Chapter 1
Learning to Diagnose with Simulations: Introduction

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Making decisions require professionals in different fields to be able to identify, understand, and even predict situations and events relevant to their professions. This makes diagnosis an essential part of professional competences across domains. Diagnosis involves identifying the problem, analyzing the context, and application of obtained knowledge and experience to make practical decisions.

Scientific understanding of diagnostic competences improved significantly in the past years, and a range of measurement tools emerged (Herppich et al., 2018; Loibl et al., 2020). The existing empirical evidence supports the claim that problem-solving facilitates complex skills in different domains (Belland et al., 2017; Dochy et al., 2003). Problem-solving and reasoning in many domains rely on epistemic activities, for example, problem identification or collecting evidence (Fischer et al., 2014), which are also relevant for diagnosing. Simulation-based learning in turn, enables approximation of practice (Grossman et al., 2009) but also provides learning opportunities which are not present in real world situations (e.g., repeating a task over and over again to practice). Effectiveness of simulation-based learning also received empirical support with moderate to high effects on learning outcomes (e.g., in medical education, see Cook, 2014), however the question of how simulations can be designed to be most beneficial for students with different learning prerequisites has been addressed to a lesser extent (but see Chernikova et al., 2020) and remains largely open.

Two strands of research on diagnostic competences are particularly dynamic and promising, namely those in medical and teacher education. Although simulations are used in different areas of professional education, little research focuses on finding

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interdisciplinary commonalities and effective design features that can be transferred from one domain to another. We assume that medical and teacher education domains can learn a lot from each other with regard to the design of learning environments to foster the development of professional competencies (Heitzmann et al., 2019).

In this book, we present a coherent set of approaches to simulation-based learning of diagnostic competences across the domains of medical and teacher education. The coherency is achieved by measures on three levels.

First, the collection builds on a joint conceptual framework specifying learning prerequisites, learning process, instructional support, diagnostic context and diagnostic competences as the outcome, which will be introduced in Chap. 2. To elaborate on one exemplary of the framework's concepts, the simulations described in the chapters vary with respect to three main *contextual dimensions*. (1) They vary with respect to the domain and topics within the domains, e.g., fever of unknown origin in medicine or text comprehension problems in primary school in teacher education. (2) The diagnostic mode, that is whether the diagnostic processes is performed alone or together with one or more additional diagnosticians (e.g., an internist and a radiologist diagnosing the causes of a patient's fiver or a biology teacher and a physics teacher determining a secondary school student's scientific argumentation skill). The third dimension (3) refers to whether documents are the main information sources (e.g., X-ray pictures; student solutions of mathematical tasks) or whether the diagnostician need to dynamically interact with persons, e.g., a patient or a student. These variations within the common framework are necessary to address the heterogeneity of situations diagnosing practitioners will face.

Second, all of the chapters refer to the same basic definitions of diagnosing and diagnostic competences. Throughout this book, diagnosing is broadly defined "as the goal-oriented collection and interpretation of case-specific or problem-specific information to reduce uncertainty in order to make medical or educational decisions (Heitzmann et al., 2019, p. 4). Diagnostic competences are "individual dispositions enabling people to apply their knowledge in diagnostic activities according to professional standards to collect and interpret data in order to make high-quality decisions" (Heitzmann et al., 2019, p. 5).

Third, the individual Chaps. 3, 4, 5, 6, 7, 8, 9, and 10 in the collection position the reported work with respect to four overarching research questions. These are (1) What processes are central to generate desired learning outcomes in simulations aimed at diagnostic competences? (2) How can learners in simulations be supported to optimize learning outcomes? (3) Which variables mediate or moderate the effects of instructional support? (4) How can the simulations be adapted to fit the individual learners?

The order of the chapters is based on the different domains included. Chaps. 3, 4, and 5 report on simulations from mathematics education. Chaps. 6 and 7 present simulations in the context of science education. Chap. 8 describes a simulation in the psychology of teacher education in which future teachers learn to identify indicators of learning disorders in school students. Chaps. 9 and 10 are situated in medical education. Chap. 11 then offers a conclusion and an outlook which is focused on the four overarching research questions mentioned above.

The simulation-based learning environments presented in this book have been developed to enable learners to actively engage in diagnostic activities in different domains. They were validated, for example, by asking experts how authentic they consider the simulations to be in relation to real world environments, or by comparing the diagnostic activities and accuracies of novices and more knowledgeable learners, including experts. The simulations allow for investigating how students proceed in applying their different knowledge bases to diagnostic problems—and how their strategies differ from those of experts. In the future, they will enable research on the effects of instructional support in simulations. When different domains are included, the scientific knowledge on the instructional design of simulations for learning to diagnose could even be tested for generalizability across domains.

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