuitive design approach. Particularly interesting was the finding that the 4C-ID methodology was evaluated more positively by the teachers than the optimized intuitive design approach. These results suggest that the ideas behind the 4C-ID methodology are in line with the teachers' experiences and ideas about instructional design.

The 4C-ID Model (van Merriënboer, 1997) is an Instructional Systems Design methodology that is developed especially for supporting design of learning tasks for CBE (Janssen-Noordman & van Merriënboer, 2002). It focuses on the development of learning environments for complex cognitive skills or professional competencies. The output of the 4C-ID methodology is a blueprint of a training (see *Figure 1)*, which contains learning tasks, organized as authentic and meaningful whole-task experiences to promote construction of cognitive schemata. Learning tasks are sequenced in 'task classes', which represent sets of simple-to-complex instances of the whole task. Each task class of the training blueprint thus consists of a series of learning-tasks which are of the same level of task complexity and which are sequenced according to a descending amount of learner support. A unit of Supportive Information, in which it is explained how domains are organized and how problems in the domain are to be approached precedes each task class. Each learning task is provided with Just-In-Time-information, referring to the

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Insert *Figure 1* about here

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task's recurrent aspects and specified algorithmically, at the moment, needed during task performance. When necessary, part-task practice, consisting of repetitive practice of recurrent tasks that require a high level of automation is provided in the blueprint of the training (van Merriënboer, Clark, & de Croock, 2002; van Merriënboer & de Croock, 2002).

Contemporary instructional theories (Van Merriënboer & Kirschner, 2001) focus on complex, realistic tasks as the driving force for learning. This type of tasks is applied in context-based learning, which is based on the concept of situated of knowledge and experience. Complex tasks require of practitioners in complex domains the ability to see the domain system as a unified whole (Spector, 2001). It is this characteristic of professional expertise in a domain that causes practical problems for teachers and instructional designers in realizing CBE. The student with little expertise in the domain or in the task will not have any overview or will not be able to see the whole, while working at a detailed realistic task. Whole-task approaches to the design of learning tasks focus on the coordination and integration of constituent skills from the very beginning, and stress that learners quickly develop a holistic vision of the whole task during the training. This form of complex learning is always involved with achieving highly integrated sets of learning goals. Complex learning has little to do with learning separate skills in isolation, but it is foremost dealing with learning to coordinate the separate skills that constitute 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 the parts. Complex learning stresses that effective performance relies on an integration of skills, knowledge and attitudes.

Two interrelated solutions have been identified by Hoogveld, Paas, Jochems and van Merriënboer, 2002, and by Hoogveld, Paas and Jochems, 2003) to enable teachers to deal with the integrative design demands of competency-based curricula. Because of lacking experience in the important analysis- and evaluation- phases of design one solution is training teachers to use an appropriate instructional design model such as the 4C-ID methodology. Another one is using collaboration to lower the integrative complexity for the individual teacher. Teachers supported

by the 4C-ID methodology can collaborate on the design task and contribute to the design task by providing input from their specific disciplines. Whereas the first solution was confirmed in a study of Hoogveld, Paas, Jochems and van Merriënboer (2001), the latter solution was investigated by Hoogveld et al. (2003) by comparing design performance of individual teachers to that of small teams of teachers. In general, team design performance did not differ significantly from individual design performance. However, whereas low individual design performers showed better design performance in a team, for high individual design performers the collaborative approach had no added value. Although under certain circumstances it might be better to have a good individual teacher/designer do the job, the general conclusion of the study was that applying the 4C-ID methodology in a team is recommendable for higher education teachers.

In this study the quality of the teacher training in the 4C-ID methodology is identified   as a potentially important factor determining the quality of the design for CBE. We explore the effects of an alternative training approach for the 4C-ID methodology on the design of learning tasks for CBE. The control strategy logically followed from the studies of Hoogveld et al. (2001, 2003), in which a 'classic' training strategy was applied to train the 4C/ID methodology. Learners first had to study product-oriented worked examples (WEs, i.e. exemplary training blueprints) followed by conventional problems. With this type of worked examples, students have to study the problem state, the goal state, and an expert's problem solution. This instructional method with product-oriented WEs, based on Cognitive Load theory (Sweller, 1988), has been found to be very effective in the training of complex cognitive tasks as compared to traditional problem solving (for an overview see, Sweller, van Merriënboer, & Paas, 1998). Cognitive load theory is concerned with the instructional implications of the interaction between information structures and cognitive architecture. Paas (1992) and Paas and van Merriënboer (1994) even found that a training fully consisting of worked examples resulted in higher test performance than a setup consisting of a mix of worked examples and conventional problems.

Recent research within the cognitive load framework focuses more and more on the optimal design of WEs (Atkinson, Renkl, Derry, & Wortham, 2000). The conventional WEs typically present the problem and its solution in terms of (intermediary) products, but not the processes of *how* these products are

attained and *why* they are attained this way. That this type of information is considered important by learners was suggested in our previous studies (Hoogveld et al., 2002; Hoogveld et al. 2003), in which we were regularly confronted with participants asking 'how' and 'why' questions when studying the worked examples. The possible benefits of adding *why* and *how*-information to WEs was recently described by Van Gog, Paas, and Van Merriënboer (2004). The alternative training approach in this exploratory study therefore consisted of process-oriented worked examples, which show *how* instructional design experts solve the problem and *why* they solved the problem that way (cf. Braaksma, Rijlaarsdam & van den Berg, 2002). These process-oriented WEs are comparable to modeling examples, which are theoretically grounded in the concepts of observational learning (Bandura, 1986) and apprenticeship learning (Collins, Brown, & Newman, 1989). On an exploratory basis we determined the differential effects on the design of learning tasks for CBE of a teacher training with a 'classical approach', with a mix of product-oriented WEs and conventional problems, and an alternative training with merely process-oriented WEs.

Method

Participants

The participants were 25 teachers (15 men and 10 women) from 13 different Dutch higher education branches of study. Their mean age was 43.4 years (SD = 7.3 years) and their average teaching experience was 12.2 years (SD = 9.3 years). All participants indicated to have 'some' instructional design experience. The participants were recruited by electronic mail and advertising. The one-day training in the 4C-ID methodology was offered to them in exchange for their participation in the experimental design test after the training.

Materials

The materials used in this experiment consisted of the training materials, two test tasks, three inquiries to measure subject characteristics, experiences with and opinions about the method, a Quality Scale to measure the design performance on the test tasks, including a Quality Scale protocol for determining design performance, and an Application Scale to determine the extent to which the design complies with the 4C-ID methodology. The training materials consisted of the PowerPoint-slides for the basic instruction, which was similar for both conditions

and which consisted of presentation and explanation of the goals, elements, concepts and phases

of the design approach.

The condition-specific materials for the process-oriented worked example (Process-WE) condition consisted of two videotapes, which were produced to show the two design processes carried out by two 4C-ID design-experts. In the first example the design problem was to teach students how to search for literature. Searching for literature is conceived as a complex cognitive skill, that can be decomposed in a more general skill to determine relevant search terms and search criteria meeting the research problem and in the specific technical skills to handle search terms in databases and in searching engines and to determine wether or not search results fit to the criteria and will be relevant to solve the research problems. In the second example the design problem referred to the teaching of a beginning help desk operator how to handle computer problems. This complex skill can be decomposed in technical troubleshooting skills and communicating skills, dealing with clients in a troublesome situation. The videotapes showed how the instructional design experts map the specific competencies in these fields of expertise by interrogating an experienced literature researcher and a help desk officer. The video recording showed a split-screen containing the screen of the computer, the experts used during design and the design expert interacting with the domain expert. A zooming technique was used to emphasize relevant aspects of the design process. Furthermore, for each of the Process-WEs, the materials contained the PowerPoint-slides, which had to support the instructor's review of the rules of thumb, the experts applied in the example.

The condition-specific instructional materials for the Product-WE condition consisted of PowerPoint-slides showing the product-oriented approach for teaching students how to search for literature. It also included a paper with a description of a design problem, with which the participants had to exercise the principles of the worked-out example. This last design problem consisted of teaching a beginning help-desk operator how to handle computer problems.

It should be noted that both of our training strategies were not purely process- or product-oriented, but were characterized by their explicit emphasis on either process-oriented

information or product-oriented information. This means that the process- or product-oriented training strategies, although implicitly, might have included product-oriented or process-oriented information, respectively.

The two test design tasks consisted of a written description of the design problem and the design criteria to be applied. Because of the relatively short training duration the test tasks had to be relatively simple design problems. A second criterion was that the participants should be highly familiar with the skills they had to design instruction for. One test task required the participants to design a training for driving a car. Learning to drive a car is conceived as a complex task, combining recognition of traffic situations, machine operation, geographical and local orientation with proactive attitudes towards other traffic-participants. The second test task consisted of the design of a training for students in the verbal presentation of a final project paper. This training can be considered an important part of the curriculum of higher education. The skill inclused the determination of what is important to communicate with the student's presupposed audience, to 'translate' complex content to the level of understanding of the audience and apply presentation techniques, such as graphical presentation and Powerpoint slides. The design-training of the participants as well as the test tasks were organized in the multimedia test laboratory of the Educational Technology Expertise Center of the Open University of the Netherlands. During the elaboration of the test design tasks by the trainer/experimenter the instructional materials and the task description were available on the participant's computer. The videotapes for the Process-WE condition could be watched in an adjoining room on a large video screen (approximately 100-cm).

Three inquiries were constructed. The first inquiry collected the participants' individual characteristics such as age, teaching experience, and design experience. The second inquiry was developed to collect the personal experience of problems by the participants during the test. It consisted of open questions referring to their success in finding the solution to the design problems, their satisfaction with the design results, the difficulties they met during the test design task, the differences with their current practice, and the usefulness of the trained approach for

their jobs. The third inquiry measured the participants' opinions about the 4C-ID methodology with an open question. It also consisted of 13 Likert-type scale ratings about their perceived insight in the trained approach, the pleasure of studying the approach, the appropriateness of the method to construct CBE, the attractiveness of the approach for them, the ease of learning the approach, their degree of mastery of the methodology, the possibility for them to reuse the method, their need for more training in the methodology, their need for more theoretical background knowledge about the method, the level of resemblance with existing approaches in their school, the estimated ease of explaining the method to colleagues, the level of recommendation of the method to colleagues, and the acceptance of the experimenter's offer for future advise about applying the method to an existing problem.

A Quality Scale was developed to measure the design performance of the participants on the test design tasks. The instrument to be used by design experts, consisted of a five-point scale to rate the quality of the participants' design results. The values and associated verbal labels of the scale were as follows: 0, for absence of material; 1, for very little or hardly quality of design; 2, for little or only partly quality of design; 3, for sufficient quality of design; 4, for excellent quality of design. The scale had to be applied to each of the three design phases of the methodology, hierarchical analysis, task classes and learning tasks. The scale was also used to give an overall rating of the participants' design performance. The scale had to be applied in combination with a rating protocol, which describes the criteria to decide between the different scale values.

An Application Scale was constructed to measure the extent to which the design complies with the 4C-ID methodology. For each step in the design materials of the test task of the participants that matched with the steps shown in the instruction, a score of 1 was given, in absence of this match a score of 0 was awarded. The summation of all scores was considered as an index of compliance with the method.

Design and procedure

An Alternative condition of the training in the 4C-ID methodology was compared to a

'Classic' condition of the same training. In the Classic condition a worked-out example was followed by a practice design problem for which the participants had to generate a solution. The Alternative approach consisted of two videotaped Process-WEs, followed by a recapitulation by the trainer of the used principles and rules of thumb.

In both conditions the same basic instruction and test problems were given, respectively, before and after the differential treatment. The 25 participants were randomly assigned to one of the two experimental conditions, in such a way that the 'classic' and the alternative conditions contained 12 and 13 participants, respectively. The training was given in a classroom setting, in which the participants worked on an individual basis.

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Two experts in instructional design with the 4C-ID methodology were trained in applying the rating protocol to the participants' design materials. Design materials were prepared in such a way that the two experts were unaware of the participants' identity and the experimental conditions. Experts had to rate the design materials independently.

Results

The data set of this experiment consists of the experts' ratings on the Quality Scale, the scores on the Application Scale, the participants' answers on the inquiries to measure subject characteristics, experiences with and opinions about the method. Random attribution of participants to research conditions resulted in 13 participants in the Classic and 12 in the Alternative condition. The differences between the experimental conditions were analyzed non-parametrically, using two-sided Mann-Whitney U-tests. Note that in the results presented below with the statistic M, the Mean rank is meant all over again.

The reliability of the expert ratings was estimated using the Intra-Class Correlation Coefficient as described by Shrout and Fleiss (1979). The average measure Intra-class coefficient

between all paired scores of both experts was 0.71. Cronbach's Alpha was 0.72. The mean score

of the experts was used to determine effects of the different treatments on design performance.

<u>Design performance</u>

With regard to the performance on the test design tasks as measured with the Quality

Scale, the Classic condition performed significantly better than the Alternative condition, as well

for the overall design performance (Alternative $M = 10.1$, Classic $M = 16.1$, $U = 40.5$, $Z = -2.08$,

$p < .038$) as for the design of learning tasks (Alternative $M = 9.6$, Classic $M = 16.7$, $U = 33.5$, Z

$= -2.45$, $p < .014$). No significant between-conditions differences were found for the 4C-ID

phases of creating a hierarchical skill analysis (Alternative $M = 11.6$, Classic $M = 14.5$, $U = 59.5$,

$Z = - 1.02$, $p < .307$) and of the design of task-classes (Alternative $M = 11.0$, Classic $M = 15.1$, U

$= 52.5$, $Z = - 1.43$, $p < .153$).

With regard to the ratings of compliance to the 4C-ID method as measured with the

Application Scale, the results showed a significant difference between conditions in favour of the

Classic condition (Alternative $M = 10.2$, Classic $M = 16.1$, $U =$

41, $Z = -2.017$, $p < .008$).

<u>Inquiries and evaluation</u>

The answers on the first and second after test-task inquiries, which were identical, were

coded as 1) yes, 2) no, or 3) neither yes nor no. No between-conditions differences were found for

the summarized test items about the teachers' perceived success in solving the design problems

(Process $M = 14.1$, Classic $M = 11.9$, $U = 64.5$, $Z = -.86$, $p < .389$), their satisfaction with the

design results (Alternative $M = 14.0$, Classic $M = 11.9$, $U = 65.0$, $Z = -.76$, $p < .446$), and

differences with their current practice (Alternative $M = 13.5$, Classic $M = 12.5$, $U = 72.0$, $Z = -$

$.37$, $p < .710$).

The test task scores with regard to the participants' perceived usefulness of the 4C-ID

methodology for solving problems in their jobs, revealed a significant advantage of the

Alternative condition (Alternative $M = 15.5$, Classic $M = 9.5$, $U = 36$, $Z = - 2.40$, $p < .016$).

Participants' opinions about the 4C-ID method were collected with the third inventory

after the last test design-task. The first item, evaluation of the method, had to be answered with an

open question. The answers on the other items were given on a five-point scale. The answers on

the open question about the 4C-ID methodology were overall positive with some critical remarks

added. The answers on the five-point scale differed significantly with regard to the pleasure the

teachers felt of being trained in the 4C-ID methodology (Alternative $M = 9.3$, Classic $M = 17.0$,

$U = 30$, $Z = -2.96$, $p < .03$) and with regard to the perceived appropriateness of the method to

construct CBE (Alternative $M = 10.4$, Classic $M = 15.8$, $U = 43.5$, $Z = -2.08$, $p < .038$).

No significant between-condition effects (all U-values $> 43,5$, all p's $> . 05$) were found

for the teachers' opinions about their insight in the trained approach (Alternative $M = 12.4$,

Classic $M = 13.7$), the attractiveness of the approach (Alternative $M = 11.9$, Classic $M = 14.2$),

the ease of learning the approach (Alternative $M = 13.5$, Classic $M = 12.5$), the degree of mastery

of the methodology (Alternative $M = 11.7$, Classic $M = 14.3$), the possibility for them to reuse the

method (Alternative $M = 10.5$, Classic $M = 15.8$), their need for more training in the methodology

(Alternative $M = 11.6$, Classic $M = 14.5$), their need for more theoretical background knowledge

about the method (Alternative $M = 12.4$, Classic $M = 13.7$), the level of concurrence with existing

approaches in their school (Alternative $M = 15.6$, Classic $M = 10.2$), the estimated ease of

explaining the method to colleagues (Alternative $M = 14.1$, Classic $M = 11.8$), the level of

recommendation of the method to colleagues (Alternative $M = 12.7$, Classic $M = 13.3$), and the

acceptance of the experimenter's offer for advise about applying the method to an existing

problem (Alternative $M = 13.1$, Classic $M = 12.8$).

Discussion and conclusions

An experiment was set up to compare the effectiveness of a training with process-

oriented worked examples (Process-WEs) to a training with a mix of product-oriented worked

examples (Product-WEs) and conventional problems, for the design of competency-based

education by higher education teachers. Teacher training in the 4C-ID methodology of Van

Merriënboer (1997) with a 'classic' training set-up, consisting of product-oriented worked

examples followed by conventional problem-tasks, has been identified as a viable solution to the

problem teachers experience when requested to design instruction for CBE. After this type of

training, teachers are able to design learning tasks for a competency-based curriculum, (Hoogveld

et al., 2002a). This study was triggered by the growing insight in Cognitive Load theory-based

research, namely that process-based information regarding the 'how' and 'why' of the solution

steps would be beneficial for the learners during training the 4C-ID design methodology. The

current exploratory study compared such an experimental training strategy with process-oriented

worked examples to the previously used 'classic' strategy, a mix of product-oriented worked

examples and conventional problem tasks.

The results based upon expert ratings of the quality of the design materials clearly show

that the overall design and, in particular, the design of learning tasks was better when teachers

were trained with the 'classic' approach with a product-oriented example and practice than with

mere process-oriented worked examples. Consistent with this finding, the results based upon the

measured correct application of the trained steps and parts of the methodology indicated that the

Classic condition outperformed the Alternative condition. Similar results were found with regard

to the participants' perceived pleasure to explore the method and on the perceived usefulness of

the methodology to create CBE. Only one finding seemed to be inconsistent with the general

superiority of the Classic condition, namely, the extent to which the teachers feel that the 4C-ID

methodology provides a solution to design problem in their own school situation. Here the

participants of the Alternative condition showed more confidence. To conclude, this experiment

is a confirmation for the existing evidence that product-oriented worked examples represent a

powerful means of training within CBE.

At first glance one could explain the difference between the conditions as a plausible

effect of the practice component (i.e., the conventional problem) in the Classic condition, which

is absent in the Alternative condition. However, for novice learners the findings of Paas and van

Merriënboer (1994) stipulate the superiority of a training strategy with worked examples only

over a strategy with a mix of worked examples and conventional problems. This might lead to the

expectation that practice alone cannot explain the observed differences. But nevertheless, a

factorial follow-up experiment is needed to further study the effects of product-oriented vs.

process-oriented examples in combination with examples only vs. examples with practice.

Another explanation stems from the fact that the advantage of the classical combination

of product-oriented worked examples may yield a better cognitive load management. Although

the process-based information represents a relevant cognitive load, which can be expected to

improve learning, the combination of the complex design task and the 'how' and 'why'

information might have exceeded the available cognitive capacity of the teachers. In terms of

cognitive load theory this situation can be considered as overload. In future research it would be

interesting to measure the level of cognitive load (Paas, Tuovinen, Tabbers & Van Gerven, 2002)

to validate this assumption.

Another explanation of the results is that the process-based information as verbalized by

the experts was too implicit and contained 'noise'. Whereas the product-based information was

explicitly presented in the product-oriented worked examples, the process-based information was

presented less explicit in a videotaped natural dialogue between the expert and the professional.

As a result of this dialogue the process-based information was also surrounded by information

that was not directly relevant to the task at hand, so called noise. Consistent with this line of

reasoning, video observation learning experiments (Jentsch, Bowers, & Salas, 2001) have shown

that the recognition of relevant expert behavior requires a minimum level of work experience and

that inexperienced people run the change of getting lost in details. In our experiment the teachers

did not have any experience with the 4C-ID methodology and might not have been able to

distinguish between relevant information and details. In future research it would be interesting to

use filtered process-oriented worked examples that only contain relevant information.

Finally, two other explanations are related to the medium used for the process-based

worked examples. In the Alternative condition the learner has to process and remember linear

presented (video) information, without the possibility to go back in the materials, imposing an

extra cognitive load. Secondly, Salomon (1981, 1984) has stated that the depth of mental

elaboration depends on the type of medium. In his view, written or 'digitally' displayed information has a potential to deeper mental elaboration than similar 'analogous' or linear displayed information via radio, television or video. According to Salomon verbally or graphically presented materials also have a higher 'status' for the learner as learning materials than materials representing familiar live situations such as displayed by television. Although, in general, the Classic condition was superior to the Alternative condition, the participants of the latter condition indicated to have more confidence in the 4C-ID methodology as a possible solution to design problems in their educational institutes. A possible explanation of this discrepancy is the fact that the observation of a successful attempt of an expert designing a training in the Alternative condition inspires more confidence than the study of a written product-oriented WE in the Classic condition by themselves. In addition, the participants in the Alternative condition heard how and why certain design steps need to be taken, which might have increased their confidence. These observations suggest that for a training in the 4C-ID methodology to be effective in terms of design skill and confidence about the methodology, it should start with product-based WEs and end with process-based WEs. In future research it would be interesting to investigate the effects of this mixed training strategy.

In summary, although process-oriented worked examples can be argued to represent a promising way of training teachers to design competency-based education, this exploratory study showed that the 'classic' combination of product-oriented worked example and practice with conventional problems are a more effective means for training teachers for this task than merely process-oriented worked examples. In follow-up research it should be excluded that practice was the most important explanation for the differences. Training with video-based process-oriented worked examples further seems to add to the teachers' confidence about the applicability of the design method. Consequently, a mixed strategy, consisting of product-oriented and process-oriented WEs, seems a promising way to support higher education teachers in their struggle to become instructional designers of competency-based education.

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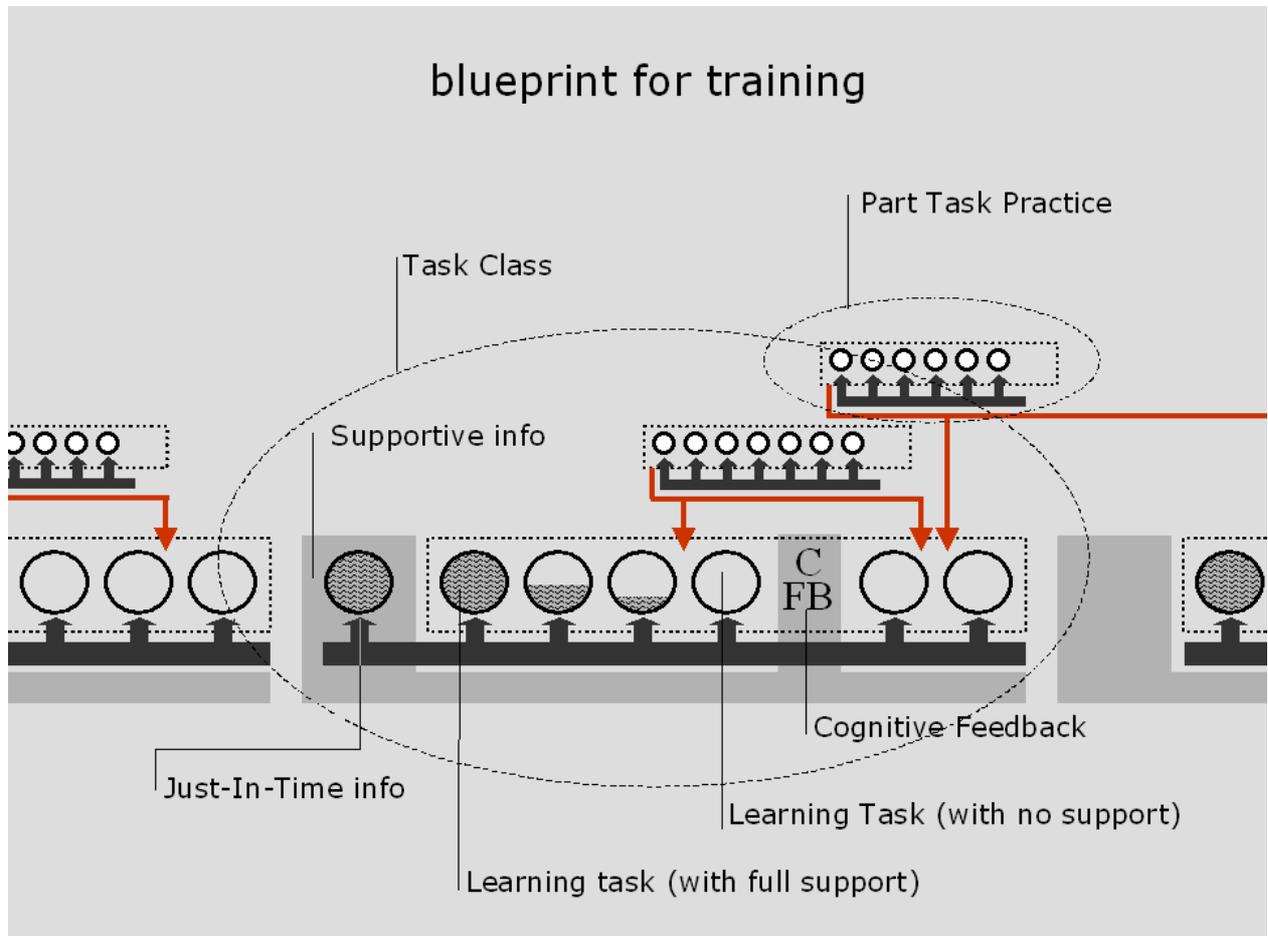*and Instruction, 9,* 257-280.

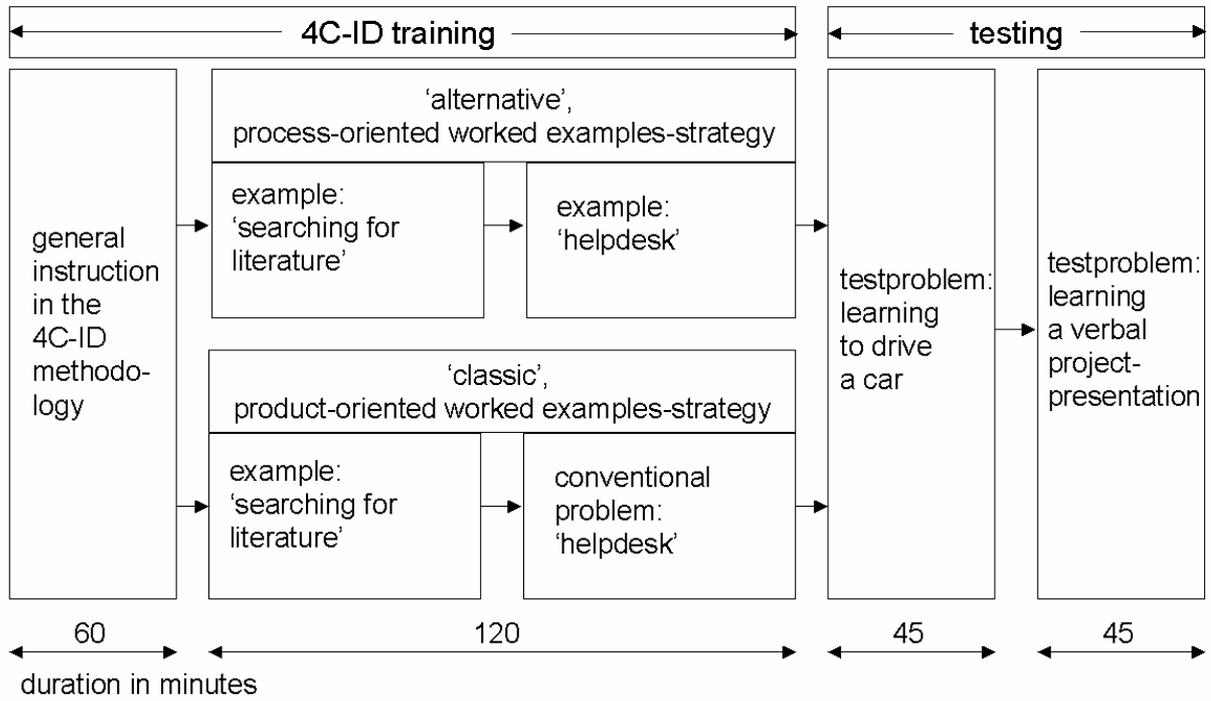*Figure 1* Schematic representation of a training-blueprint created with the 4C-ID methodology.

Figure adapted from: Van Merriënboer, Clark and de Croock (2002).

Figure 2 Experimental design of the study.

blueprint for training

Part Task Practice

Task Class

Supportive info

Cognitive Feedback

C
FB

Just-In-Time info

Learning Task (with no support)

Learning task (with full support)

4C-ID training			testing	
general instruction in the 4C-ID methodo-logy	'alternative', process-oriented worked examples-strategy		testproblem: learning to drive a car	testproblem: learning a verbal project-presentation
	example: 'searching for literature'	example: 'helpdesk'		
	'classic', product-oriented worked examples-strategy			
	example: 'searching for literature'	conventional problem: 'helpdesk'		

60   120   45   45

duration in minutes