3. Practical Solutions for the Diagnosis of Progressing Mental Models

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Abstract: The question of how to diagnose the learning-dependent progression of mental models has been discussed extensively over the last 20 years. However, many questions about the diagnosis of changes in mental model construction still remain unsolved. This chapter begins with a critical analysis of assessment techniques in order to illustrate a variety of methods for assessing externalized knowledge structures such as mental models. However, in addition to choosing an adequate assessment technique for the diagnosis of changing models it is also necessary to define a satisfactory statistical procedure for the measurement of change. The chapter thus continues with a historical synopsis of measurement of change which illustrates the general statistical concerns involved in quantitative studies over time. The dilemma of how to measure progressing mental models adds even more complexity to the ambitious project of diagnosing progressing models. Therefore, the chapter closes by presenting eight empirically tested methodological solutions for further investigation of the progression of mental models.

Keywords: Measurement of change; progression of mental models; methodology.

Introduction

Diagnosis is the systematic and theory-based collection and preparation of information with the aim of justifying, controlling and optimizing conclusions and procedures. In the social and behavioral sciences, the diagnosis of change and the detailed investigation of why and how change takes place is of particular interest. Investigating changes of knowledge structures and understanding how to influence them is the key to well-designed and effective learning environments. Seel (1999, p. 180) concludes that “each subject should be measured repetitively over extended periods of time in order to understand the continuous progression of learning and thinking.”
For the last 20 years, the diagnosis of the learning-dependent progression of mental models and how to influence them through instruction has been discussed extensively (see Johnson-Laird, 1989; Seel, 1991; Al-Diban, 2002). However, many questions about the diagnosis of the learning-dependent progression of mental models still remain unsolved (Ifenthaler & Seel, 2005). Are there reliable and valid assessment techniques for capturing changing models? Which statistical procedures meet the requirements for an analysis of longitudinal data? Are tools and computer software available for these statistical procedures? Which experimental designs that use repeated measurements are suitable for a precise investigation of changing models? A researcher will be confronted with these and other problems whenever mental models and their learning-dependent progression are the focus of empirical study. However, before going into the problems involved in diagnosing the progression of mental models, we will briefly describe the frequently used concepts measurement of change, variability, and change from a methodological point of view.

According to Kleiter (1987), the measurement of change comprises all data collection and statistical procedures used to test the same phenomenon in multiwave measurements over a defined period of time. Since changes in learning and thinking take place continuously, educational research needs to move beyond the traditional two-wave design in order to capture these changes more precisely (see Willett, 1988). It is therefore necessary to conduct multiwave longitudinal experiments when complex changes over time are of central interest (Seel, 1999).

But when will a researcher report intraindividual change over time and when will she or he report intraindividual variability? For Nesselroade (1991, p. 94), the answer is straightforward: “Intraindividual variability identifies short-term, relatively reversible changes or fluctuations. [...] Intraindividual change designates long-term changes that usually are relatively not so reversible.” According to Eid (2003), intraindividual changes can interfere with situation-dependent variability. Therefore, the experimental design for the measurement of change must exclude such variability. These definitions of concepts provide the methodological foundation for the later sections of this chapter.

First, this chapter will provide an overview of different techniques for assessing changing models. The following historical synopsis of measurement of change will focus on doubts, problems and solutions of various statistical approaches during the last century. We will then discuss special dilemmas involved in the measurement of changing models and present methodological solutions from recent empirical research studies. The chapter will conclude with suggestions for future research on the diagnosis of changing models.

**Assessment Techniques**

Seel (1997) claims that the question of valid and reliable measurement of changing models is one of the central problems of mental model research. As