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Abstract

An important condition for efficient multimedia learning is that the learner takes an active part in using the material to be learned. One possibility to initiate active learning and intensive information processing is to provide exercises of multiple complexity and difficulty. Hence, the question of how to support the systematic design and construction of multiple exercises for multimedia learning is of critical interest for instructional designers.

This paper presents the psychological background and the application of the Exercise Format (EF) and the Exercise Format-Editor, a multimedia tool kit for the systematic construction of learning tasks. The development of this tool kit was based on psychological findings on task analysis and on self-regulated learning with multimedia learning environments.

In order to support the construction of a large variety of exercises, EF (a) allows the integration of various learning contents, materials and media, (b) allows the preparation of different item forms, (c) allows an automatic assessment of the learner's response, and (d) provides informative tutoring feedback types for typical mistakes.

From a psychological viewpoint, an important prerequisite of efficient self-regulated learning is that the learners actively use the material to be learned. This entails gaining selected information on a particular subject, working through this information, analysing it, and relating this information to one's own knowledge.

For these purposes learning tasks or exercises are of particular interest because they can initiate and support the active and intensive information processing. Numerous studies (for a review see Hamaker, 1986) reveal that working with exercises can facilitate (a) a longer retention and deeper understanding of the learning material, (b) the structuring and application of knowledge, and (c) the test of the acquired knowledge. Moreover, learning tasks in self-regulated learning via multimedia technologies play a prominent role in monitoring and managing the learning process, because correctly respective incorrectly solved tasks can provide a great deal of information (e.g. feedback whether the learning objectives are achieved, cues as to which concepts and principles are important to know, feedback indicating mistakes and thus helps to identify the learning material that should be repeated). However, useful information is only provided if learning tasks of different complexity and difficulty are constructed systematically with regard to the instructional objectives of the given learning context and with regard to learner characteristics (e.g. prior knowledge, motivation). In order to help instructional designers to construct learning tasks that meet these requirements we developed the Exercise Format (EF) on the basis of the current knowledge on task analyses (for a detailed description see Jonassen, Tessmer & Hannum, 1999) and on self-regulated learning (c.f. Boekarts, 1996).

Constructing learning tasks with regard to different learning objectives and different learner characteristics requires knowing which dimensions and/or attributes of a learning task can be varied systematically in order to design exercises of different complexity and difficulty. Hence, the purposes of this paper are (a) to give an overview of the dimensions and attributes that can be varied systematically when constructing learning tasks, and (b) to describe the functions and some applications of the EF-editor.

Dimensions of (complex multimedia) learning tasks

In general a task consists of two elements: the question or problem, and the answer respective solution. According to Klauer (1987), an exercise can be defined as the interconnection of a stimulus component and a response component. The stimulus component consists of the content, which is presented in a certain item form. The response component specifies what the learner should do with the stimulus component, e.g. to mark the correct alternative, to write down a short answer, or to write an essay in order to solve the task. Klauer (1984) mentioned that the item form together with the presented content determine the cognitive demands of a test item that a learner has to cope with.

This definition is useful for the systematic construction of test items. However, we are especially interested in constructing learning tasks that, beside the test of the acquired knowledge, should promote and facilitate the knowledge and skill acquisition as well as the acquisition of meta-cognitive knowledge and skills. In contrast to test items, such learning tasks should offer the possibility to solve the task by providing informative feedback and multiple-try strategies (see Narciss & Huth, in this volume). Thus, the learner can solve the learning task in an interactive way. This interactive solving of a learning task entails not only a stimulus component and a response component, but also feedback loops as well as repeated working on one task, respectively subtask. Thus, we propose to describe (complex) learning tasks or exercises by at least three dimensions (see figure 1): First, each exercise is related to a specific part of a knowledge domain in addition to cognitive operations that are required for the task solution. These aspects – (a) the content, and (b) the cognitive operations - both belong to the cognitive dimension in learning tasks. Second, in order to initiate and promote an active self-regulated learning the interactive dimension of learning tasks is of particular importance. This dimension consists of (a) a feedback component, and (b) an instructional tutoring component. The third dimension is the formal dimension of learning tasks and refers to (a) the item composition, and (b) the form and mode in which the content is presented.

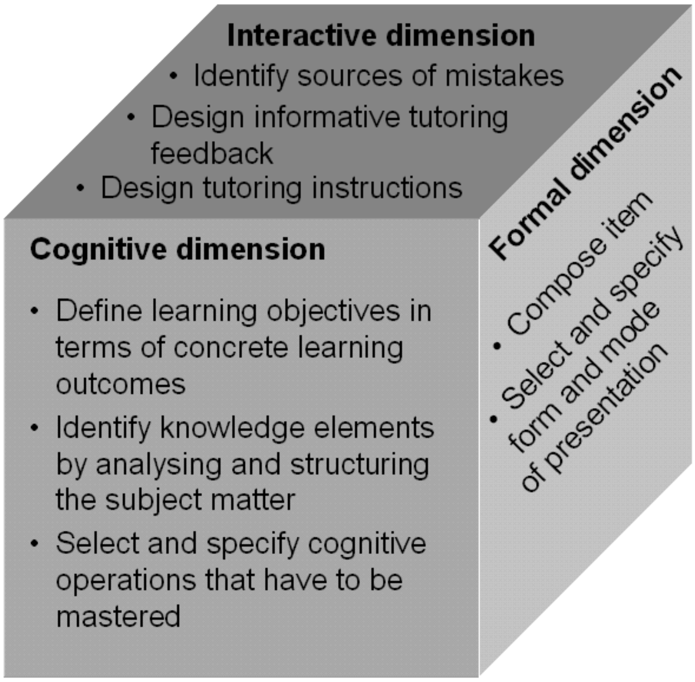

Figure 1: Three dimensions of complex multimedia learning tasks and relevant steps for the systematic construction of learning tasks

The cognitive dimension

The cognitive dimension of an exercise is determined by (a) basic elements of the instructional content which are presented in the exercise (e.g. facts, events, rules), and (b) the cognitive operations (e.g. recognize, recall, transform, identify, classify) that are required within the exercise. The aim of a systematic task construction is to develop exercises that differ in their difficulty and complexity. Thus, it is necessary to take into consideration different levels of knowledge elements, just as different levels of cognitive operations for the item construction.

The basis for the identification of relevant knowledge elements and cognitive skills is the detailed definition of learning objectives in terms of concrete learning outcomes. This specification indicates precisely what the learners have to do with the selected knowledge elements. “Applying a fact to solve a problem is a different instructional outcome from just stating a fact.” (Jonassen, Tesssmer & Hannum, 1999, p. 208)

For identifying the relevant knowledge elements it is convenient to analyse and structure the subject matter using procedures of content analyses (for a detailed description see Jonassen et al. 1999, or Albert & Lukas, 1999). This entails breaking down the extensive content into smaller elements differing in their complexity, e.g. from simple facts across principles to particular theories. In the next step, relationships between and among the knowledge elements have to be identified and depicted. Such relationships for example could be semantic, e.g. "y is condition to x", "x is a generic term of y", "x is prior knowledge to y". These relationships for example can be used for sequencing exercises with several difficulties from the most simple to the most complex. In addition, the results of the cognitive task analyses can be useful for the determination of transparent evaluation criteria and the formulation of instructional tutoring information and feedback messages to help learners succeeding the task.

The specification of the cognitive operations that can be applied to the selected knowledge elements of the subject matter can be based on a familiar taxonomy of learning objectives such as Bloom's taxonomy of educational objectives (Bloom, Hastings, & Madaus, 1971). This cognitive taxonomy is divided into six major categories: (a) knowledge, (b) comprehension, (c) application, (d) analysis, (e) synthesis, and (f) evaluation. Each category is further subdivided into more specific objectives. Often the categories of these familiar taxonomies are still too general and must be broken down into more specific categories before being used for systematic item construction (Jonassen, et al. 1999).

In the present approach for systematic exercise construction we propose to specify the relevant set of cognitive skills with regard to the learning objectives and the given domain of knowledge. This goal-related strategy of skill categorization provides the opportunity to determine and match the intended cognitive operations specifically for the given learning context. In an instructional context on operant conditioning the learning objectives for example might be to acquire the principles of reinforcement and apply them to the analysis of problematic situations in instructional contexts. The cognitive operations related to these objectives could, for example, be defined as (a) remembering, (b) transforming, (c) classifying, (d) arguing and/or concluding (Narciss & Proske, 2001).

In general, it is possible to assign each knowledge element to each cognitive operation in order to construct a learning task. But in some cases the assignment is not suitable for all combinations. The decision which cognitive operations should be required for which knowledge element should be rather matched to the learning objectives defined before. Furthermore, exercises should be designed for each of the defined learning objectives.

The interactive dimension

As mentioned before, the learner-learning task interaction is of particular interest in multimedia settings. Improving the (meta-cognitive) knowledge when working with learning tasks is only possible if there is information available which supports the solving of the tasks. Without this interactive function of learning tasks a self-regulation of the learning process is difficult or even hardly possible.

The interactive dimension of learning tasks consists of (a) a feedback component and (b) an instructional tutoring component. For each of these components the content, function and modus in which the information will be provided has to be selected. These decisions depend, on the one hand, on learning objectives and on the other hand on expected sources of mistakes or difficulties for the given exercises.

In order to identify sources of systematic mistakes several approaches of error analyses might be used. First, the identification of typical errors might be based on teachers' or instructors' experiences in the relevant field of knowledge. Second, an empirical item and error analysis can be used to detect systematic errors. Third, the results of tasks analyses might be used to determine potential sources of errors related to (a) the relevant knowledge elements, (b) the cognitive operations to proceed, and (c) the meta-cognitive knowledge and strategies that are required in order to solve the task. The feedback and the instructional tutoring information can refer to each of these aspects of the learning task (Narciss & Huth, in this volume).

In computer based instruction it is particularly important to determine the way feedback will be presented to the learner. With regard to the instructional objectives and the cognitive requirements of the exercise there are different possibilities to provide feedback information, e.g. knowledge of result or knowledge of the correct result, as well as elaborated feedback. For the purpose of supporting the interactive solving of a complex learning task elaborated tutoring feedback forms are of major interest. In general, the content of a elaborated feedback message consists of two components: (a) an evaluative component that provides information on the learner's performance level, and (b) a informational component that gives additional information related either to the content of the learning task, the strategy to succeed, or the error(s) that have been occurred. Such additional information could be, for example, hints on possible information sources, hints on meta-cognitive strategies, analogies, or examples (Narciss & Huth, in this volume). The function of elaborated tutoring feedback in interactive instruction is to support learners in mastering the requirements of the learning tasks and to initiate further learning activities. Thus, feedback should not immediately offer the correct response, but provide knowledge on how to proceed in combination with a multiple-try strategy (for detailed description of feedback design see Narciss & Huth, in this volume).

Whereas feedback has to be presented after working on learning tasks or sub-tasks, instructional tutoring information can be provided during the whole instructional process. Thus, if the learner needs some more information for the task solution the possibility is given to look for helpful information. The content of the instructional information is similar to the informational component of the feedback information, and could be related to the content of the exercise, to successful strategies for the task solution, or to possible sources of errors. In order to avoid a cognitive overload, this information should be provided in manageable pieces. The form and modus of the presentation of these tutoring pieces of information depends on the learning objectives and the cognitive task requirements. In multimedia settings, it is possible to give the learner the opportunity to actively get such instructional information, e.g. by clicking on a help button. But it is also possible to present this information automatically after a particular time period without learner entries.

Formal dimension

Formal aspects of learning tasks determine how the selected knowledge elements and cognitive operations are presented to the learner. This facet addresses the issues of (a) the item composition and (b) the form of presentation.

Central issues related to the selection and composition of an item form are:

- What question should be answered by the learner?
- In which way should the problem be processed?
- What has the learner to do to proceed with the task?
- What are the correct solutions?

The item form is determined first by the kind of problem formulation and second via the response mode of the exercise. In general, learning in multimedia settings do not include the possibility to ask an instructor if a learning task is incomprehensive. Hence, it is of particular importance to generate exercises with transparent demands in order to make clear how the learner has to behave to solve the task correctly. Furthermore, only well-defined items ensure (a) that the item can be solved correctly if the required knowledge and skills are mastered, (b) that a false answer does not appear although the required knowledge and skills are acquired, (c) that the evaluation of the learner's answer contains information that is useful in order to guide the further learning process. Thus, it is of particular importance to specify not only the problem formulation, but also the response mode and the correct solution during the process of item composition. In order to ensure that the problem formulation is clear enough to initiate the intended solution behaviour, a recursive process between item formulation and the specification of the response mode and the correct solution is necessary.

The problem formulation refers to the kind of question the learner is asked. Such a question, for example, could be: (a) a w-question, e.g. "What do you have to do to change a sentence from active into the passive voice?", or "Which verb form has to be used in order to form the passive voice of a sentence?" (b) a matching problem, e.g. "Match the correct sentence in active voice to the corresponding sentence in passive voice. " or "Match the different verb forms below into the corresponding sentence.” (c) an arrangement problem, e.g. “Arrange the following sentence in the order of their tense. Begin with the verb in the present tense.” There are many other kinds of question possible, such as exercises that necessitate the selection of the exact alternative, or that can be answered by shortly writing down the correct solution.

Of course it is also possible to combine several kinds of problems into a superior complex problem formulation. That means for an application in multimedia learning environments that the required steps for task solution in the problem formulation must be made very explicitly to the learner.

In general, there are two response modes: – the producing response mode and the identifying response mode. An exercise with producing response mode requires that the question must be answered in a free form, whereas items with identifying response mode always contain the correct answer, which has to be identified correctly within the problem formulation (Proske, 2000). A typical example of the producing response mode is a short-answer question. Multiple-choice questions, for example, are considered as questions with identifying response mode.

The arising different types of exercises all have typical advantages and disadvantages. This fact should be kept in mind during the construction process to ensure the design of exercises that differ in their difficulty and complexity and that can be applied to their intended function in the learning process adequately. There is specific literature providing instructions considering such aspects in exercise construction (e.g. for multiple-choice items and higher-order educational objectives Aiken, 1982; for parallel short-answer items and multiple-choice items Proske, 2000). Moreover, it is important to take care of the demands that are arising through the selection of a specific item form together with the level of the relevant knowledge element. Such different exercises also should differ in the specification of their cognitive requirements. For example, an exercise for testing recall of knowledge should not be answered by inferring the knowledge from the information presented in the exercise, or an exercise for testing logical thinking should not be solved by pure recall (Klauer, 1984). These issues should be taken into account during the exercise composition and revision.

As mentioned earlier, another important point is to design a transparent problem, including an explication of the learner’s behavior that will lead to success. During the exercise composition this can be realized via the exact determination of the correct solution. Successful work on the task should only depend on the status of the knowledge and skill acquisition. If the learner knows the relevant content and is able to perform the required cognitive operations the task should be solved correctly. This fact should be controlled after composing the question by revising the exercise with regard to the expected learner’s behaviour.

Furthermore, the determination of the correct solution ensures an informative evaluation of the learner's solution. Here, another major fact for a multimedia application of exercises occurs. Because there is usually no communication possible between instructor and learner in multimedia settings there, it is particularly important to pay attention to possible correct solutions other than the one specified within the exercise composition. Therefore, the constructor should to think of, for example, synonyms and paraphrases for the correct solution that are also correct. Furthermore, similar words must be separated from the correct one in order to determine whether an answer is correct or not, and in multimedia settings spelling mistakes within the learner's answer should be debugged by the system automatically.

Form and mode of presentation of learning tasks are of major interest, especially for the construction of learning tasks for multimedia instruction. Instructional designers have for example to decide which material has to be presented in which presentation mode. This issue refers to the medium, coding and modality (see Mayer & Moreno, 2002) as well as the instructional form in which a particular content is submitted to the learner by the exercise. In multimedia learning environments there are many possibilities to vary the form and modus of presentation, for example (a) the variation of the medium: text, video, audio; (b) the variation in coding: only text, only pictures, a combination of text and pictures, a combination of a chart with captions; (c) the variation of the modality: visual, acoustical, visual-acoustical; (d) the variation of the instructional form: text paragraph, definition, example, table.

The selection of the form and mode of a learning task depends on the content that will be presented, the cognitive requirements, and the intended function of the learning task. For example, it might be not very useful to present video material within a learning task that requires reading a text, or the presentation of text material seems a little dubious in a learning task for dialogue comprehension.

Complex learning tasks with the EF-editor

As shown in the chapter above the systematic construction of complex multimedia exercises is an ambitious task. In order to help instructors to master this ambitious task, we have developed a format called "Exercise Format" (EF) which is a plain text format describing the abstract data of an exercise and providing the possibility to save the data within a file. Via this format the exercises can be applied in different multimedia settings. In order to support the editing of EF-files we have designed a tool called "Exercise Format Editor" (EF-editor).

The development of the Exercise-Format is, on the one hand, based on the above-mentioned psychological knowledge on systematic task construction. On the other hand, it is based on a conceptual framework for the design of informative tutoring feedback (for a detailed description see Narciss & Huth, in this volume). The next sections outline the functions of the EF-editor and illustrates these functions with some examples.

Functions of the Exercise Format

The development of the Exercise Format is based on psychological findings on cognitive task analysis and on self-regulated learning with multimedia learning environments. Our main concern is the design of a tool that can be used universally and independently from a specific field of knowledge.

When using the EF-editor most exercises can be generated without any programming knowledge. The Exercise Format for example facilitates the construction of different multiple-choice exercises, matching exercises, drag & drop exercises or short answer exercises.

In order to give an overview the functionalities of EF are listed below. The Exercise Format:

(a) Allows the generation of exercises within a pre-structured template;
(b) Allows the generation of exercises in various item forms;
(c) Allows the combination of several item forms within one problem formulation;
(d) Allows the combination of exercises into a comprehensive exercise (so-called “multi-exercise”);
(e) Provides general and specific instructional tutoring information within the question;
(f) Assesses the learner’s answer automatically (the evaluative component of the feedback message);
(g) Provides special informative feedback related to typical mistakes defined during the exercise composition (the informative component of the feedback message);
(h) Compiles exercises into html- and Word-format easily;
(i) Uses the developed exercises within different learning environments independently from a specific field of knowledge;
(j) And applies the developed exercises within different teaching – learning settings.

The user-interface of the EF-editor consists of three areas: an editor, a browser preview and an explorer for navigation within the EF-files. The constructor must develop the exercises in the editor. The figure below shows a screenshot of the EF-editor’s user interface.

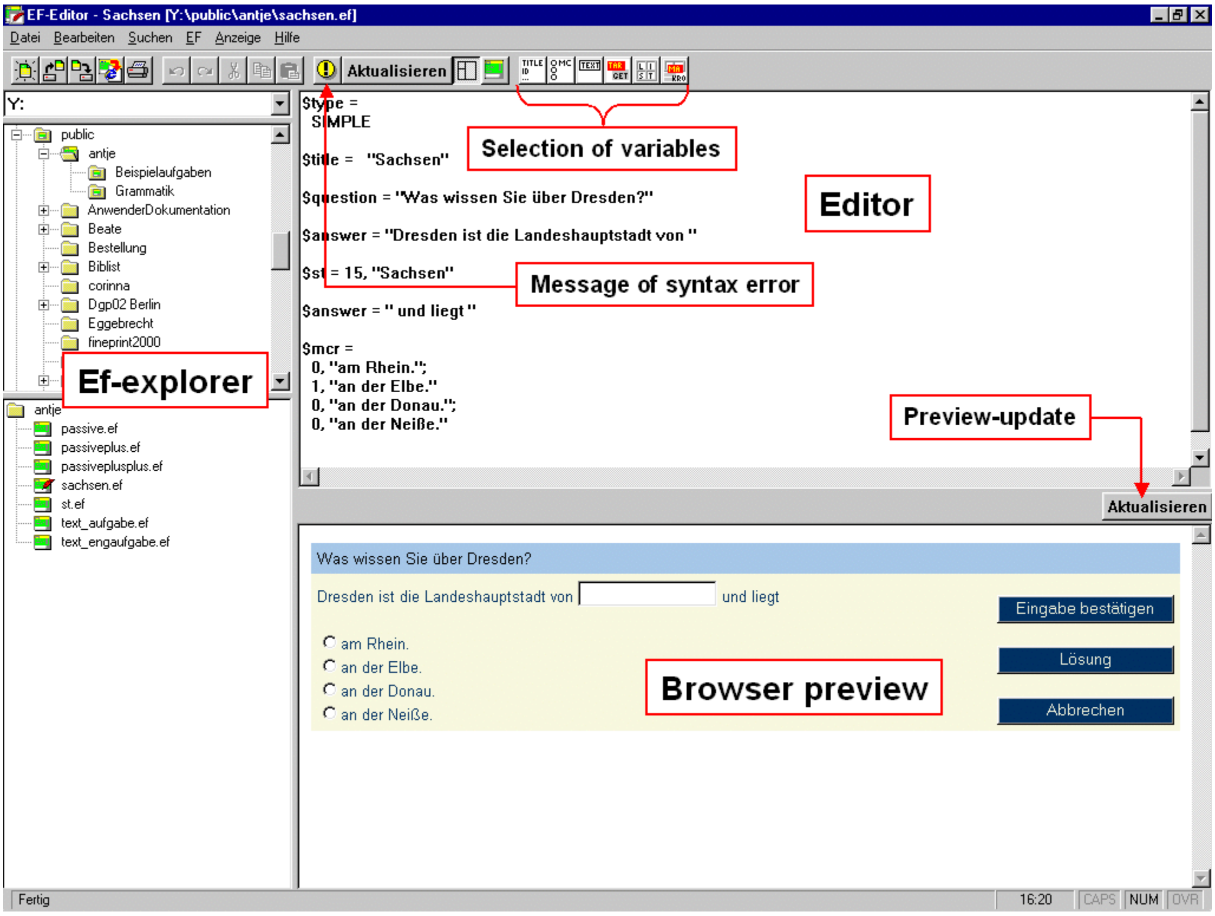

Figure 2: Screenshot of the user-interface of the EF-editor

The specific components of an exercise, such as the question or the answer text, are included in the learner's working window, or the correct solution are defined as variables that each are identified by a dollar symbol "$". The content of the particular component must be written between quotation marks, and different variables (=components) have to be separated by semicolon. For example, the question "What do you have to do to change a sentence from active into the passive voice?" has to be specified in the EF-editor in this way:

```
$question = "What do you have to do to change a sentence from active into the passive voice?";
```

When the constructor has made all relevant entries he can click on the update-button to see his entries in the browser preview immediately, where he or she can also control the functioning of the task. Errors that would eventually be made in exercise generation can be seen at once and corrected without the necessity of checking the exercise within the later application. As can be seen, on the top of the screen the EF-editor warns in case of a false syntax-entry via the appearance of a yellow exclamation mark ("!"). By clicking on this exclamation mark specific information related to the kind and location of the syntax error is given.

In the example above a combination of two item forms – short answer and multiple-choice with radio buttons– within one problem formulation is seen. Such combinations are possible for all the item forms offered by EF. These item forms span from simple short answer and multiple-choice items across several types of completion texts to complex types of matching tasks. Furthermore, it is possible to integrate various types of media and material into the exercise. Material that can be interpreted by a current web browser is also able to be used for EF-exercises. The EF-editor also allows the use of different templates that encourage the constructor to generate exercises in several appearances and/or languages (for a detailed documentation of all the EF-functionalities see http://www.studierplatz2000.tu-dresden.de/english/efeditor.htm).

Designing a complex learning task with EF

In order to illustrate both the above-referred ideas for a systematic exercise construction and some functions of the Exercise Format, we will now describe the procedure of designing a complex learning task with EF. In our example, the subject matter is "principles for writing a comprehensive text". Such principles are readability (use simple phrases and words), organisation (provide structure in order to make the text as clear as possible), coherence (write in a clear and vigorous prose), conciseness (make each sentence maximally informative, but as brief as possible), and stimulation (use interesting additives) (e.g. Amiran & Jones, 1982). These principles might be considered as the set of relevant elements of knowledge which is the basis for the definition of a knowledge space related to this subject matter (see Albert & Lukas, 1999). The learning objectives related to the given subject matter can be defined as (a) acquisition and (b) application of the principles for writing a comprehensible text. The cognitive operations and skills that must be mastered in order to achieve these objectives are: (a) remember and describe the principles, (b) identify and classify the principles, (c) apply the principles for writing or revising a text.

In order to make students use these cognitive operations and skills, teachers use tasks such as "write a text dealing with the topic …" or "revise the following paragraph of a text." These tasks are very complex and do not precisely indicate that the learners should revise or write the text applying the principles of writing a comprehensible text. Thus, if the task is solved unsatisfactorily, it might be due to a misunderstanding of the task requirements. A specification of the task requirements might prevent this misunderstanding (e.g. Revise the following paragraph of a text applying the principles of writing a comprehensive text). However, the task is still very complex. It consists in the least of the following sub tasks or task requirements:

- remember the principles
- detect in the text where the principles are hurt
- identify for each error which principle is hurt and why it is hurt
- reformulate the incorrect sentences

Mastering all these task requirements affords procedure in a strategic way. A strategy that might be useful for the first two sub tasks is for example to list all the principles of writing a comprehensive text, then check for each principle where and why it is hurt in the given paragraph of the text and finally, document the results of these steps by marking the type of error in the paragraph of the text. In a further step, the incorrect sentences can be reformulated. However, many students do not proceed in such a systematic way, and thus the risk that the task is solved unsatisfactorily is still very high. Furthermore, we want to emphasize here that complex tasks requiring a lot of covert cognitive operations (e.g. remembering, detecting errors, identifying type and source of errors) do not allow to determine why they are solved unsatisfactorily. In our case, each failure in a sub-task might result in an unsatisfactory task completion. Hence, we propose to transform the covert task steps into overt steps by asking learners to solve the sub-tasks overtly. This transformation results in the following task: "Revise the following paragraph of a text using the principles of writing comprehensive texts. In order to prepare the revision, (a) list the principles of writing comprehensive texts, (b) mark and note for all passages in text, where a principle is hurt, which principle is hurt and why it is hurt. Finally, reformulate these passages." Such a transformation of covert sub-tasks into overt sub-tasks has multiple advantages for the implementation of complex tasks in multi-media learning environments. First, all subtasks that do not require the production of long text can be evaluated automatically. Second, as it is now possible to diagnose, which of the sub-tasks is mastered or not, informative feedback can be provided for each sub-task.

In order to design and implement this exercise with the EF-editor put the above mentioned question and task instructions in the `$question`-field and the selected paragraph of an incomprehensive text in the `$answer`-field. Then provide a table with three columns as working or response space (see figure 4). The left column of this table is for listing the principles of writing a comprehensive text. The cells of the second column are used for the detection and identification sub-task. EF also offers the possibility to design this sub-task as a drag-&-drop task. The cells of the right column offer the space for the revising sub-task. EF offers the possibility to design the cells of such tables with flexible sizes. Hence, for the producing sub-tasks the cell size is adapted automatically to the length of the text which is written in the cell.

As mentioned above, this exercise consists of several sub-tasks that can be and must be evaluated separately in order to diagnose potential problems. The Exercise Format provides this opportunity to evaluate the sub-tasks separately.

In order to use this opportunity, the correct solution(s) of each sub-task has(ve) to be specified in the solution field. This specification of the correct solution is the basis for providing informative tutoring feedback components (e.g. knowledge of result, indicating location of errors, hints for error correction, or knowledge of the correct solution). As recommended by Narciss and Huth (in this volume), such informative tutoring feedback components should be presented in a multiple try procedure. Hence, the feedback procedure implemented in EF uses such a combination of informative tutoring feedback components and multiple try procedures. Thus, in our case after the learner has solved the task or a sub-task, he or she can check the solution by clicking on the "Confirm" button.

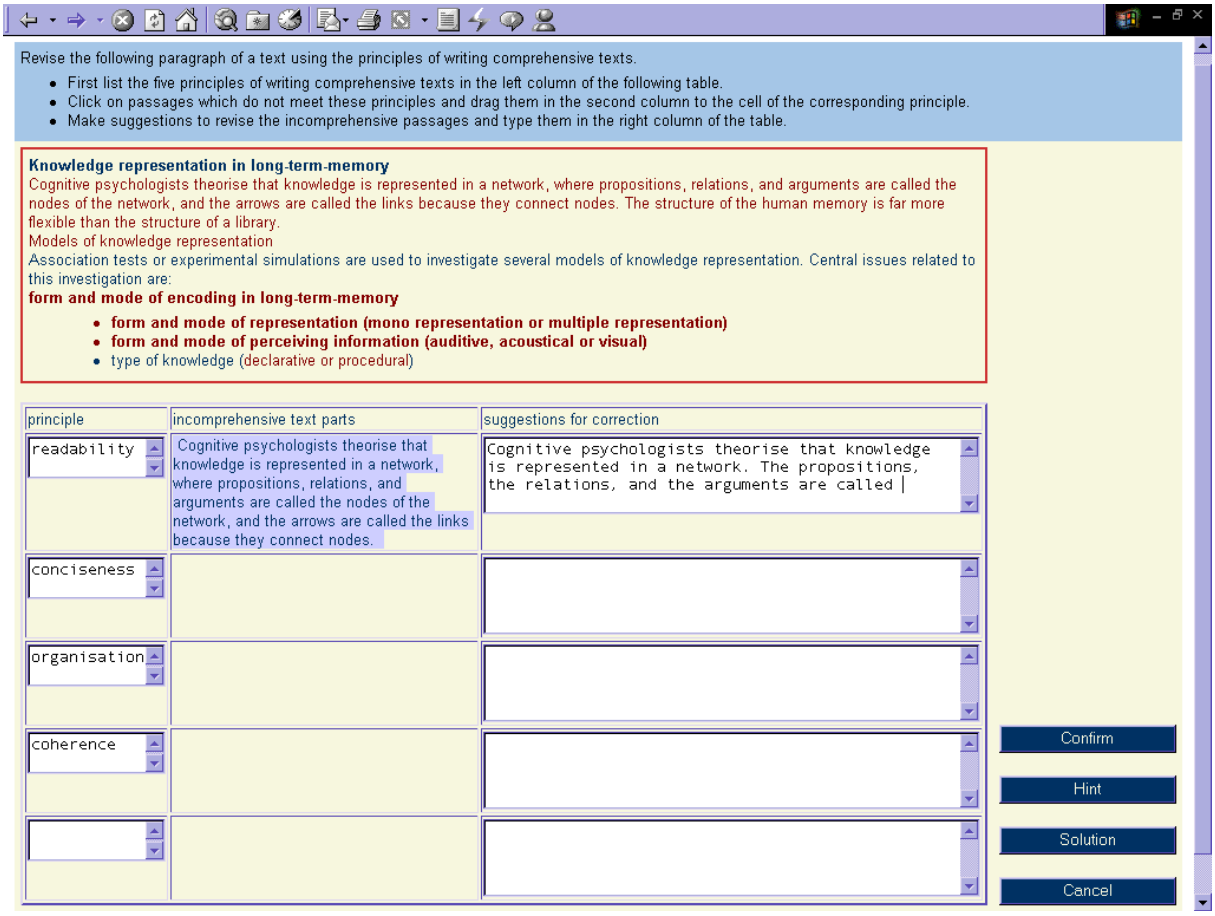

Figure 3: A complex interactive multimedia exercise in the EF-editor

The Exercise Format provides knowledge about result (correct/sorry, there are errors in your solution, try again). The learner then has the opportunity to solve the task again. After this second attempt an evaluation of the overall performance is given by indicating the percentage of correctly solved sub-tasks and the location of errors (correctly answered sub-tasks are marked green, incorrectly answered sub-tasks are marked red). In cases of errors the learner has the possibility (a) to click on the button “Solution” and compare the own answer with the correct one, or, (b) to solve the problem again.

Designing informative tutoring feedback with EF

As mentioned above, the Exercise Format offers the opportunity to implement elaborated, bug-related tutoring feedback. Implementing such a bug-related tutoring feedback entails a diagnostic routine, which is based on the specification of typical systematic errors. Furthermore, it requires the specification of informative tutoring feedback components that can be provided if the systematic errors occur. The specification and implementation of such informative tutoring feedback components is a rather complex procedure which must be based on error and task analyses (for a detailed description see Narciss & Huth, in this volume).

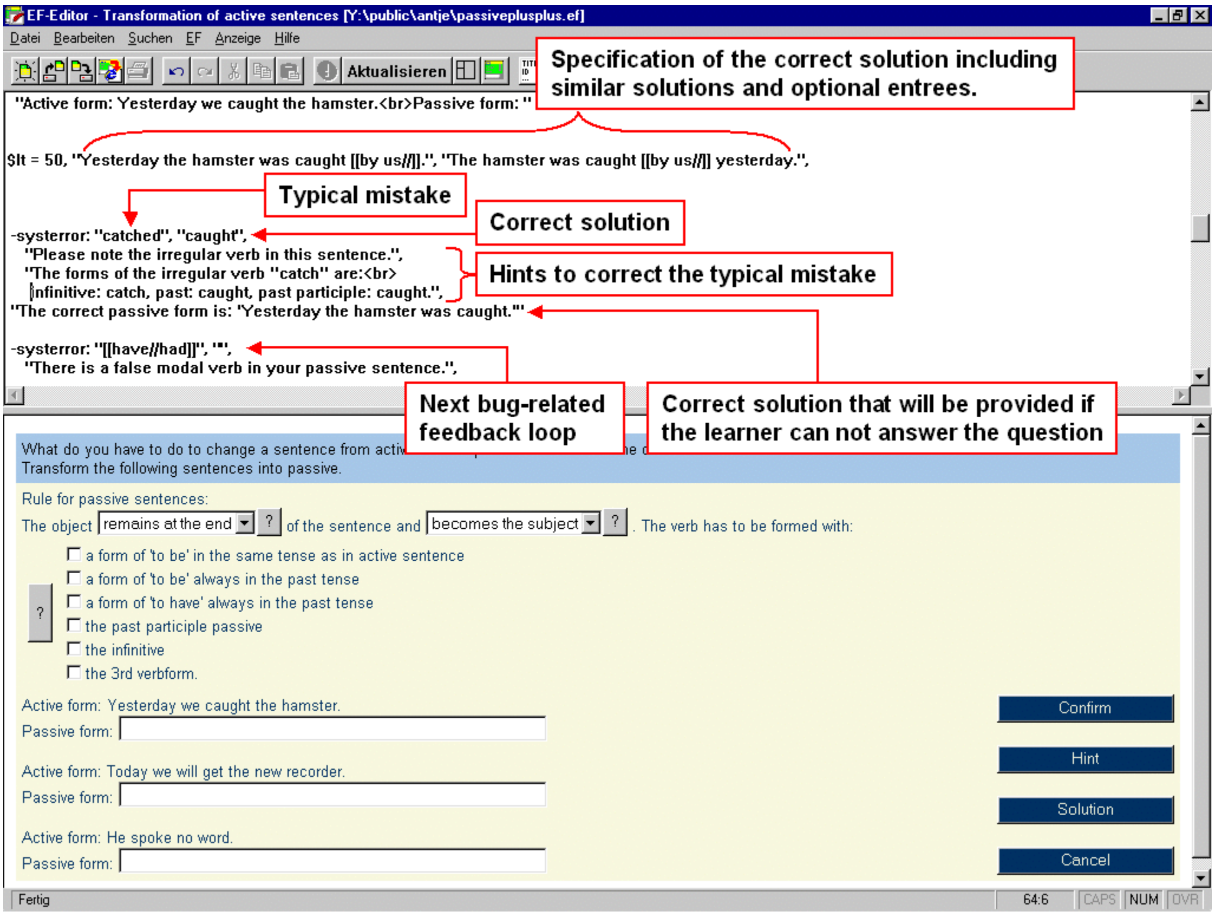

Figure 4: Syntax for generation of bug-related feedback hints in EF-editor

The following example outlines how the selected informative components can be used in order to design bug-related tutoring feedback procedures with the Exercise Format. Take, for example, the learning task “Transform the active sentence into passive: Yesterday, we caught the hamster”. For the diagnostic routine (a) all the correct solutions, and (b) all systematic errors must be specified. In our case such systematic errors are for example using the false modal verb (to have instead of to be), using the false tense (present tense instead of past tense), or ignoring the irregular verb (catched instead of caught). As shown in figure 4, both the correct solutions and the systematic errors must be documented in the related EF-fields. Furthermore, the hints related to these systematic errors must be listed systematically, in order to generate bug-related hints within the EF-editor. If there are several hints for one systematic error they have to be separated by commas (see figure 4).

As described in the previous section, the bug-related feedback components are presented stepwise if there is more than one hint for an error. In complex tasks requiring several sub-tasks, each containing the risk of systematic errors, it is important to keep the relation between errors and hints transparent. Thus, the hints are either presented automatically in the order they occurred or the learners are provided the opportunity to open a bug-related hint by clicking on the "?" besides the incorrect response (see the browser preview in figure 4).

Summary and Conclusion

In multimedia instruction learning tasks play a prominent role for the self-regulation of learning if they are (a) constructed systematically, (b) differ in their complexity and difficulty, (c) include informative feedback and tutoring information. Tools like the EF-editor help to meet these requirements of a systematic design and construction of multiple learning tasks for multimedia applications. Based on knowledge about cognitive task analyses and self-regulated learning, the Exercise Format allows the integration of various learning contents, materials and media in learning tasks of several item forms, including tutoring information and specific informative feedback loops. Hence, the EF-editor can be used to develop and implement a large variety of exercises for multiple learning settings, such as web-based learning, hybrid arrangements of learning (c.f. Kerres, 2001), or collaborative distributed learning. However, the systematic construction of multiple learning tasks (for multimedia instruction) is still a very demanding task. Thus, further research is needed in order to (a) reduce the demands related to the systematic construction of learning tasks, (b) overcome technical limitations in the automatic assessment of the learner's answer, and (c) improve the facilities for designing psychologically founded tutoring feedback and instructional help.

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