One Exercise – Various Tutorial Strategies *

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Abstract. Narciss' theoretical framework for informative tutorial feedback (ITF) suggests to adapt the feedback along the dimensions: content, procedure, form, and presentation according to the task, the learner's response and to the learner's characteristics and particular situation. As prerequisites for the adaptations we devised a knowledge representation for exercises to which various tutorial and presentation strategies can be applied. We also developed techniques for generating the procedure, form and presentation of feedback.

1 Introduction

Widely investigated feedback strategies in computer-based instruction are 'knowledge of result' (KR) that just informs the learner whether her answer is correct or incorrect, 'knowledge of the correct response' (KCR).[1] Informative Tutorial Feedback (ITF) refers to elaborate feedback types that provide strategically useful information. The empirical results about the benefits of those strategies are inconclusive.

[5] provides a theoretical framework for ITF that postulates the need to adapt the feedback's content, procedure, form, and presentation not only to the student's response and task but also to the learner's characteristics and to the particular situation. Hence, our ultimate goal is to adapt feedback in ActInMath along those dimensions.

As prerequisites for the adaption of feedback in interactive (multi-step) exercises we devised a knowledge representation for exercises to which a number of tutorial and presentation strategies can be applied. We also implemented functions that transform an exercise representation into a representation with a common tutorial stratgey extracted from teachers' practice, Naricss' experiments, and our own tutoring experience.

2 Generation of Tutorial Strategies

ActInMath's exercise system player can handle pre-scripted and generated exercises. Pre-scripted exercises are authored as finite state machines (FSM)

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[1] also called bottom out

including edges representing correct and typical incorrect student input and its diagnosis, and nodes representing the system's (re)action to correct responses and to the causes of errors.

There are three types of states in an exercise FSM: tasks, so-called interactions representing interactive elements using which the learner enters the solution, and feedbacks of different types. As we see later, such separation provides a basis for reusability of different states when applying tutorial strategies.

Exercises can be also completely generated with the help of a domain reasoner. A partial FSM of such an exercise is dynamically generated from the solution space of the problem produced by the domain reasoner.

A Tutorial Strategy defines the *procedure* of the interactions, as well as *form* and *content* of feedback, presented to the learner. These dimensions of feedback are considered to be important for learning, as suggested in [5]. Therefore, our main research question is how to devise Tutorial Strategies and exercise representations enable adaptation to these substantiated dimensions.

Technically, in order to change the procedure and the form of feedback, (as part of) an exercise FSM is transformed into another FSM. In order to choose appropriate feedback content, a feedback generator component is invoked. Feedback generator first tries to find the feedback of the needed type in the exercise FSM and if such is not authored, generates it. Since interactions are separated from tasks, the strategy can vary the procedure of interactions without modifying the tasks, the form and content of feedbacks can be varied as well in which the feedbacks with needed properties only are shown or replaced with generated ones.

Two commonly used tutorial strategies that we have implemented are *decompose-into-subgoals* and *simpler-version*.

The algorithm for *decompose-into-subgoals* transforms a problem statement into subgoals - this is a procedure change. The algorithm for *simpler-version* strategy transforms the content. The resulting feedback suggests to solve an easier problem for the same concepts and competencies, and when the student succeeds with that the original problemis reinvoked.

The set of simpler versions of a problem may be dependent on several parameters, such as the focus concepts, the task, learner's mastery values etc.

A Presentation Strategy defines the GUI appearance of the exercise. It defines how parts of the exercise states are rendered. This includes windows, buttons, placement of feedbacks within a window and other presentational aspects such as different foreground and background color, highlighting, icons, etc. A Presentation Strategy can also define whether previous responses, feedback and hints should be visible or not.

3 Recent Related Work

Instructional benefits of elaborate feedback were obtained in empirical studies which selected the feedback components on the basis of cognitive task and error analyses, and assembled them as a multiple try feedback (e.g., [1, 6]). The relatively simple variations for elaborate feedback included a varying number of student trials plus location of error and KCR vs. KR and KCR only.

A corpus study of human-human dialogues in foreign language learning [3] elicited a number of feedback strategies teachers use in foreign language learning: for positive feedback this includes acknowledgement, acceptance, repetition, and rephrasing; corrective giving-answer strategies include repetition, recast, explicit correction, give answer, show (location of) error; corrective prompting-answer strategies include clues without giving the target form, clarification request, and elicitation.

Related work also includes Hefernan's Ms.Lindquist [4] that has four feedback strategies for algebra word problems: concrete-articulation, explain-verbally, abstraction-and-substitution, and worked-example. Its rich tutorial strategies resulting from observation of tutors are used in a fixed way and encoded in the exercise representation. The actual presentation is fixed too.

4 Future Work

The issue how and when Tutorial and Presentation Strategies should be used to optimize learning is future collaboration with our psychology partners. Based on their empirical results we shall devise a model for the adaptation of tutorial strategies and presentation strategies. This model will comprise not only the type and cause of error and task but also the student's competencies and motivation.

For instance, if a learner has a weak self-efficiacy, it is detrimental to provide negative feedback [2]. Therefore, an alternative feedback to an incorrect answer could be to pose a similar but simpler task which still trains the same skill.

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