

Human Fallibility

The Ambiguity of
Errors for Work and Learning

Professional and Practice-based Learning

Volume 6

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Professional and practice-based learning brings together international research on the individual development of professionals and the organisation of professional life and educational experiences. It complements the Springer journal *Vocations and Learning: Studies in vocational and professional education*.

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- understanding and making explicit the complex and massive knowledge that is required for professional practice and identifying ways in which this knowledge can best be initially learnt and developed further throughout professional life.
- analytical explications of those processes that support learning at an individual and an organisational level.
- understanding how learning experiences and educational processes might best be aligned or integrated to support professional learning.

The series integrates research from different disciplines: education, sociology, psychology, amongst others. The series is comprehensive in scope as it not only focusses on professional learning of teachers and those in schools, colleges and universities, but all professional development within organisations.

Johannes Bauer • Christian Harteis
Editors

Human Fallibility

The Ambiguity of Errors for Work
and Learning

 Springer

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Series Editors' Foreword

Human fallibility is a particular source for practice-based learning. Specifically, learning from errors has become an issue of increased and widespread interest and recognition, as complexity becomes a crucial feature of various domains of daily life: Business, society, education, biography. Two insights are now accepted as features of these domains. Firstly, complex problems and fuzzy rules shape an environment of human behaviour which makes errors unavoidable; and, secondly, errors can be fruitful incidents for further development. Hence, contemporary life on the one hand offers the increased prospect of human fallibility, but, on the other hand, provides a rich source for (lifelong) learning. However, scientific analyses of errors have a long tradition. For example, errors shape the crucial moment of Darwin's evolutionary theory of variation and selection. Frederick Taylor established his approach of scientific management amongst others on the idea of avoiding errors by precise regulation of work division. These examples indicate the role that errors have already played during the nineteenth century. Yet, research on learning from errors is still quite young in its development, and it is quite scattered across academic disciplines. Up to now, many of the published accounts focus on learning from errors in school or university contexts. However, some work has also been conducted in the area of working life contexts, and this body of work stands to directly contribute to developing a coherent pattern for learning from errors. Insight is necessary into how best to describe errors, the processes of learning through them and their outcomes.

This volume seeks to make these contributions explicit, including methodological issues associated with understanding errors and their relationships to learning. It comprises four parts. The contributions to Part I and Part II address general issues of researching learning from errors. Parts III and IV comprise contributions that focus on specific work contexts and on the challenge of how to support learning from errors in daily working life. In this way, the purpose of the volume is to integrate international research conducted more or less independently at different locations and under different theoretical or methodological paradigms within one book. In an overview, this volume describes theoretical approaches of identifying errors, tracing processes of learning from errors, supporting learning from errors and

identifying outcomes of learning from errors – especially in professional contexts of daily life. Hence, it provides theoretical concepts and empirical evidence for understanding under what conditions professionals or teams of professionals are able to learn from their errors at work. In this context, ‘errors’ are conceptualised as actions or decisions that result in a deficient deviation from a desired goal and endanger the attainment of higher order goals. The interest in the topic emerged for the editors from observations that professionals and the organisations they are working for often act under particular error avoidance strategies. This error aversion probably results from concerns about costs and risks at various levels of impact. On the individual level, one reason individuals dislike errors is that they cause distress. They indicate deficiencies in performance, for instance, where we did not pay enough attention, or misjudged a situation, thus questioning our standing and our pride as proficient workers. Furthermore, errors may be dangerous and can cause undesirable events to occur. On the level of an organisation, they can endanger the creation of economic value, but can also be hazardous to employees, clients, or customers. Certainly, the research on safety and accidents is full of examples of minor errors leading to disastrous outcomes. As a consequence, there is a long tradition of research on human factors and safety management, aiming to provide approaches for estimating a system’s reliability, evaluating the potential damage from specific errors, analysing error causes, and preventing errors. Unfortunately, in contrast to the existing lines of inquiry on error prevention, less empirical evidence underpins views about potential benefits of errors at work. In particular, the issue of experiential individual or team learning from errors in the process of daily work has received little attention in research. Evidence for the ways in which the potential of errors can contribute to individuals’ and teams’ learning in terms of the improvement of their knowledge and performance is presented here from studies on learning environments in school as well as in work contexts. Moreover, research on the development of expertise, experiential learning, case-based reasoning, and learning through work has indicated that errors can be significant sources for professional learning. In all, the contributors to this volume elaborate in different approaches professional and practice-based learning from errors.

Stephen Billett, Hans Gruber and Christian Harteis

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Chapter 1

The Ambiguity of Errors for Work and Learning: Introduction to the Volume

Johannes Bauer and Christian Harteis

“By mistakes we learn” is a commonly used truism. However, from the perspective of research, the questions on how and under what conditions we learn from mistakes are hard to answer. One reason for this is that there is a huge variety of errors (e.g., lapses of memory versus using a wrong cognitive strategy for solving a problem; Norman, 1981; Rasmussen, 1987a; Reason, 1990). In addition, errors occur in various contexts (e.g., school, work, sports, everyday life), which may involve multiple causes and may lead to different learning potentials. Therefore, investigating under what conditions individuals, teams, or organisations can learn from errors is a demanding issue for research, which poses theoretical and methodological challenges (Billett, 2012; Mehl, 2010; Mehl & Wehner, 2012).

The present volume comprises analyses on these questions in the context of professional work. In this context, we understand ‘errors’ to be actions or decisions that could result in a deviation from a desired goal and endanger the attainment of higher order goals (Frese & Zapf, 1994; Hacker, 1998; Lipshitz, 1997; Rasmussen, 1987b; Senders & Moray, 1991; Zhao & Olivera, 2006). In professional contexts, we require more elaborate theoretical frameworks, which explain learning from errors, methods and research instruments that allow its measurement, as well as systematic research that investigates relevant determinants of learning from errors in different professions. Knowing what conditions may enhance or constrain learning from errors at work is relevant for explaining individual or collective differences in it as well as

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for the practical goal of creating work environments that support learning from errors (Bauer, Mehl, & Wehner, 2010; Bauer & Mulder, 2011; Harteis, Bauer, & Gruber, 2008).

The main idea of this book dates back to the year 2002 when we started a project, together with Hans Gruber and Helmut Heid at the University of Regensburg, aimed at investigating and describing work conditions that are supportive for employees' workplace learning and professional development. One of our major interests was how errors – that are inevitably made in all work contexts – may serve as learning opportunities for individuals, teams, and organisations (Bauer, Gartmeier, & Harteis, 2012; Harteis et al., 2008). This question resulted from the observation that professionals and their organisations often seem to act according to particular error avoidance strategies (Tjosvold, Yu, & Hui, 2004; Van Dyck, Frese, Baer, & Sonnentag, 2005; Wehner & Mehl, 2003; Zapf, Frese, & Brodbeck, 1999). On the individual level, one reason for our dislike of errors is that they cause us distress (Zapf, 1991). Errors show our deficiencies, including where we did not pay enough attention, or when we misjudged a situation, thus questioning our reputation and our pride as proficient workers. Besides, errors may be dangerous and can cause adverse things to happen (Glendon, Clarke, & McKenna, 2006; Perrow, 1984; Reason, 1990). On the organisational level, errors can endanger the creation of economic value and may also put employees, clients, or customers at risk. The research on safety and accidents has endless examples of minor errors leading to disastrous outcomes (Perrow, 1984; Reason, 1990). As a consequence, there is a long tradition of research on human factors and safety management with the aim of providing approaches for estimating a system's reliability, evaluating the potential damage from specific errors, analysing error causes, and preventing errors (Flanagan, 1954; Glendon et al., 2006; Rasmussen, 1987a; Senders & Moray, 1991; Strauch, 2002; Woods, Dekker, Cook, Johannesen, & Starter, 2010; Zimolong, 1990).

The error-avoidance approach described creates a dialectical tension: on the one hand, professionals as well as companies are keen to avoid errors; on the other hand, scholars have indicated that errors cannot be completely prevented and that a heavy reliance on error prevention can have detrimental effects (Kohn, Corrigan, & Donaldson, 1999; Perrow, 1984; Rybowskiak, Garst, Frese, & Batinic, 1999; Senders & Moray, 1991; Van Dyck et al., 2005; Volpert, 1992; Wehner, 1992; Wehner & Mehl, 2003; Wehner, Mehl, & Dieckmann, 2010; Zapf et al., 1999). Instances of such detrimental effects are: the potential occurrence of errors may be insufficiently anticipated; employees lose their skills in dealing with them; and learning opportunities are missed.

For these reasons, a shift from an exclusive error prevention approach to an error management strategy has been proposed (e.g., Zapf et al., 1999). Error management concepts suggest, in addition to prevention, an efficient way of dealing with errors and learning from them. The error management approach is based on the assumption that a systematic analysis of occurring errors can provide organisations with information about necessary adjustments of knowledge, strategies, and behaviour. Moreover, errors may evoke new insights that lead to learning beyond the mere

prevention of similar errors (Ellström, 2001; Peters & Peters, 1987; Wehner, 1992). Consequently, learning from errors is an important technique of organisational learning (Argote & Todocara, 2007; Argyris, 1982; Cannon & Edmondson, 2005; Ellström, 2001; Kriegesmann, Kley, & Schwering, 2005; Peters & Peters, 1987; Senge, 1990; Sitkin, 1992).

Hence, although it seems obvious that errors should be avoided in professional work because they endanger the attainment of desired goals, a prerequisite for avoiding errors as well as for capturing the potential benefits that arise through errors is to be open to their occurrence and to learn from them (Harteis et al., 2008; Van Dyck et al., 2005; Wehner, 1992). This seeming dilemma shapes the ambiguity of errors for work and for learning.

In the following section, we briefly sketch the current state of research on errors at work and learning from them as an introduction to the present volume. Next, we provide an overview of the articles in this book and how they contribute to the existing lines of inquiry.

Perspectives on Errors at Work and Learning from Them

Several areas of research on errors and learning from errors already exist (cf. Bauer et al., 2010; Bauer & Mulder, 2008). First, there is a large body of research on *human error and safety management* that focuses on the conditions, classification, and prevention of human error. There are several classical discourses on this topic (Frese & Zapf, 1991; Perrow, 1984; Rasmussen, 1987c; Reason, 1990; Senders & Moray, 1991) as well as a vast literature on safety management in general and on issues in specific domains such as health care (Aspden, Corrigan, Wolcott, & Erickson, 2004; Bogner, 1994; Glazinski & Wiedensohler, 2004; Glendon et al., 2006; Holzer, Thomeczek, Hauke, Cohnen, & Hochreutener, 2005; Kohn et al., 1999; Strauch, 2002). A special topic is the discussion on critical incident reporting systems (IRS), that is, knowledge management databases – which are used, for example, in aviation and health care – serving for the collection and analysis of occurring critical incidents (Barach & Small, 2000; Dovey & Phillips, 2004; Hofinger, 2010; Holzer et al., 2005; Kaufmann et al., 2002; Uribe, Schweikhart, Pathak, & Marsh, 2002; Zhao & Olivera, 2006). The actual contribution of IRS to learning from errors is, however, still a subject of debate among experts in the field (Hofinger, 2010; Pfeiffer & Wehner, 2012).

Second, in contrast to error prevention, there is a smaller but more diverse body of literature focusing on potential positive effects of errors for developmental processes and on detrimental effects of a very strict emphasis given to error prevention. This literature on *error friendliness* employs arguments from evolutionary biology (von Weizsäcker & von Weizsäcker, 1998), the irony of automation (Bainbridge, 1987), or work psychology (Mehl, 1993; Volpert, 1992; Wehner, 1992). Recently, Gartmeier (2009) advanced the notion of error friendliness in his work on the acquisition of error-related knowledge (cf. Gartmeier & Schüttelkopf, 2012).

Third, *organisational learning and human resource management* research has focused on optimising inner-firm processes and firm performance by applying strategies of quality management and organisational learning. Next to the classical works on organisational learning (Argyris & Schön, 1996; Senge, 1990), a number of journal articles and book chapters have stressed the importance of learning from errors for organisational learning (e.g., Argote & Todocara, 2007; Kriegesmann et al., 2005; Sitkin, 1992).

Fourth, there is a line of inquiry focusing on enabling learning from errors in the context of *education and professional training*. In education, learning from errors has been an issue in research on learning and instruction (Große & Renkl, 2007; Mathan & Koedinger, 2005; Van Lehn, 1988). Starting with some seminal studies in Switzerland, an intensive discussion about the prevalence and creation of a constructive error culture in the classroom has begun (Althof, 1999; Oser & Spychiger, 2005; see also Dalehefte, Prenzel, & Seidel, 2012; Heinze & Reiss, 2007; Klockmann, 2005; Meyer, Seidel, & Prenzel, 2006; Seifried & Wuttker, 2010; Weingardt, 2004). A related field investigates training that aims at the development of strategies to deal with errors in an efficient and learning-oriented way (Frese, 1995; Heimbeck, Frese, Sonnentag, & Keith, 2003; Keith, 2005, 2012; Keith & Frese, 2005, 2008).

Finally, studies on individual and team learning from errors in professional contexts arose from various lines of research on *professional learning and development, expertise, and workplace learning*. Some classic analyses from work and organisational psychology have explained processes of learning from errors in the context of action–regulation theories (Frese & Zapf, 1994; Hacker, 1998; Volpert, 1992). Recent studies have focused on the organisational climate for learning from errors (Kluge, Schilling, & Putz, 2010; Putz, Schilling, & Kluge, 2012) or on the role of negative emotions (Zhao, 2011). Moreover, research on the development of expertise, experiential learning, case-based reasoning, and learning through work has indicated that errors can be significant sources for professional learning (Ellström, 2001; Eraut, 1994; Ericsson, 2006; Gruber, 1999; Klein, 1997; Kolodner, 1983; Ohlsson, 1996). Hence, learning from errors has already been addressed in studies on expertise, the development of professional competence, and learning in the process of work (Arndt, 1996; Bauer & Gruber, 2007; Bauer et al., 2010; Bauer & Mulder, 2007, 2008, 2010, 2011; Cannon & Edmondson, 2001; Cseh, Watkins, & Marsick, 2000; Edmondson, 1996; Ellis, 2012; Ellis & Davidi, 2005; Eraut et al., 1998; Harteis et al., 2008; Harteis & Frost, 2012; Meurier, Vincent, & Parmar, 1997; Tjosvold et al., 2004; Tucker & Edmondson, 2003; Van Woerkom, 2003, 2012). A particular challenge in this context is modelling and measuring outcomes of learning from errors, and from errors that almost occurred, in terms of knowledge (Gartmeier, Bauer, Gruber, & Heid, 2008, 2010; Gartmeier, Gruber, & Heid, 2010; Gartmeier, Lehtinen, Gruber, & Heid, 2010; Gartmeier & Schüttelkopf, 2012; Gruber & Mohe, 2012; Järvinen & Poikela, 2001; Oser, Näpflin, Hofer, & Aerni, 2012).

Overview of the Book

Scope and Audience

As discussed in the previous section, there is a huge body of research on errors and learning from errors at work from various disciplines and fields of inquiry. However, there is currently no coherent book which systematically presents these different perspectives in order to explain the processes and determinants of learning from errors in professional contexts. The primary objective of this volume is to integrate theoretical and empirical studies on learning from errors at work written by researchers of various backgrounds. This book contributes towards a deeper understanding of the conditions in which professionals are able to deal with errors productively and to learn from them by bringing together theoretical models and useful research strategies as well as empirical evidence on processes and outcomes of learning from errors from diverse perspectives. Together, the chapters in this volume draw a quite comprehensive picture of the current state of the art in research on human fallibility and learning from errors at work. Moreover, the reader will also be impressed by the wealth of different approaches.

The intended audience of this volume are researchers who are interested in human fallibility and learning from errors, for example those in the fields of education, cognitive and educational psychology, psychology and sociology of organisations and work, management, human resource development and workplace learning. Likewise, evidence-oriented practitioners in the said fields and in workplaces that demand high levels of safety will find new significant perspectives. We hope that the contributions in this volume will inspire theory, research, and evidence-based practice in these fields.

Organisation and Content

This volume is organised in four major parts. *Part A* contains theoretical contributions on errors, their learning potential, and the processes of learning from errors. A particular theme is modelling the outcomes of learning from errors in terms of knowledge. *Part B* presents chapters which address the question on what methodological procedures and instruments are appropriate for investigating errors and learning from errors. *Part C* presents results from empirical studies on learning from errors, its determinants, and outcomes in selected professions. Finally, *Part D* includes research on interventions and training studies, which aim to utilise errors for learning and the creation of conditions that enable learning from errors. Readers can find an overview of the chapters in their respective parts below.

Part A: Errors, Their Learning Potential, and the Processes of Learning from Errors

Billett (2012) opens the discussion on errors and learning from errors at work from a socio-cultural perspective. His contribution in this chapter anchors the issues of errors and learning from them in a deep theoretical understanding of the processes and conditions of workplace learning. Referring to recent studies and theorising about the subjective or personal and social bases of learning through work, Billett discusses what constitutes an error and how learning can arise from errors depending relationally on personal and social (i.e., cultural and situational) factors. That is, errors and learning from errors happen through and are dependent on the interaction of individual workers – considering their personal background – with the socially and culturally shaped affordances that workplaces provide.

Gartmeier and Schüttelkopf (2012) emphasise the importance of investigating the outcomes of learning from errors. Similar to Oser et al. (2012), they advance the concept of *negative knowledge* as a conceptual framework, that is, knowledge about potential errors in a given situation and conditions for their occurrence. After sketching the advantages of a perspective on the outcomes of learning from errors and elaborating on the concept of negative knowledge, the authors provide a discussion of conceptual and methodological conclusions for the investigation of negative knowledge. Particularly, they argue that error-related knowledge should be seen as dually embedded in an individual's experience and in a particular social context.

Oser et al. (2012) continue the discussion of negative knowledge and address the question on how mistakes that were prevented just in time (i.e., near misses) may foster the development of such knowledge. Their chapter aims to show that near misses can bear an equal – if not superior – learning potential as compared to errors that actually happened. From their qualitative research, the authors present compelling examples of near miss situations in everyday and professional domains. Moreover, in a further quantitative study with apprentices, they show that there is a positive correlation between the apprentices' perception of a positive culture of learning from mistakes within companies and achievement-related variables, such as the apprentices' self-efficacy and performance motivation. The positive correlation of the above mentioned variables is moderated by gender differences, that is, males seem to depend on a supportive error culture more strongly than females.

Gruber and Mohe (2012) review and integrate theory and research on knowledge about errors from various disciplines, such as educational science, business management, work psychology, and computer science. Based on a classification model from the psychology of knowledge, the authors distinguish the acquisition, representation, and application of knowledge about errors. The authors exemplify the results of their analysis in relation to the professional domain of business consulting.

Part B: Methodological Strategies

Mehl and Wehner (2012) raise critical questions concerning methodological problems in research on errors and learning from them. Referring to the examples of classic studies, they demonstrate that the search for potential causes – a hallmark of models of learning from errors – quickly becomes a matter of attribution from hindsight that may be biased and rests upon untestable assumptions. Also, the authors show that the classification of error types is not such a clear-cut matter as existing taxonomies of error types may suggest. They conclude the chapter by arguing convincingly that training simulators provide an appropriate setting for the investigation of learning from errors and probably help to overcome many of the methodological problems.

Putz et al. (2012) present a study on the development of a questionnaire, which measures the organisational climate for learning from errors. They developed this instrument according to a theoretical model that systematically combines “process-stages” of learning from errors with relevant influences on the individual level (i.e., employees’ and supervisors’ behaviour) and on the level of the workplace affordances (i.e., operating procedures and task structures, organisational principles and values) (cf. *Billett, 2012*). In their study, the authors evaluated the psychometric properties of the instrument and found evidence that supports the assumed theoretical structure. In addition, correlations of the newly developed instrument with external criteria, such as group cohesion and customer satisfaction, provide first evidence of criterion-related validity.

Part C: Learning from Errors in the Professions

Van Workom (2012) investigates the error orientation of teams and how this orientation mediates the relationship between other team characteristics and the innovative potential of teams. Her findings from a large study involving teams from several organisations indicate that team autonomy is an important predictor for problem solving orientation toward errors within a team. Moreover, teams with such a problem solving orientation also tend to feel they are in a more innovative team climate. In contrast, teams with a blaming approach to errors are rated as being significantly less innovative by their managers. These findings illustrate the importance of creating a social climate and culture in organisations that allows dealing with errors openly and in a reflective manner (cf. *Putz et al., 2012*).

Harteis and Frost (2012) investigate error orientation in emergency medicine, a domain that requires rapid and intuitive decision making. In their laboratory study, the authors test the hypothesis that physicians’ error orientation influences their intuitive behaviour as well as the quality of their casework on simulated emergency situations. The most important finding from this study is that physicians with a less anxious orientation towards errors make better intuitive decisions in the medication

of emergency cases. As expected, the physicians' work experience had an impact on their decision making, with this impact being moderated by the emotional handling of errors.

Bauer et al. (2012) summarise findings from a research program involving multiple studies on the processes, outcomes, and conditions of learning from errors in various professions. A major finding is that socially shared reflection with colleagues about potential causes of an error as well as joint development of strategies for improved performance are important activities for learning from errors. Engagement in such learning activities seems to depend on the subjective estimation of errors as relevant for learning as opposed to motivational tendencies to conceal errors. Concerning the outcomes of learning from errors, negative knowledge about relevant errors and conditions for their occurrence could be elicited in studies with geriatric nurses.

Part D: Enabling Learning from Errors

Keith (2012) reviews research on how errors can be used in training for supporting competence development. She presents a theoretical model along with supportive evidence showing that encouraging participants to make and explore errors during training (i.e., error management training) leads to better performance in tasks that require adaptive transfer. This effect is mediated by emotional control and metacognitive activity. These variables are also fostered by error management training. In sum, the presented findings are an impressive demonstration of the potential of learning from errors.

Dalehefte et al. (2012) present a study on errors in the context of the teaching profession. In shaping learning environments that are conducive to students' learning, teachers have the task to foster a learning-oriented approach towards errors and to create a supportive social climate. In their study, the authors analysed classroom conditions for making errors and the social climate for dealing with them by comparing classrooms in Germany and the German-speaking parts of Switzerland. Based on videos of physics lessons and data from student questionnaires, the authors found differences between these countries indicating that Swiss teachers are better at creating a supportive climate for learning from errors.

Ellis (2012) discusses the role of after-event reviews, that is, an experiential learning procedure for learning from errors. After-event reviews involve structured reflection processes after completing a task in order to analyse and understand potential reasons for their performance. This process is guided by a facilitator. In this chapter, Ellis reviews findings from several of his studies that provide explanations how after-event reviews promote learning from experience. Most importantly, after-event reviews enhance the quality of self-explanation, data verification and interpretation processes, provide process feedback, enhance self-efficacy, and have beneficial effects on motivation.

Pfeiffer and Wehner (2012) provide a critical discussion on how IRS in hospitals can contribute to individual and organisational learning from errors. Based on learning

theories, the authors analyse questions about the subjects of IRS, the motivation of clinicians for using them, modes of learning, and potential learning outcomes. As a result of their analysis, Pfeiffer and Wehner conclude that current forms of the implementation of IRS remain within a single-loop learning scenario and largely fail to stimulate a deeper, more critical reflection of organisational routines, premises and values. Based on their analysis, the authors draw conclusions for the future improvement of IRS.

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