Chapter 16

Epilogue

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As we finish the work of editing this book and look back at the process behind that effort, we have the feeling that it has simultaneously been one of the most inspiring experiences and one of the most challenging undertakings of our professional careers. The idea of creating a book on the state of the art of problem solving research was conceived in a series of formal and informal meetings among the authors, and it has been shaped in a number of discussions and e-mail exchanges since then.

Editors of collected studies always begin their endeavor with clear goals, and when they read the first drafts of the chapters, they often suggest revisions to reach those goals. At the same time, they may also revise their original intentions. During the editing process, we did so in two respects. On the one hand, the materials we have received represent a much broader perspective on the field and cover a number of recent aspects of problem-solving research that were not visible at the beginning of the project.

On the other hand, at the beginning we envisioned a well-structured, textbook-like volume with clear definitions of concepts and a consistent use of terminology throughout the book. However, over the past years, we have had to revise our own original ideas, as it has become obvious that the use of the terminology is so diverse that the way the authors use it is far from consistent.

When we attempted to establish a uniform terminology, we realised that proposing the terms we prefer would limit the authors in expressing their ideas; furthermore, we knew they would use their preferred terminology in their other publications anyway. Such a strong editorial approach might have made this book terminologically more consistent, but it would have created inconsistency between the authors' present and other publications and would not have aided in making the terms used in the field any clearer. Therefore, we accepted the authors' terminology as they use it to express their ideas in their own way, but in this concluding chapter, we discuss this issue and propose a conceptual system only for the most crucial issues.

The problem of the terminology for problem solving is not unique at all. The difficulty becomes clear if we think of the disputes surrounding interpretations of some other general terms, such as knowledge, skills, competencies, intelligence, creativity, aptitude and ability, and the relationship between them. There are a number of factors that make it difficult to develop a consistent terminology. One is the historical issue. As we discussed in the first chapters, the conception of problem solving has evolved over a century, and different schools and traditions have used different sets of terms that are not always easy to map onto each other. In recent decades, problem-solving research has expanded at an accelerating speed. At this stage of rapid development when researchers identify and define its ever newer forms, it would not be practical (if even possible) to freeze the current state of categorisation or propose a rigid terminology.

Another issue is a linguistic one, as problem or problem solving may have different connotations in different languages. In different languages, the sections of the continuum that spans from carrying out routine tasks to solving complex problems may be referred to differently, and the point from where the activity is called problem solving may be found at different places. For example, problem in terms of "mathematical word problem" would be translated as *Aufgabe* into German or *feladat* into Hungarian, although a cognate for the word *problem* exists in both languages. Some languages have different terms for the simpler forms of problem solving, reserving their version of the term *problem solving* for the more complex forms and thus no adjective is needed to express its complex nature. These different linguistic tools shape our thinking about problem solving in different ways, which also contribute to the difficulty in using a consistent terminology. Nevertheless, we have to notice that although the usage of the terms throughout this book does not always seem consistent, the way of thinking across the authors of the chapters seems very consistent indeed.

The terms describing types of problem solving we have used in the chapters of this book may best be characterised by five pairs of antinomies:

1) analytical/complex
2) static/dynamic
3) individual/collaborative
4) domain-specific/domain-general
5) subject-specific/cross-curricular.

The nature of these antinomies has been elaborated in several chapters and in different contexts, so we think it is unnecessary to go into detail here. But at least a short summary of our understanding of the dichotomies will be presented here.

We propose the "analytical/complex" dichotomy as the most general division of the categories of problem solving. Needless to say, we consider the complex side the more interesting and challenging field of research, and this book tends to deal with that. Analytical problems are closed problems in the sense that all the necessary information that a problem solver needs to arrive at a solution is given. In complex problems, there is no clear-cut border to the problem situation.

The "static/dynamic" dichotomy is highlighted when the nature of dynamic problem solving is explained, and static in this context simply means not dynamic. Dynamic problem solving has become the focal area of research recently, as it can best be realised by means of computer simulation. We consider dynamic problem solving the most advanced form, and thus a subcategory of complex problem solving. Dynamic problem solving always involves an interactive knowledge acquisition phase. Therefore, in certain contexts it may be called interactive problem solving when its interactive nature is emphasised; however, in general, the term dynamic is more precise. There is also a great deal of overlap between the connotations of static and analytical; it is the context that determines which one is more appropriate.

The "individual/collaborative" dichotomy indicates the social context of problem solving and also describes a relatively new field of research. Collaborative problem solving also involves interactions, in this case those between problem-solving individuals. Collaborative problem solving originally denoted human-to-human interactions, although there have been attempts to replace one of the humans with agents (computer-simulated collaborators). Such simulated environments may be used for assessment purposes, although certain aspects of real social interactions may thus be lost. Some facets of reality are also lost when simulation is used in dynamic problem solving, and so one of the most interesting issues in current research is how well human-agent interaction represents human-human interactions and what the relationship between these and the process of dynamic problem solving is.

The "domain-specific/domain-general" dichotomy indicates the scope of the problem-solving skills, with the domain-general side tending to be closer to the complex side of the "analytical/complex" dichotomy discussed above. The "subject-specific/cross-curricular" division reflects the same issue in an educational context.

Several combinations of these adjectives may be reasonable. For example, we may deal with domain-general dynamic problem solving or domain-specific static problem-solving skills. A number of other adjectives may also be attached to problem solving to highlight some of its specific contexts or aspects, for example scientific problem solving. The volume that reported problem solving for PISA 2012 was entitled "Creative problem solving", thus highlighting the creative nature of dynamic problem solving, which had been included in the assessment instruments.

We have witnessed the birth of a new level of problem-solving research. We have also seen ever newer fields being made measurable in the domain of problem solving in a broader sense; indeed, one of the most interesting goals of research is to make measurable that which cannot yet be measured. Educational assessment provides vital feedback for several levels of education systems. PISA 2003 introduced the assessment of problem solving to large-scale international programs, and the 2012 assessment brought to light its broader potential in evaluating the quality of students' knowledge and skills. We hope with time that PISA will consider incorporating problem solving into its assessments in innovative domains when country differences may change due to their efforts to improve the quality of education. We also believe that as the feasibility of assessment is demonstrated at an international level, it will inspire countries to include an assessment of problem solving in their national assessment systems, as the testing of reading, mathematical and scientific literacy did. Technology-based assessment of problem solving may also pave the way for developing student-level feedback systems as well.

Precise and reliable assessment is a precondition for the empirical testing of a number of exciting hypotheses. There is a growing consensus among researchers of cognition that the most important general abilities are plastic; their development may be accelerated and extended if the developing mind is stimulated with proper exercises at the right time. By reviewing current research results, we may conclude that problem solving is amenable, but so far there has been too little research on how it can be improved in school contexts. Making this domain measurable with easy-to-use instruments may give new impetus to well-controlled interventions, thus strengthening the scientific foundations of development in education. We envision that training experiments will create the most promising domain of future research on problem solving.