Contemporary Educational Psychology **27,** 229–249 (2002)
doi:10.1006/ceps.2001.1089, available online at http://www.idealibrary.com on IDEAL®

Cueing for Schema Construction: Designing Problem-Solving Multimedia Practicals

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Published online November 29, 2001

In competency-based learning environments, schemata play an important role in solving complex and authentic problems. Adequate *task-valid cueing* is considered to facilitate both recall and interpretation of available schemata (task performance) and the construction of new schemata (learning). This article provides guidelines for cueing which aim at the improvement of (1) task performance in complex learning environments, (2) schema construction, and (3) monitoring. A model presents the relationships between cueing on the one hand and schema interpretation, schema construction, and monitoring on the other hand. The guidelines are used to evaluate *worked-out examples* and *process worksheets,* two formats of task-valid cueing that appear useful in competency-based learning environments. Worked-out examples support the inductive processing of concrete descriptions to construct schemata, while process worksheets support the deduction of concrete problem solving steps from general prescriptions. Illustrations are provided from the domain of law.

Key Words: schema construction; cueing; complex problem-solving; competence; electronic learning environments.

Graduates from higher education should be able to apply acquired knowledge and skills in their professional domain. They should demonstrate sufficient problem-solving ability to handle complex tasks in a variety of authentic situations (Brown, Collins, & Duguid, 1989; Jonassen, 1991). The ultimate goal of higher education is the achievement of competence, and the associated form of learning is called *competency-based learning*. We define competence as the whole of knowledge and skills which people have at their disposal and which they can efficiently and effectively use to reach certain goals in professional situations (Kirschner, Van Vilsteren, Hummel, & Wigman, 1997).

Solving complex problem tasks may be seen as a form of competency-

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0361-476X/01 $35.00

based learning, where available schemata have to be recalled and interpreted and more efficient schemata have to be constructed. *Schemata* are cognitive structures that relate task characteristics to each other and to approaches to solve problems (Gagné, Yekovich, & Yekovich, 1993). Adequate cueing provides learners with information about the task, which facilitates both interpretation and construction of schemata.

Instructional guidelines on adequate cueing appear to be scarce. Effects of cueing have primarily been studied in contrived experimental learning situations in the form of outcome feedback, provided after a learner responds to relatively simple and self-contained tasks (e.g., Mory, 1996). Results from these studies cannot be used for competency-based learning environments that are based on more complex and interrelated tasks with diverging solutions. We should therefore reexamine cueing within a paradigm where learners must actively interpret and construct schemata while solving these complex and authentic tasks. In other words, it should provide support for learners to create meaning and internal reality of their own and not simply for accepting someone else's single reality.

Cueing supports both performance and learning when it takes the form of *task-valid* cognitive feedback (e.g., Balzer, Doherty, & O'Connor, 1989), i.e., containing information about task characteristics and the state of task execution. Recent research (e.g., Narciss, 1999; Whitehall & McDonald, 1993) shows a positive effect of task-valid cueing on the interpretation of available schemata; a larger amount of task-valid information in cueing leads to better *performance* on the complex task. Balzer, Doherty, and O'Connor (1989) show that task-valid cueing improves *learning* to continuously monitor the adequacy of available schemata and the necessity to construct more efficient schemata. We provide guidelines to determine what constitutes adequate cueing and describe how cueing relates to schema interpretation, schema construction, and monitoring in a model. To achieve this, the structure of the article is as follows.

Tasks and Cueing in Complex Learning Environments describes the kind of tasks and possible formats of cueing in Competency-Based Multimedia Practicals (CMP). As an example of such an environment we use the CMP ''Preparing a Plea'' (from the domain of law), where students are taught to prepare the pleading of a case in court. Four formats of cueing are distinguished, depending on the orientation (either process- or product-oriented) and the information (either abstract or concrete) they contain: worked-out examples, modeling examples, templates, and process worksheets.

Cueing and Schema Interpretation describes how cueing facilitates the interpretation of available schemata in complex task performance when it (a) reflects the complexity of the task, (b) serves as an embedded support device, and (c) makes learners persevere in attaining the goal competency.

Sometimes available schemata appear insufficient to solve a problem and new, more efficient schemata need to be constructed. Cueing and Schema Construction describes how cueing facilitates schema construction when it (a) reflects the relations between task characteristics, (b) saliently presents these task characteristics, (c) facilitates cognitive transfer, (d) optimizes available working memory, and (e) is presented just-in-time. We argue why a combination of process worksheets (process/abstract) and worked-out examples (product/concrete) appears most suitable to facilitate schema construction.

A learner continuously monitors whether cues can be understood by interpreting available schemata or new schemata need to be constructed. Cueing and Monitoring describes how cueing facilitates monitoring when it (a) stimulates evaluative questioning during problem solving, (b) provides information about the progress, and (c) provides information about intermediate results. The relations between cueing, schemata, monitoring, and learning outcomes are brought together in a model for schema construction.

Finally, the discussion contains a preliminary assessment of the suitability of process worksheets and worked-out examples for competency-based learning. Indicative findings with ‘‘Preparing a Plea’’ are related to future research on timing and orientation of cueing in CMP. Table 1 shows the list of guidelines, each of which is explained in the upcoming sections.

TASKS AND CUEING IN COMPLEX LEARNING ENVIRONMENTS

Complex and authentic tasks can be performed in CMP. They provide realistic situations in which meaningful learning through contextualized practice takes place (e.g., Brown, Collins, & Duguid, 1989). According to the four-component instructional design model for training complex skills (4C/ID model; Van Merriënboer, 1997), in complex learning both recurrent (procedural) constituent skills and nonrecurrent constituent skills, for which the desired behavior is highly contextually dependent, have to be acquired and combined. Mastering *nonrecurrent constituent skills* especially requires schema construction, since the application varies from problem situation to problem situation. Mastering *recurrent constituent skills* especially requires schema automation, since the application is the same for different problem situations. Attaining an integrated set of these constituent skills is referred to as the ‘‘*goal competency,*’’ for which transfer should occur from problem situation to problem situation.

Kind of Tasks in CMP

Tasks within CMP typically have a well-defined begin state, many possible pathways, and not a well-defined end state, but well-defined constraints. Such tasks can be extremely large, but usually have a study load of about 30–50 h. The task itself can be practiced as a whole, provided that the necessary support is given to the learners. Examplary tasks are Identifying envi-

TABLE 1
Relations between a Number of Conditions in Complex and Authentic Problem-Solving Tasks and Guidelines for Effective Cueing

(if . . .) Conditions in complex tasks	(. . . then) Guidelines for adequate cueing
Complex learning	
1. The task is complex	Cueing should reflect task complexity
2. There is a need for performance support in the complex learning environment	Cueing should serve as an embedded support device in the learning environment
3. Learner's inclination to comply with the task assignment needs to be increased	Cueing should (a) not be disparate from the targeted competence and (b) induce perseverence in attaining this
Schema construction	
4. Complex relations exist between tasks and subtasks	Cueing should reflect the relations between and within tasks
5. Relations between task characteristics can be made clear	Cueing should be task ordered and saliently describe relevant task characteristics
6. Task characteristics can be related to approaches that are applicable to a variety of tasks	Cueing should both support practice and facilitate cognitive transfer
7. Mental effort needs to remain within threshold working load capacity	Cueing should redirect attention from extraneous to germane processes in optimizing available working memory
8. Task characteristics determine when schemata need to be constructed or used	Cueing should be presented just-in-time, depending on the task characteristics
Monitoring	
9. Self-oriented and goal-oriented complex learning needs evaluative questioning	Cueing should induce or provide evaluative questioning of the learning process
10. Information on how to proceed in task execution is needed	Cueing should provide elaborated (task-valid) information on how to proceed (e.g., about completeness/correctness)
11. Progress in the execution of complex tasks needs assessment	Cueing should contain task-valid information about attaining (intermediate) stages in the task execution

ronmentally protected areas (soil science) (Ivens et al., 1998), Modeling stress factors that cause mental overload in workers (labor psychology) (Gerrichhauzen et al., 1998), and Selecting a suitable employee (personal assessment) (VanderMeeren et al., 1997).

We draw examples from the CMP ''Preparing a Plea'', which teaches students to prepare a plea in court (Wöretshofer et al., 2000). The systematic approach to the problem (SAP) of ''pleading a case X in court'' consists of nine steps (or subtasks), in which constituent skills are practiced and combined: (1) ordering the file of case X, (2) getting acquainted with the file,

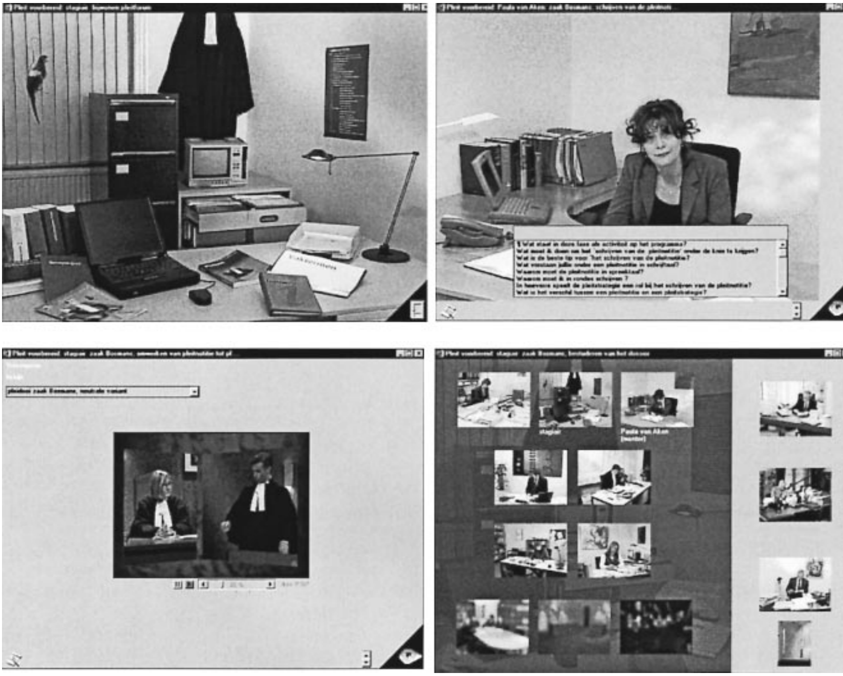

FIG. 1. ‘‘Preparing a Plea’’: An example of a CMP in the domain of law. The learner is given the role of trainee or junior lawyer in a (virtual) legal firm. He or she must prepare a plea for various cases. A (virtual) mentor introduces the way a plea should be prepared and comments on various activities of the learner during preparation. Clockwise you find the following virtual environments: The trainee’s office (where he/she can look into the file cabinet, the mailbox, or e-mail reports on tasks to the mentor), the mentor’s office (where the trainee may go to ask questions), an overview of external experts and colleagues within the law firm that learner can consult, and a videoplayer on which the trainee can observe—both good and bad—examples of pleas by others with the help of a ‘‘plea-checker.’’

(3) studying the file, (4) analyzing the plea situation, (5) determining the strategy for plea nota and plea making, (6) writing a pleading note, (7) transforming the plea nota into a plea, (8) practicing the plea, and (9) actually carrying out the plea. The first seven subtasks are practiced and controlled individually by means of the CMP; the last two are practiced and controlled by means of role play. Figure 1 presents some of the screens a learner may encounter in ‘‘Preparing a Plea.’’

Formats of Cueing in CMP

The term ‘‘cueing’’ was introduced in Brunswik’s (1956) lens model. In that model, both characteristics of tasks and learners’ progress on tasks are described in terms of a set of features or a profile of *cues*, used to predict final performance. According to Wood (1986) the execution of complex tasks involves a multiplicity of cues, a high degree of coordination among cues, and changing relations between cues. Cues provide information about the attributes of multiattribute objects of judgments in complex tasks. Schemata can represent the relations within and between these multiattribute objects.

More specifically, *task-valid cueing* contains information about task characteristics and their relations. On the one hand, it can be either process oriented (e.g., a heuristic or a SAP) or product oriented (e.g., a semantical network or a contents table). On the other hand, it can give either abstract or concrete information about the task. These aspects can be operationalized by four different formats of cueing (see upper box in Fig. 2): (1) concrete, product oriented cues, like worked-out examples (in ‘‘Preparing a Plea’’ this could be a completely worked out pleading note); (2) concrete, process oriented cues, like modeling examples (in ‘‘Preparing a Plea’’ this could be a demonstration of how to write a pleading note); (3) abstract, product oriented cues, like templates (in ‘‘Prepearing a Plea’’ this could be a standard contents table of a pleading note); and (4) abstract, process oriented cues, like process worksheets (in ‘‘Preparing a Plea’’ this could be a list of questions to be answered to write a pleading note).

Templates and process worksheets are more abstract formats of cueing that are generally applicable in a variety of tasks. Templates reflect the commonalities in a set of worked-out examples (e.g., each pleading note should consist of an introduction, a body of content, and a final conclusion). Process worksheets reflect the commonalities in a set of modeling examples (e.g., leading questions that must be answered in order to draw up each pleading note). Worked-out examples and modeling examples are more concrete formats of cueing, offering a lot of context of the specific task at hand, but making it more difficult to discover standard structures or approaches that can be more generally applied.

Process worksheets (abstract, process oriented) and worked-out examples (concrete, product oriented) are expected to differ in their effects on schema construction and learning outcomes, are both found in CMP, and can be considered useful from the perspective of the 4C/ID model (Van Merriënboer, 1997) and in relation to Cognitive Load Theory (Sweller, 1988). In addition to this, ‘‘traditional’’ education has concentrated on the second, while ‘‘new’’ education now focuses on the first. We now present an example of both formats.

In the CMP ‘‘Preparing a Plea’’ many task characteristics have to be considered in each step of the SAP, some of which are interrelated. For each step learners are offered a *process worksheet* (PW) with leading questions. For instance, when analyzing a pleading situation (step 4) in order to draw up a plea inventory, some of these questions are as follows:

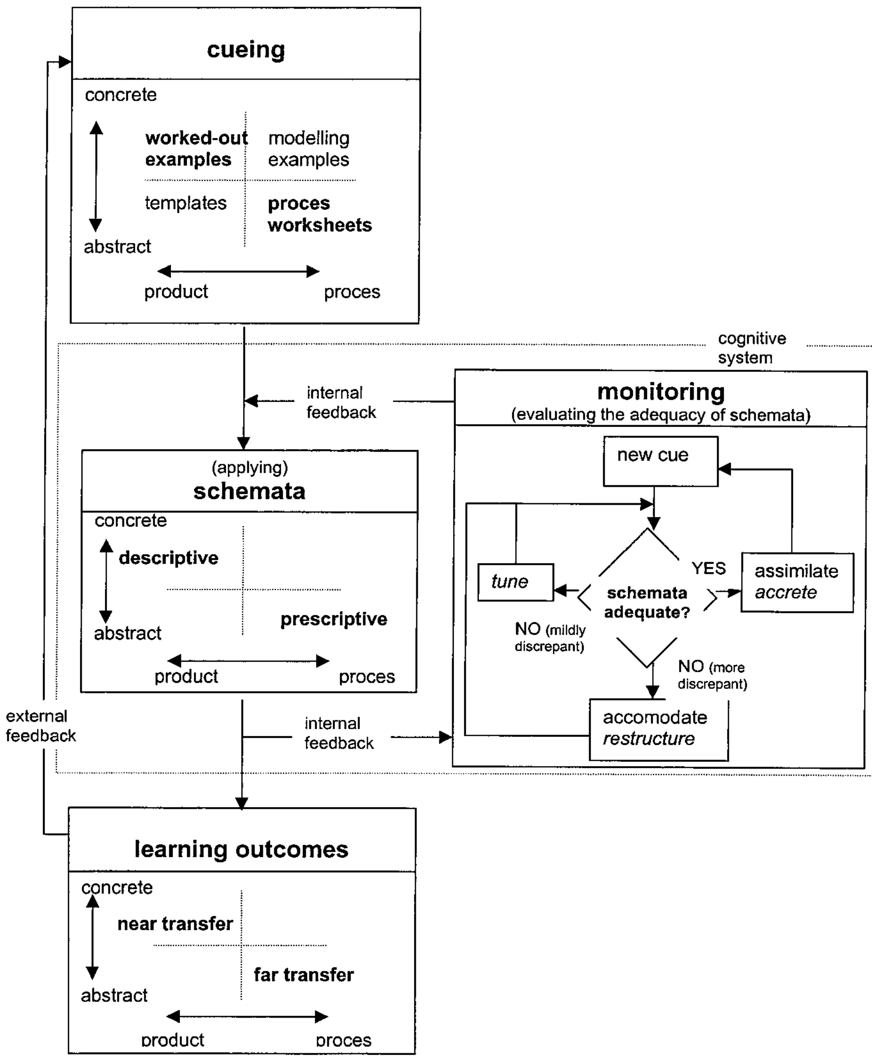

FIG. 2. Model for schema construction.

4a. What are the most important arguments of the opposing party?
4b. Could you refute these arguments? If so, how?
5. Which articles of the law are of importance for this case?
6. Which criteria should be fulfilled?
7. What are the judicial consequences if these criteria are/are not fulfilled?
8. Which judicial consequence suits your client the most/the least?

At the end of each step learners can compare their reports with *worked-out examples* (WOE) of the mentor to find out how an expert would deal with the questions in the PW. For instance, (a part of) the plea inventory (step 4) might look like this (article numbers referring to Dutch law):

5. Which articles of the law are of importance for this case?
   Art. 6:265 BW: in case of dissolution of agreements
   Art. 6:271 BW: relating to overrulings (of disqualifications)
   Art. 6:98 BW: relating to the amount of the compensation
   Art. 6:74 BW: relating to the compensation
   Art. 6:75 and 6:78 BW: relating to circumstantial evidence and accountability
6. Which criteria should be fulfilled?
   Relating to shortcomings in the compliance:
   1. the demand is claimable (6:38–6:40 BW)
   2. compliance stays out or is carried out in a inferior way. To establish this the content of the obligation concerned needs to be examined accurately (art. 3:33, 3:35, 6:2, 6:248 BW)
   3. no compliance is not justified by an appeal on the authority to suspend

   Relating to dissolution (6:265 BW):
   1. there has to be a mutual agreement
   2. there has to be a shortcoming in the compliance

CUEING AND SCHEMA INTERPRETATION

Problem solving in a complex domain has been characterized as first recalling appropriate schemata available in long-term memory and then interpreting these schemata within the specific parameters of the problem at hand (Chi, Feltovich, & Glaser, 1981). Recalled schemata determine how the problem is solved because they determine what conceptual knowledge is used to elaborate the problem statement and what approaches are used to solve the problem (Gagné, Yekovich, & Yekovich, 1993). Schemata have a dual function in complex learning: (a) They support the storing/retrieval of information in/from long-term memory and (b) reduce the burden on working memory (by allowing multiple elements of information to be treated as a single element or chunk). Adequate cueing provides learners with opportunities to examine the adequacy of schemata based on information about the task characteristics and the state of task execution. We now give guidelines for cueing that facilitate the recall and interpretation of schemata held in long-term memory by (a) reflecting the complexity of the task, (b) serving as an embedded support device, and (c) increasing the inclination to comply with task assignments.

Cueing Should Reflect Task Complexity (1)

What makes a learning task a complex one? This article focuses on the *component* complexity of the task, operationalized by the number and form of information cues and judgments *within* the steps a learner takes during task performing (Wood, 1986). Learners should realize that authentic learning tasks require more judgments based on multiple cues. For instance, an experienced lawyer drawing up a draft version of a plea to be held in court weighs a variety of both communicative and legal criteria which are often contradictory.

Cueing Should Serve as an Embedded Support Device (2)

Novice learners are unfamiliar with the complex problems presented in CMP and do not yet know how to approach them. The problem tasks representing the goal competency can be practiced as a whole, provided that necessary support is embedded in the learning environment. This article focuses on adequate task-valid cueing *within* the specific (nine) steps or subtasks identified in the SAP described above. Cueing should serve as an embedded support device (Martens, 1998) in the learning environment and give direction to the problem-solving process. Here, the term ‘‘performance constraint’’ is probably more appropriate than the term ‘‘performance support.’’ We could compare this kind of support with training wheels on children's bikes, which prevent them from falling over (Carroll & Carithers, 1984). Cueing should be an important training wheel in CMP, while others are task decomposition and sequencing. [Nadolski, Kirschner, van Merriënboer, and Hummel (in press) present an ID model that offers guidelines for optimizing the size and sequence of steps in CMP.]

Cueing Should Increase the Inclination to Comply with the Task Assignment (3)

In complex learning environments it is important that task-valid information is processed successfully and that learners are motivated to persevere in attaining the ‘‘goal competency.’’ Cueing should be used to support learners in successfully processing the information and attaining that competence, if we consider cues to be mathemagenic agents that can give birth to learning and positively influence what and how something is learned.

According to Rothkopf (1996), ‘‘instructional events’’ induce a targeted competence in at least some learners in at least some situations at least some of the time, and three variables determine the inclination to successfully process an instructional event once it has been encountered, namely (a) disparity between the representation of instructional information and the representation of the targeted competence, (b) persistence of elicited mathemagenic activity, and (c) instruction-relevant experience (and knowledge) of the learner. We recommend cueing to increase the likelihood of competent executions of tasks by providing information about those tasks that resembles the targeted learning processes and outcomes as closely as possible and directs and motivates learners to act as they are supposed to. Cueing should (a) not be disparate from the targeted competence and (b) provide learners with experiences (information, events, and happenings) to persevere in attaining that competence.

CUEING AND SCHEMA CONSTRUCTION

Restraining to familiar schemata can inhibit learning and result in surface processing of information instead of deep, meaningful processing. Unfamiliar problems require learners to construct new, more efficient schemata. Chi, Feltovich, and Glaser (1981) found that the ability to solve problems is not a sufficient condition for the construction of more efficient schemata. Subjects who solved problems with relative ease were unable to abstract from their solutions the (more general) principles and approaches used in solving these problems. Cueing should focus learners' efforts on these principles (e.g., leading questions in PW), provide additional information about the solutions (e.g., explicating relations in WOE), help abstract more general problem-solving approaches, and construct more efficient schemata. In this section we give guidelines for cueing that facilitate the construction of more efficient schemata by (a) reflecting relations between and within tasks, (b) saliently presenting task characteristics, (c) facilitating cognitive transfer, (d) optimizing available working memory, and (e) facilitating just-in-time presentation.

Cueing Should Reflect the Relations between and within Tasks (4)

The tasks in CMP are solved by following SAPs that are valid for more problem situations within the same domain and beyond (Van Merriënboer, 1997). SAPs indicate the relations *between* subtasks, and sub-SAPs indicate the relations *within* subtasks (between sub-subtasks). The sub-SAPs in ''Preparing a Plea'' are manifested in a PW for each step, providing information about the principles, concepts, and rules of that specific step. The relations between task characteristics and more general principles are referred to as problem's ''deep structure'' (e.g., Dufresne, Gerace, Thibodeau-Hardiman, & Mestre, 1992). These deep structure features embody the relations that exist within the subtask and between the sub-subtasks. For instance, in following the PW for drawing up a plea inventory you have to answer some questions before being able to move on to the next.

Cueing Should Saliently Present Relevant Task Characteristics (5)

For transfer to occur the essential principles of problem's deep structure should be presented to the learner very clearly. Learners should not be left guessing too long which task characteristics should be chosen as the most relevant or critical ones, especially in complex tasks where there is a large amount of both relevant and irrelevant or even misguiding characteristics involved. According to Phye (1990) this saliency requirement is more likely to be met when (sub-)tasks are ordered by type and accompanied by cueing that describes the critical features of these (sub-)tasks. For instance, in ‘‘Preparing a Plea’’ cueing is task ordered around steps in the preparation of a plea and directed at the intended outcomes of these steps (e.g., a plea inventory after step 4).

Studies of problem categorization (Dufresne et al., 1992) indicate that experts view two problems as similar when the same deep structure features could be applied to solve both problems, whereas novices view two problems as similar when the problems share surface structure features, such as terminology or objects. They argue that this deep structure should be made salient.

Cueing Should Facilitate Cognitive Transfer (6)

Mastering complex skills requires highly variable performance over situations, far transfer skills for which the desired exit behavior depends on the problem situation. Therefore, cueing should reveal problem’s deep structure for a variety of problems. Cueing should highlight the importance of the initial classification of problems by asking the user to identify the applicable principles and asking to focus attention on concepts and procedures by which principles are instantiated (Chi et al., 1981). We advocate that cueing should be both specific enough to represent all relevant aspects of the (training) task during practice and at the same time be applicable to a variety of (criterion) tasks within or even beyond the training context.

Cueing Should Optimize Use of Working Memory (7)

Task-valid cueing should be used for (a) optimizing working memory and (b) improving learning efficiency. Since complex tasks make severe demands on the cognitive capacity of the learners (problems are ill-defined, multi-attributed, and have contradicting and misguiding cues and diverging solutions, and so on) instruction should be optimized in such a way that working memory is capable of processing information and propagating schema construction at the same time. A brief description of Cognitive Load Theory will explain this.

Working memory load may be affected by (a) the intrinsic nature of the material (causing *intrinsic cognitive load* on the learner), (b) the manner in which the material is presented and learning activities are guided, and (c) the effort invested by the learner (Sweller, Van Merriënboer, & Paas, 1998). *Extraneous cognitive load* is the additional effort required to process poorly designed instruction. *Germane cognitive load* reflects learners’ efforts in actual learning that, in particular, contribute to the construction and mindful abstraction of schemata. Instruction should decrease extraneous cognitive load (e.g., by providing cueing that focuses attention) in order to make it possible for germane cognitive load to increase (e.g., by providing cueing that offers anchorpoints for the learning task), but only if the total cognitive load stays within limits (threshold working memory load). Redirecting attention from extraneous to germane processes improves the balance between learning efficiency (i.e., cognitive load and schema construction during training) and improved transfer test performance. Several studies have identified guidelines for reducing extraneous cognitive load, but few have focused on inducing germane cognitive load (Sweller et al., 1998).

Cueing Should be Presented Just-in-Time (8)

Just-in-time (JIT) presentation of cueing can be effective for (a) optimizing working memory and (b) improving learning efficiency. Available results on immediate and delayed cueing (e.g., Kulik & Kulik, 1988) need reexamination for more complex and authentic problem-solving tasks. We expect that the ‘‘teachable moment’’ of such cueing may depend not so much on the information, but on the task characteristics and the stage of task execution.

According to the 4C/ID model (Van Merriënboer, 1997), nonrecurrent constituent skills require supportive knowledge (heuristics or models) that is best presented *before* practicing sets of interrelated tasks. JIT presentation of supportive information induces schema-based behavior since the learner connects new information to available cognitive schemata, making them more efficient. Recurrent constituent skills require prerequisite knowledge (facts, concepts, and principles) that is best activated *during* task practice. JIT presentation of prerequisite information during practice induces rule-based behavior and schema automation. The final purpose of whole task practice in CMP is schema construction and schema-based behavior, the ability to perform unfamiliar (far transfer) task aspects because of the availability of cognitive schemata. The availability of generalized, more abstract cognitive schemata is revealed by higher performance on task transfer to new situations.

Comparing PW and WOE

At this point we argue why PW and WOE appear suitable for facilitating schema construction. Both PW and WOE in CMP are ordered by subtask and reflect the relations of important task characteristics (guideline 4). However, in PW critical features of subtasks are presented more saliently (guideline 5).

The demand for transfer (guideline 6) constitutes an optimization problem between offering PW and WOE, depending on the characteristics of the learner. Novice learners still need the support of more concrete, product-oriented cueing, containing a lot of surface features about the task (e.g., objects and terminology). WOE directly support training practice by providing concrete information about the context and facilitate the construction of ‘‘rich,’’ descriptive schemata that lead to near transfer on tasks in a similar context, like preparing a plea for another case in the same type of court (and consequently provide less support for far transfer). More expert learners benefit more from more abstract, process-oriented cueing that embodies the ‘‘deep structure’’ of the subtask (Dufresne et al., 1992). PW provide an approach that is generalizable to a larger variety of tasks and facilitate the construction of ‘‘broad,’’ prescriptive schemata that lead to far transfer on tasks in another context, like preparing a plea in a different type of court (e.g., criminal vs civil) outside the training context (and consequently provide less support for near transfer). In Fig. 2 the relations between cueing, schemata, monitoring, and learning outcomes are shown in our model for schema construction (the content of the monitoring box is explained in the upcoming section).

Both PW and WOE could increase germane cognitive load and decrease extraneous cognitive load at the same time (guideline 7), since they focus learners’ attention on relevant questions and features in the solution and restrain them from searching through irrelevant information. However, the suitable format of cueing depends on the task characteristics: Is the task process or product oriented? Does the task require abstract or concrete information?

Finally, both PW and WOE can be provided just-in-time (guideline 8). Timing of cueing depends on task characteristics and stage of execution of the subtask. PW contain more supportive information that is best provided before practice. WOE may contain more prerequisite information that is best provided during practice or after practice (as important input for the next subtask or step).

In the next section we consider the role of monitoring in complex learning. Cueing should get monitored in relation to the problem-solving process, and guidelines should also address this process of cognitive monitoring.

CUEING AND MONITORING

In review studies (Boekaerts & Simons, 1993; Pintrich, 1999) monitoring is considered to be an important predictor of complex learning outcomes. Cueing can facilitate monitoring, leading to more efficient learning and better (deeper, more meaningful) learning outcomes. When describing formats of cueing, each format was considered as a whole. In fact, this cueing always consists of several cues (i.e., several critical features in a WOE or several leading questions in a PW). Each cue is a piece of new information that should find its place in available cognitive schemata. Every cue gets monitored in relation to the problem-solving process: Is this information new and usable for this problem? Where can this new information be attached? Should available schemata be modified?

This section describes the internal feedback processes (see Fig. 2) within the cognitive system that make up this continuous monitoring process. Cognitive monitoring, for the most part, deals with constantly (for each cue) evaluating and adjusting the adequacy of available schemata (assimilation) and integrating new elements into more adequate schemata (accommodation).

Guidelines for Cueing and Monitoring

Rumelhart and Norman (1978) distinguish three qualitatively different modes of learning: accretion, tuning, and restructuring. In complex learning the first step is the accretion (merely addition) of information in currently available schemata (similar to Piaget's assimilation) to create a reasonable database of knowledge, followed by the construction of new schemata (restructuring) to organize these data structures appropriately (similar to Piaget's accommodation). Then, continued learning consists of further tuning of those schemata (and possibly restructuring of schemata, which in turn have to be tuned). Whether schemata need to be restructured or merely tuned depends on the discrepancy of the arriving cue and the available schemata. If this information is only mildly discrepant, tuning of schemata may be sufficient; if the information is more discrepant, restructuring of schemata is required.

We now give guidelines for cueing that promotes these monitoring processes by (a) stimulating evaluative questioning, (b) providing information about the progress, and (c) providing information about the intermediate results.

Cueing Should Induce or Provide Evaluative Questioning (9)

Monitoring has to do with constantly (for each incoming cue) asking about the adequacy of available schemata, and cueing should promote this process of continuous evaluative questioning. According to Ertmer and Newby (1996) problem solvers, on the one hand, evaluate by asking themselves *outcome-oriented questions,* like ''How reasonable and accurate is the product that resulted from the learning task?'' and ''To what extent is the goal achieved (already)?'' Product-oriented formats of cueing (like WOE) are most adequate in supporting this type of evaluative questioning. On the other hand, they also ask themselves more *process-oriented questions,* like ''How effective has the overall process been (so far), as well as its supporting steps in achieving the goal (e.g., correctness of used schemata and efficiency of used approaches)?'', ''Which obstacles were encountered?'', ''How well were they anticipated, avoided, or managed?'', ''How effective and efficient is the overall plan?'', and ''Should it be modified to use with similar tasks in the future?'' Process-oriented formats of cueing (like PW) are most adequate in supporting this type of evaluative questioning.

Cueing Should Provide Information on How to Proceed (10)

If learners can link cueing with intermediate achievements, they will feel supported in their monitoring. Cueing should enable learners to examine progress in their problem solving (e.g., Whitehall & McDonald, 1993). For instance, a PW may concern relevant features of the task, but also consecutive questions or steps within the task. Through the use of such PW the learner acquires schemata that enable him or her to reflect on the quality of the problem-solving process. PW provide best support for an evaluation of the *completeness* of used schemata, since learners can check which criteria or questions have been checked or answered during the learning process, while the *correctness* of a solution can best be assessed with WOE.

Cueing Should Contain Information on Intermediate Stages (11)

Cueing should be related to the targeted performances and products. Cueing should not only resemble these outcomes (guideline 3) and provide information about the progress (guidelines 9 and 10), but preferably also contain information about milestones during the task execution so that learners can assess (intermediate) solutions at various stages of task execution.

For instance, while ordering documents in a law file (step 1), the correct number of documents in submap ''documents in the case'' is (just) one cue that predicts the targeted performance, i.e., a correctly ordered law file. Values for this single cue might be ''there aren't any documents yet,'' ''about half of the documents is still missing,'' and ''ordering is nearly done.'' Other cues for performance on this task might be the correct (e.g., chronological) ordering within the submap ''documents in the case,'' the number of correctly filed documents in other submaps, and the ordering of those documents (e.g., correspondence and notes on telephonic or other communication). Cues can correlate with each other. Each cue alone, and the set of cues together, may predict whether this trainee will ultimately achieve a correctly ordered lawfile.

FIRST EXPERIENCES WITH CUEING IN DEVELOPING THE CMP "PREPARING A PLEA"

At the end of the development of ''Preparing a Plea'' a field trial was carried out with a Beta-release to determine the instructional effectiveness of provided cueing and stepsize. Students were given the same tasks and version of the CMP and were questioned about their appreciation of provided cueing. In this Beta-version PW are given at instruction (feedforward), and WOE are given after learner reports have been submitted (feedback).

Method

Participants, Materials, and Procedure. A small group of sophomore law students (N = 12) was selected at random from both the Open University of the Netherlands (OUNL), an institution offering distance education for a heterogenous population of students varying in age, of which most have a steady job while studying (a subgroup of 2 male and 4 female students had no plea experience at all), and the University of Maastricht (UM), an institution offering contact education (project-oriented) to 18- to 23-year-old students (a subgroup of 2 female and 4 male students with some plea experience as members of a debating club). The CMP was developed for use by students without plea experience.

Learner reports within the CMP and study times on the CMP were collected by log files, and pleas were scored and videotaped. Learning reports are filled-in process worksheets that have to be sent to the virtual mentor. In the CMP these (intermediate) products are not used for assessment. For research purposes, however, we have extracted them from the program and assessed them. A jury consisting of three persons (two teachers and one trainer) scored students' results on the pleas.

All field-trial students were sent a questionnaire afterward, to be returned within 3-weeks, and offered the prospect of receiving a videotape of their plea(s) during the role play sessions (as was promised during the field trial) and a small company gift on CD-ROM (as was promised when sending the questionnaire). We received all questionnaires back. Data were collected on *subjective* appreciations of aspects of both step size and complexity of (sub-)tasks (Nadolski, in press) and the timing and orientation of cueing.

Results and Discussion

Study times, learner reports, and pleas. Study times and learner reports of 8 students (equally divided over subgroups) could be collected and analyzed. Study times show large variations, e.g., on the law file ‘‘Bosmans’’ they range from 40 to 664 min ($M = 341$, $SD = 134$). Means of OUNL students ($M = 499$, $SD = 213$) and UM students ($M = 134$, $SD = 52$) differ significantly, with Mann–Whitney's $U = 6.5$, $p = .01$.

Learner reports show that most students followed the SAP and worked their way through consecutive steps, using the PW and WOE provided. Since we did not require students to work out and submit intermediate learner reports, this route was taken on a voluntary basis. The quality of learner reports and pleas was sufficient, according to the assessments of content experts involved. All students completed the CMP successfully and were, according to the jury, able to conduct a plea in court. However, validated instruments to assess the quality of reports and pleas were lacking during the field trial.

Questionnaires. All students reported to have been highly motivated ($M = 3.4$, $SD = 0.6$) and self-confident while preparing the plea ($M = 2.9$, $SD = 0.6$) and to have enjoyed working through the CMP, appreciating the general setup of the program. Male students reported feeling significantly more self-confident during the study than female students ($U = 10$, $p = .03$), while OUNL students were less confident than UM students ($U = 12$, $p = .09$) (but about equally motivated). Students' mean scores on items on cueing are listed in Table 2.

Students report that information (in general) was helpful ($M = 2.5$, $SD = 0.9$) while studying the CMP. Timing of cueing was considered adequate both for PW ($M = 1.9$, $SD = 0.3$) and WOE ($M = 2.7$, $SD = .61$). Both PW and WOE were found helpful while executing subtasks ($M = 2.9$, $SD = .61$ and $M = 2.9$, $SD = .83$), for understanding the executed subtasks ($M =$

TABLE 2
Students' Appreciations of Relevant Items (Translated and Abbreviated) in the Questionnaire

Results	Students (N = 12)	
	M	*SD*
Item 1. Motivational level at work [1(low) − 4(high)]	3.4	0.6
Item 2d. SAP is not necessary to hold pleading [1(disagree) − 4(agree)]	2.4	1.1
Item 5. Confidence level at work [1(little) − 4(much)]	2.9[a]	0.6
Item 6. Information (in general) is helpful [1(little) − 4(much)]	2.5	0.9
Item 7a. Timing of PW [1(inadequate) − 2(adequate)]	1.9	0.3
Item 7b. Timing of WOE [1(inadequate) − 3(adequate)]	2.7	0.6
Item 8a. WOE are helpful for understanding tasks [1(disagree) − 4(agree)]	2.9	0.8
Item 8b. WOE are helpful for executing tasks [1(disagree) − 4(agree)]	2.8	0.6
Item 8c. PW are helpful for executing tasks [1(disagree) − 4(agree)]	2.9[b]	0.6
Item 8d. PW are helpful for understanding tasks [1(disagree) − 4(agree)]	3.0[b]	0.7
Item 9a. WOE are helpful during study [1(disagree) − 4(agree)]	3.1	0.7
Item 9b. PW are helpful during study [1(disagree) − 4(agree)]	2.7	1.0

[a] With UM students scoring significantly higher than OUNL students.
[b] With OUNL students scoring significantly higher than UM students.

3.0, SD = .68 and M = 2.8, SD = .58), and during study (M = 2.7, SD = .95 and M = 3.1, SD = .66).

OUNL students value cueing more over all items and significantly more on ‘‘helpfulness of PW in executing a task'' (U = 10, p = .03) and ‘‘helpfulness of PW in understanding the task'' (U = 8, p = .02). This significant difference is confirmed by negative (Spearman's rho) correlations between institution and appreciations on these items, $r_s = -.59$* and $r_s = -.66$**, respectively. For WOE no significant correlations were found.

Other significant intercorrelations were found between (data omitted in the following text, are given in Table 3) item 6 with items 8c, 8d, 9b, and 2d(r_s = .56*), indicating an overall appreciation for PW; item 8c with item

TABLE 3
Intercorrelations (Spearman's Rho) between Some Relevant Items on Cueing

Items		Students ($N = 12$)						
		6	8a	8b	8c	8d	9a	9b
6.	Information (in general)	—						
8a.	WOE for understanding tasks	.46	—					
8b.	WOE for executing tasks	.47	.39	—				
8c.	PW for executing tasks	.65*	.31	.12	—			
8d.	PW for understanding tasks	.65*	.27	.16	.92**	—		
9a.	WOE during study	.23	.28	.22	.60*	.52	—	
9b.	PW during study	.74**	.31	.04	.95**	.89**	.56*	—

* $p < .05$.
** $p < .01$.

2d($r_s = .66$**), indicating an appreciation for SAP (for the execution of the task) and PW (for the execution of subtasks) as an interrelated whole; items 8c, 8d, 9a, and 9b, indicating consistency between these cueing scores; and item 9a with two items pertaining the complexity of subtasks (plea inventory and plea), with $r_s = .74$** and $r_s = .88$** respectively, indicating that students feel especially supported by WOE when cases get complex.

In conclusion, students enjoyed working through the CMP and appreciated the general setup of the program with the cueing as was provided. The quality of learner reports and pleas appears to be sufficient. These findings show (1) that the cueing developed according to our model is highly valued and appears effective, which gives tentative support for the use of task-valid feedback and combined use of PW and WOE in CMP. With regard to the two subgroups, it appears (2) that confidence gives students reason to believe that tasks are less complex and can be studied in less time, and in a more self-regulated fashion, with less need for externally provided cues, like PW. Since OUNL students are more accustomed to a system of self-guided study and material, in which embedded support devices are incorporated, the difference in appreciation might also be attributed to unfamiliarity. Finally, (3) interesting relations were found between students' appreciation of the SAP (for the execution of the task) and PW (for the execution of subtasks) and between reported complexity of subtasks and helpfulness of WOE.

GENERAL DISCUSSION

CMP are aimed at achieving goal competencies to be applied in a variety of tasks beyond the context of the CMP. These complex skills require schema-based behavior, which should be facilitated and monitored by providing task-valid cueing. Our main instructional hypothesis is that demonstrating a ''goal competency'' requires the combined application of both automated schemata for recurrent aspects and more general schemata for nonrecurrent aspects. A combination of both WOE and PW in instruction therefore appears most suitable to facilitate schema construction in a variety of tasks. Both formats have been studied from the perspective of the 4C/ID model (Van Merriënboer, 1997) and in relation to Cognitive Load Theory (Sweller, 1988) and have appeared suitable in complex learning.

Findings from a study on the appreciation of the CMP ‘‘Preparing a Plea’’ indicate that a combination of PW and WOE indeed guides and promotes competency-based learning. Based on these preliminary data, we assert that process-oriented PW contribute to cognitive schema construction *during* the execution of (complex) subtasks, that process-oriented SAPs are helpful in following a metacognitive strategy *during* task execution, and that product-oriented WOE are of most value for understanding task exection *afterward*. Our students reported that the presence of both process- and outcome-oriented cueing has led to better performances (pleas) and more focused information searching (while preparing the plea), as was found earlier (e.g., Earley, Northcraft, Lee, & Lituchy, 1990; Johnson, Perlow, & Pieper, 1993).

Relations between cueing, schemata, monitoring, and learning outcomes were depicted in a model. Guidelines on adequate cueing were presented throughout the article and provide us with an evaluative framework. PW and WOE were described in more detail as possible formats of task-valid cueing and could be evaluated with these guidelines on their suitability to facilitate schema construction. However, since our model has not yet been thoroughly tested, further research has to be conducted to justify our assertions and improve the model and guidelines. The most important question to be addressed at this moment is when and how cueing should be provided in authentic problem-solving tasks.

Cueing should not be studied from the level of specific subtasks (in-step operations) alone, but also in relation to the task as a whole. Nadolski et al. (in press) present an ID model that addresses the issues of task decomposition and step size in relation to cueing in CMP. In the design phase of their two-phase six-step model, variability of practice is suggested through a combination of WOE and problems accompanied by PW.

Relations between the aspects of timing and orientation of cueing, on the one hand, and learner and task characteristics in competency-based learning, on the other hand, is an interesting issue to be clarified further. For instance, moving from novice to expert, learners can be confronted more with PW and less with WOE. Having control over timing and formats of cueing may help learners optimize their allocation of cognitive resources.

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