Educational Research and Innovation

The Nature of Problem Solving

USING RESEARCH TO INSPIRE 21ST CENTURY LEARNING

Edited by Benő Csapó and Joachim Funke

Centre for Educational Research and Innovation

OECD

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BETTER POLICIES FOR BETTER LIVES

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Foreword

The demands on learners and thus education systems are evolving fast. In the past, education was about teaching people something. Now, it's about making sure that students develop a reliable compass and the navigation skills to find their own way through an increasingly uncertain, volatile and ambiguous world. These days, we no longer know exactly how things will unfold, often we are surprised and need to learn from the extraordinary, and sometimes we make mistakes along the way. And it will often be the mistakes and failures, when properly understood, that create the context for learning and growth. A generation ago, teachers could expect that what they taught would last a lifetime for their students. Today, teachers need to prepare students for more rapid economic and social change than ever before, for jobs that have not yet been created, to use technologies that have not yet been invented, and to solve social problems that we don't yet know will arise.

The dilemma for educators is that the kind of skills that are easiest to teach and easiest to test, are also the skills that are easiest to digitise, automate and outsource. There is no question that state-of-the-art disciplinary knowledge will always remain necessary. Innovative or creative people generally have specialised skills in a field of knowledge or a practice. And as much as "learning to learn" skills are important, we always learn by learning something. However, success in life and work is no longer mainly about reproducing content knowledge, but about extrapolating from what we know and applying that knowledge in novel situations. Put simply, the world no longer rewards people just for what they know – Google knows everything – but for what they can do with what they know. Problem solving is at the heart of this, the capacity of an individual to engage in cognitive processing to understand and resolve problem situations where a method of solution is not immediately obvious.

Conventionally our approach to problems in schooling is to break them down into manageable pieces, and then to teach students the techniques to solve them. But today individuals create value by synthesising disparate parts. This is about curiosity, open-mindedness, making connections between ideas that previously seemed unrelated, which requires being familiar with and receptive to knowledge in other fields than our own. If we spend our whole life in a silo of a single discipline, we will not gain the imaginative skills to connect the dots, which is where the next invention will come from.

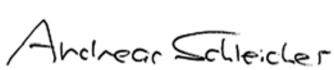
Perhaps most importantly, in today's schools, students typically learn individually and at the end of the school year, we certify their individual achievements. But the more interdependent the world becomes, the more we rely on great collaborators and orchestrators who are able to join others to collaboratively solve problems in life, work and citizenship. Innovation, too, is now rarely the product of individuals working in isolation but an outcome of how we mobilise, share and link knowledge. So schools now need to prepare students for a world in which many people need to collaborate with people of diverse cultural origins, and appreciate different ideas, perspectives and values; a world in which people need to decide how to trust and collaborate across such differences; and a world in which their lives will be affected by issues that transcend national boundaries. Expressed differently, schools need to drive a shift from a world where knowledge is stacked up somewhere depreciating rapidly in value towards a world in which the enriching power of collaborative problem-solving activities is increasing.

These shifts in the demand for knowledge and skills are well understood and documented, and to some extent they are even intuitive. Not least, many school curricula highlight the importance of individual and social problem-solving skills. And yet, surprisingly little is known about the extent to which education systems deliver on these skills. This is not just because school subjects continue to be shaped by traditional disciplinary contexts. It is also because educators have few reliable metrics to observe the problem-solving skills of their students - and what doesn't get assessed doesn't get done.

The OECD Programme for International Student Assessment (PISA) sought to address this. Its 2012 assessment contained the first international metric of individual problem-solving skills and the 2015 assessment took this further, assessing collaborative problem-solving skills. The results turned out to be extremely interesting, in part because they showed that strong problem-solving skills are not an automatic by product of strong disciplinary knowledge and skills. For example, Korea and Japan, which both did very well on the PISA mathematics test, came out even stronger on the PISA assessment of problem-solving skills. In contrast, top mathematics performer Shanghai did relatively less well in problem solving. Such results suggest that it is worth educators devoting more attention to how problem-solving skills are developed both in disciplinary and cross-disciplinary contexts.

But while problem solving is a fairly intuitive and all-pervasive concept, what has been missing so far is a strong conceptual and methodological basis for the definition, operationalisation and measurement of such skills. This book fills that gap. It explores the structure of the problem-solving domain, examines the conceptual underpinning of the PISA assessment of problem solving and studies empirical results. Equally important, it lays out methodological avenues for a deeper analysis of the assessment results, including the study of specific problem-solving strategies through log-file data.

In doing so, the book provides experts and practitioners with the tools to better understand the nature of problem-solving skills but also with a foundation to translate advanced analyses into new pedagogies to foster better problem-solving skills.



Andreas Schleicher

Director for Education and Skills
Special Advisor to the Secretary-General

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This book stems mainly from the collaboration of the members of the OECD Problem Solving Expert Group (PEG) of PISA 2012. This PEG group started its works in 2009 and finished their official work in 2014. The group consisted of the following eight members:

- Joachim Funke (Chair), Heidelberg University, Germany
- Benő Csapó, University of Szeged, Hungary (ex officio PGB representative)
- John Dossey, Illinois State University, United States
- Art Graesser, University of Memphis, United States
- Detlev Leutner, Duisburg-Essen University, Germany
- Richard Mayer, University of California, United States
- Tan Ming Ming, Ministry of Education, Singapore
- Romain Martin, University of Luxembourg, Luxembourg

Members of the PEG group have already been involved with problem solving for a long time, and their meetings under the umbrella of the PISA work inspired a number of other meetings and co-operative studies involving people from other organisations and institutions. Influenced by the creative atmosphere of the PEG meetings, some of the members met and presented their work together at other professional meetings as well. Amongst these were the annual meetings at Szeged University in the framework of Szeged Workshop of Educational Evaluation (SWEE; since 2009 a yearly repeated event), the TAO days in Luxemburg (March, 2011), the AERA meeting in New Orleans (April, 2011), two symposia at the EARLI biennial meeting in Exeter (September, 2011), the European Conference of Psychology in Istanbul (July, 2011), two symposia at the International Conference on Psychology in Cape Town (July, 2012), and more recently the "Celebrating Problem Solving" conference at the University of Szeged (November 2015). Many related journal articles have been published in the meantime – too many to be listed here.

These productive meetings brought together researchers interested in problem solving, assessment of cognitive skills, and technology based assessment, and so initiated empirical works in the overlapping areas of these special fields. For example, as already mentioned, one of

the major shifts from PISA 2003 problem solving to PISA 2012 problem solving was the shift from paper-and-pencil based to computer-based assessment that required strong interactions between item developers and the group taking care of the technical implementation. Within a rather short time scale, software tools had to be developed and implemented that allow for the necessities in international large-scale assessment studies (e.g. preparing for more than 100 different languages, different character sets including left-to-right and right-to-left, and different levels of computer equipment).

The PEG group was supported by a wonderful team from ACER (Australian Council for Educational Research, Melbourne, Australia): the "trio" consisting of Barry McCrae, Ray Philpot, and Dara Ramalingam. They prepared meetings and materials in a fantastic way and helped us through a jungle of dates, deadlines, and data. Ray Adams worked as Interim Chair in the beginning of the project. All of this contributed to the success of PISA 2012.

Maybe unique in the history of PISA expert groups, this community of researchers, while developing the assessment framework and creating the instruments discovered the potentials of an emerging field: the possibilities offered by computerised, dynamic, interactive assessment of problem solving. Using multimedia and simulation to present the test tasks, capturing students' responses in novel ways, logging student's activities and using log-file analyses for exploring cognitive processes, perseverance and motivation have opened new and exciting directions for research. They have been continuing their collaboration far beyond their task in the 2012 assessment cycle.

The individual chapters in this book have been reviewed by members of the group and by reviewers from the OECD. This process hopefully helped to improve the quality of the chapters. At the same time, these activities delayed the publication process a bit.

Lastly we would like to extend our thanks to Andreas Schleicher for his support throughout the publication process.

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