Chapter 6
Intelligent Model-Based Feedback: Helping Learners to Monitor their Individual Learning Progress

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ABSTRACT
Automated knowledge assessment methodologies provide the technological background for producing instant feedback at all times during the learning process. It is expected that the availability of such individual, dynamic, and timely feedback supports the learner’s self-regulated learning. This chapter provides the theoretical background for an intelligent feedback approach and introduces two automated model-based feedback tools: TASA (Text-Guided Automated Self Assessment) and iGRAF (Instant Graphical Feedback). The chapter concludes with a discussion of the two feedback approaches and future research directions.

INTRODUCTION
The nature of feedback plays a critical role in learning and instruction, especially in computer-based and self-regulated learning environments (Simons & de Jong, 1992). Hence, feedback is considered a fundamental component for supporting and regulating learning processes. Depending on theoretical perspective, learning and instructional goals, objectives, research purposes, as well as methodological approaches, feedback can take many forms. Wagner and Wagner (1985) consider feedback to be any type of information provided to learners.
The importance of feedback for improving knowledge and skill acquisition has been discussed controversially in educational research (e.g., Azevedo & Bernard, 1995; Bangert-Drowns, Kulik, Kulik, & Morgan, 1991; Narciss, 2008; Narciss & Huth, 2004; Shute, 2008). Widely accepted forms of feedback include (a) knowledge of result, (b) knowledge of correct result, (c) knowledge of performance, (d) answer until correct, (e) knowledge of task constraints, (f) knowledge about concepts, (g) knowledge about mistakes, (h) knowledge about how to proceed, and (i) knowledge about metacognition (Narciss, 2008). Additionally, Schimmel (1983) found that feedback is most effective under conditions that encourage the learner’s conscious reception and engages the learner in reflecting on the response.

Automated knowledge assessment methodologies (e.g., Ifenthaler, 2010b; Pirnay-Dummer, Ifenthaler, & Spector, 2010) provide the technological background for producing instant feedback at all times during the learning process (Ifenthaler, 2009). It is expected that the availability of such individual, dynamic, and timely feedback supports the learner’s self-regulated learning (Zimmerman & Schunk, 2001).

Accordingly, this chapter will introduce the theoretical background for an intelligent feedback approach. Based on these theoretical assumptions, two intelligent and automated model-based feedback tools are described in the next section: (1) TASA (Text-Guided Automated Self Assessment), which generates automated feedback to learners based on natural language text input (Pirnay-Dummer & Ifenthaler, in press). (2) iGRAF (Instant Graphical Feedback), which automatically generates graphical representations based on the prior knowledge of the learner (Ifenthaler, 2009, 2010a). Finally, the chapter concludes with a discussion of the two feedback approaches and future research directions.

**THEORETICAL BACKGROUND**

The large body of theoretical and empirical studies on feedback provides very diverse insight into possible ways to support and regulate learning processes. Even meta-analyses (Azevedo & Bernard, 1995; Kluger & DeNisi, 1996; Schimmel, 1983) have provided contradictory results. However, feedback is considered to be an elementary component for facilitating learning outcomes. As feedback can take on many forms depending on the theoretical perspective, the role of feedback, and the methodological approach, it is important to consider which form of feedback is effective for a specific learning environment.

**Informative feedback** refers to all kinds of external post-response information used to inform the learner of his or her current state of learning or performance (Narciss, 2006, 2008). Furthermore, from an instructional point of view, feedback can be provided by internal (individual cognitive monitoring processes) or external (various types of correction variables) sources of information. Internal feedback may validate the externally provided feedback, or it may lead to resistance against it (Narciss, 2008). However, the empirical evidence regarding the effects of different types of feedback is rather inconsistent and somewhat contradictory (e.g., Bangert-Drowns, et al., 1991; Clariana, 1993; Kluger & DeNisi, 1996; Kulhavy, 1977; Mory, 2004).

Feedback on mental model construction, such as the use of **conceptual models** to help persons to build mental models of the system being studied, has also been investigated and discussed (see, for example, Mayer, 1989; Pirnay-Dummer & Ifenthaler, in press). Conceptual models highlight the most important objects and associated causal relations of the phenomenon in question. However, not only do new developments in computer technology enable us to dynamically generate simple conceptual models and expert representations, but they may also be used to generate direct responses to the learner’s interaction with the learning en-