Human Fallibility

The Ambiguity of
Errors for Work and Learning

Professional and Practice-based Learning

Volume 6

Series Editors:

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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*.

Professional learning, and the practice-based processes that often support it, are the subject of increased interest and attention in the fields of educational, psychological, sociological, and business management research, and also by governments, employer organisations and unions. This professional learning goes beyond, what is often termed professional education, as it includes learning processes and experiences outside of educational institutions in both the initial and ongoing learning for the professional practice. Changes in these workplaces requirements usually manifest themselves in the everyday work tasks, professional development provisions in educational institution decrease in their salience, and learning and development during professional activities increase in their salience.

There are a range of scientific challenges and important focuses within the field of professional learning. These include:

   - 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

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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; Rybowiak, 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 & Wuttke, 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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Part I
Errors, Their Learning Potential, and the Processes of Learning from Errors

Chapter 2
Errors and Learning from Errors at Work

Stephen Billett

Errors, Learning and Work

Coming to understand what constitutes errors at work and what learning can potentially arise from them are quite central to considerations of work and learning as arising through socially-shaped, but personally enacted practices. It is proposed here that, through engaging in activities and interactions, such as those at work, individuals come to both practice and learn, much of it through incomplete, partial or poorly performed actions and activity (i.e. in error, insofar as they fail to completely meet the needs of the goal-directed activity). So, from such a definition of errors, the very processes of undertaking work and learning through and for work and across working lives are inherently premised on making and resolving errors, and, moreover, these processes underpin both working and learning. If this was not the case, the process of learning new knowledge and its refinement and honing would be straightforward and our subsequent performance would be flawless. Instead, the very process of learning through or for work is mainly incremental and, sometimes, transformational. Incrementally, much of our learning of work activities is a process of improving on our previous performance, which had perhaps then wholly fulfilled work requirements. Technically, this process is referred to as engaging in increasingly mature approximations of the tasks to be achieved (Collins, Brown, & Newman, 1989). Yet, this process is un-ending across working lives as performance work requirements change and even those nominated as experts continue to make errors both in learning and work (Ericsson, 2006). Through our ongoing engagement in work tasks, we have the opportunity to undertake and repeat activities through

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rehearsal and come to ultimately perform at a required level. In this way, our initial attempts are likely to fall short of the required performance (i.e. they are errors). Yet, progressively, the errors associated with new learning are eliminated through processes of refinement and honing, but this process is never complete because we are constantly engaged in new learning. Therefore, there are close associations among errors, learning and work. As a starting point, therefore, making errors when engaging in work activities should not be taken as being inherently wrong or unde- sirable. It is central to individuals' development of capacities and the inevitable process of engaging in work and other kinds of tasks.

Moreover, this error-making is usually anticipated in the places where work is enacted. It exists as a social fact used to shape the sequencing and access to activi- ties and interactions in the workplace by workers. Indeed, often, workplace tasks are organised on this very premise: that is, the engagement in activities is ordered on a premise of managing errors. Lave (1990) identifies the management of errors and their consequences as a central principle of organising apprentices' work and learn- ing experiences. She noted how apprentice tailors engaged in activities premised on the likelihood and consequence of errors, with only experienced workers engaging in tasks where the consequences of errors would be unredeemable. For example, when I first started working in the pattern-making department of a large clothing manufacturing company, my activities were restricted to cutting patterns for compo- nents that did not require the same level of precision as the lining and fabric patterns that I progressively went on to complete later. To avoid me making errors on patterns where the implications of those errors would be expensive and far reaching, my initial tasks were organised to restrict my errors to components that would tolerate my developing skills. Indeed, the most common form of learning people undertake, the honing and refinement of what we do, is directed towards progressively securing levels of adequate performance. That is, learning through a process that progres- sively reduces the elements of error in what we do.

Moreover, the learning of new knowledge quite often also arises through making errors with and discovering the inadequacy of our existing knowledge. That is, we are confronted with situations for which our existing knowledge is inadequate and we make errors, albeit in how we spell a word, cook a meal, interact with col- leagues, and perform societal roles, such as being a parent to a growing child. It is in attempting to spell the word, cooking a particular kind of meal, misunderstanding the purpose and process of interaction with colleagues and how we engage with our children as we move through different levels of maturity in our activities through which we make mistakes. If errors comprise incompetent performance of an activity or an interaction, then these are central to both our learning new knowledge and engaging in tasks that are novel to us. In addition, it is through deliberate efforts to avoid errors that direct our intentional learning.

So, to reinforce this point, engaging in processes that involve making errors is central to how we learn, and come to perform in and through work and across work- ing life. Of course, immature, incomplete or downright wrong performances can have a range of consequences and need to be managed for both the purposes of work and learning. Yet, these consequences also merely heighten the fundamental relations

between errors and learning. Therefore, it is worthwhile considering the form and nature of errors of their relationship with both learning and work.

However, beyond emphasising this key relationship, the central claim made here is that errors are not wholly objective events. That is, a behaviour can always be taken as an unqualified error. Instead, what constitutes errors have both personal and social connotations. Indeed, they have dualistic qualities existing in the separate domains of the personal and social worlds, and are premised on relational bases between the two of them. In preview, individuals may or may not view a particular action as being an error, and that error may or may not be recognised as such in the setting in which it is enacted. Instead, what constitutes an error is often person and situation dependent. What for one individual is seen to be an inadequate performance, for another it might be seen as being quite an adequate or even excellent performance. The elite soccer player who kicks the ball right across the football field towards the goal, only to see the ball land close to and be caught by the goalkeeper, might view that performance as an error. Whereas, for others, myself for instance, even getting a football into the penalty area would be an excellent performance. Moreover, if the elite footballers' team has a six goal lead over the opposing side, it is unlikely the footballer will be chastised for this error by his team mates and managers. However, if the footballers' team is one goal down and in the final moments of the cup final and she had previously made this 'error' before, then she might be taken to be error prone and incompetent by the team supporters, spectators, team members and her coach alike. Of course, this relational account of errors can easily be applied to other forms of work. The hospital surgeon who fails to save the life of a road trauma victim by not recognising a specific life-threatening injury, when having been successful with previous patients, might be seen to have made an error. However, this would not be the case for the local general practice doctor who was first on the scene at a road crash, and whose skills and experiences were not helpful in assisting her in recognising and treating that injury. Yet, if this victim was only one of 50 elderly tourists who had been injured in a bus crash and the surgeon was simultaneously caring for many critically injured passengers, this oversight would be less likely to be seen as being a crucial error, except perhaps by the deceased's family. So, there are both relationally personal and situational factors that shape what constitutes errors, and what are taken as the consequences from that error making.

Moreover, both individual and situational factors will also shape how productive learning can arise from the error. For instance, depending whether those making errors are allowed to admit to them and gain support for learning from them, or need to hide their mistakes if at all possible, will likely shape the potential for learning (Bauer & Mulder, 2007). Hence, the degree by which the culture of the workplace is tolerant of errors, and the situations in which they occur are supportive or punishing of what is taken and constitutes mistakes, will both be central to the mediation of individuals' learning. Therefore, to conceptualise and understand further what constitutes errors and what learning arises from them requires considerations of personal and situational factors and relationships between these factors.

These propositions are now elaborated and discussed, drawing on recent studies and theorising about both the subjective and social bases of engaging in and learning through work. Work practices and workplaces are particularly helpful to understand what constitutes errors because the goal-directed activities in workplaces are focused on achieving specific ends, yet performed by individuals with different levels of capacities and interest in those activities. Yet, because much of work performance is shaped by goals that are situated in specific work settings, this performance and what constitutes errors needs to be understood both separately from, but alongside, the constructions of work tasks and errors by individual workers. Moreover, given the capacities of workplaces to sustain particular kinds and levels of performance, and workers' different levels of concerns for performing effectively, the negotiations between these personal and social worlds will be central to the kinds of learning that occur though work. So, more than being good or bad, or generative of rich or weak learning, a consideration of errors at work can richly inform about learning through work.

In advancing this case, the situational, cultural and personal bases for what constitutes errors and the relationships among them are discussed and elaborated in the next section. This is followed by a brief concluding section on considerations of how individuals learning through errors are shaped through these relational bases. However, before engaging in these discussions it is important to understand what constitutes human performance at work, as fallibility with and errors in work are commonly associated with failure to perform adequately (i.e. falling short of a required performance).

Performance and Errors at Work: The Social Dimension

To explain what constitutes errors and how individuals might learn through them at work, it is necessary to identify the benchmarks of what constitutes work performance. These benchmarks permit an informed account of what constitutes failures to perform adequately: errors and human fallibility. Yet, understanding what comprises competence at work needs to accommodate both socially-derived and personally-constituted perspectives of that competence. Here, the social perspective is advanced.

Much of the requirements for performance of occupational activities in workplaces are expressions of needs and requirements of the social world. Searle (1995) refers to these as institutional facts that require human needs and institutions for their existence. These facts include sets of human needs for survival, shelter, sustenance, good health, education, order and security that often find form as paid occupations. So, for instance, the performance of nurses, cooks and police officers are premised, respectively, upon societal needs when we seek to be taken care of, to produce food to eat, and law and order. Hence, most occupations arise from particular institutional needs and requirements and are shaped, and also transformed, by particular cultural requirements.

It follows, therefore, that there are expectations of occupational performance that arise from these defined cultural needs. Hence, errors are seen to occur when these requirements are not met. Consequently, when nurses are seen to be not caring for patients, food judged to be inedible, and police officers seemingly failing to secure law and order then they are seen to be in error. These expectations are often at the heart of what constitutes competence at work. For instance, beyond the technical requirements of being a competent nurse, there are expectations that they will be discreet and act personably, even under duress. So, there are a set of culturally prescribed performance expectations that constitute the adequate or inadequate (i.e. in error) forms of work, and, beyond that, occupational performance can be quite situational.

Rather than being uniform across occupations, however, the expectations of work performance are quite diverse across work situations. Although there are occupationally common concepts, values and practices – the canonical knowledge of the occupation, which if violated is seen to be in error – across workplaces, their application likely differs quite widely. This is because there are quite distinct performance requirements in specific work situations. As Darrah (1997, p. 249) claims "… jobs seem so diverse as to obviate the need for generalisations about how people perform work". Therefore, what constitutes the performance of these occupations is likely to differ across the situations in which they are applied.

Across countries and cultures, there are different requirements for occupational performance thereby making what constitute performance errors subject to these cultural requirements. Different cuisines requiring quite particular techniques, ingredients and expectations have particular geneses. Restaurant customers selecting particular cuisines do so on the basis of expectations about the kind of food they are ordering. Hence, work performance is likely premised on meeting those expectations, which may have to be modified in response to the available ingredients. Therefore, performance and performance errors are premised upon expectations about that cuisine. As with cuisine, differences in climate may also extend to performance. The requirements for occupations are often played out differently in countries that have hot summers and frigid winters. Some of the tasks undertaken and performance required of automotive engineers and construction workers in northern Europe, Canada, and northern American states are unlikely to be the same as their counterparts in most places in Australia, South American countries, or other warmer climates, and vice versa. One occupational requirement for the former is to ensure that vehicles and houses are protected against very cold weather. So, mechanic or construction workers from a warmer climate would be in error if they failed to account for these brute facts.

Other differences shape occupational requirements within similar kinds of work. For instance, some retail work is highly segmented and routinised, as is the case in grocery stores. Shoppers in large supermarkets would have little expectation that retail staff would be able to advise them about the attributes of particular products. Errors in performance here are more likely to be associated with directing a customer to the wrong aisle to find goods, which would be expected, than advice about particular items, which would not. Yet, in hardware stores, retail workers are

expected to provide advice to customers about products and processes for applying products (Bernhardt, 1999). Consequently, in what constitutes work performance comprising the same occupation, there are variations in occupational practices that necessitate particular forms of workplace competence.

However, beyond performance requirements at the cultural level, there are also situational factors that shape these workplace competencies. For instance, it was found that performance for hairdressing had distinctive features across four salons (Billett, 2003), three of which were in the same Australian state. What comprises hairdressers' work, for instance, is likely shaped by a combination of factors comprising the location, clientele, staff and workplace arrangements. In a fashionable inner-city salon, the performance requirements were the ability to transform the clients' appearance through interesting haircuts and colouring. The hairdressers were also required to have appearance, interests and values aligned with its clientele. Here, not being fashionably dressed or 'cool' would be an error. Yet, in a salon in a low socio-economic suburb, an important work requirement was to manage a precarious business and a clientele that included demanding and difficult clients. A key performance requirement here was to manage these 'awkward' customers, particularly when they complained about their treatment. Hence, an error here would be to not remind these clients repeatedly that the treatments they demanded would require considerable care and maintenance and the use of particular kinds of conditioners. In another salon, the clientele comprised elderly women who came to the salon fortnightly, as much for companionship as to have their hair dressed. Here, the hairdressers' knowledge of clients' personal histories, knowing the names and circumstances of family and friends, was an important expectation of the clientele. Hence, confusing the name of one of the clients' brothers or sisters with a relative who had died recently could be taken as a significant error. In these ways, local factors shaped in quite distinct ways what constituted expectations of workplace performance in each of these salons. In each situation, failing to fulfil these expectations would be seen as an error within that particular salon. Such considerations are not restricted to this kind of occupation. For instance, the work of nurses, motor mechanics, teachers and doctors, to name a few, are shaped by the circumstances in which they practice. In a country like Australia with many small and remote communities, the requirements of those occupations are likely to be quite different in those communities, than in regional centres and cities. Hence, both performance requirements and the making of errors will be shaped by the expectations of those communities. Consequently, understanding what constitutes workplace performance and errors with that performance cannot wholly rely on occupational-level 'objective' analyses. Instead, national, cultural, local, and enterprise-level factors all shape workplace performance requirements: the 'objective' account of workplace requirements, and what are taken as errors.

Moreover, the requirements for performance also change over time, meaning that what is an acceptable performance at one point in time will be inadequate (i.e. an error) at another. The entrepreneurial banker, praised in times of strong growth and shareholder demand for high return, may well be later seen as erring in imprudence when bad debts mount, and, of course, vice versa. Work requirements are constantly