IEA Research for Education 16
A Series of In-depth Analyses Based on Data of the International Association for the Evaluation of Educational Achievement (IEA)

Maria Magdalena Isac
Andrés Sandoval-Hernández
Wanda Sass *Editors*

Knowledge and Willingness to Act Pro-Environmentally

Perspectives from IEA TIMSS 2019 and ICCS 2016 Data

IEA

OPEN ACCESS

Springer

IEA Research for Education

A Series of In-depth Analyses Based on Data of the International Association for the Evaluation of Educational Achievement (IEA)

Volume 16

The International Association for the Evaluation of Educational Achievement (IEA) is an independent nongovernmental nonprofit cooperative of national research institutions and governmental research agencies that originated in Hamburg, Germany in 1958. For over 60 years, IEA has developed and conducted high-quality, large-scale comparative studies in education to support countries' efforts to engage in national strategies for educational monitoring and improvement.

IEA continues to promote capacity building and knowledge sharing to foster innovation and quality in education, proudly uniting more than 60 member institutions, with studies conducted in more than 100 countries worldwide.

IEA's comprehensive data provide an unparalleled longitudinal resource for researchers, and this series of in-depth peer-reviewed thematic reports can be used to shed light on critical questions concerning educational policies and educational research. The goal is to encourage international dialogue focusing on policy matters and technical evaluation procedures. The resulting debate integrates powerful conceptual frameworks, comprehensive datasets and rigorous analysis, thus enhancing understanding of diverse education systems worldwide.

Maria Magdalena Isac
Andrés Sandoval-Hernández • Wanda Sass
Editors

Knowledge and Willingness to Act Pro-Environmentally

Perspectives from IEA TIMSS 2019 and ICCS 2016 Data

Springer IEA

Editors
Maria Magdalena Isac
Centre for Political Science Research
KU Leuven
Leuven, Belgium

Department of Education
University of Bath
Bath, UK

Andrés Sandoval-Hernández
Department of Education
University of Bath
Bath, UK

Wanda Sass
Freudenthal Institute
Utrecht University
Utrecht, The Netherlands

ISSN 2366-1631 ISSN 2366-164X (electronic)
IEA Research for Education
ISBN 978-3-031-76032-7 ISBN 978-3-031-76033-4 (eBook)
https://doi.org/10.1007/978-3-031-76033-4

This work was supported by The International Association for Evaluation of Educational Achievement

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Series Editors' Foreword

IEA's mission is to enhance knowledge about education systems worldwide and to provide high-quality data that will support education reform and lead to better teaching and learning in schools. In pursuit of this aim, it conducts, and reports on, major studies of student achievement in literacy, mathematics, science, citizenship, and digital literacy. These studies, most notably TIMSS, PIRLS, and ICCS, are well established and have set the benchmark for international comparative studies in education.

The studies have generated vast datasets encompassing student achievement, disaggregated in a variety of ways, along with a wealth of contextual information which contains considerable explanatory power. The numerous reports that have emerged from them are a valuable contribution to the corpus of educational research.

Valuable though these detailed reports are, IEA's goal of supporting education reform needs something more: deep understanding of education systems and the many factors that bear on student learning advances through in-depth analysis of the global datasets. IEA has long championed such analysis and facilitates scholars and policymakers in conducting secondary analysis of our datasets. So, we provide software such as the International Database Analyzer to encourage the analysis of our datasets, support numerous publications including a peer-reviewed journal—*Large-scale Assessment in Education*—dedicated to the science of large-scale assessment, and publish articles that draw on large-scale assessment databases. We also organize a biennial international research conference to nurture exchanges between researchers working with IEA data (https://www.iea.nl/our-conference).

The IEA Research for Education series represents a further effort by IEA to capitalize on our unique datasets, so as to provide powerful information for policymakers and researchers. Each report focuses on a specific topic and is produced by a dedicated team of leading scholars on the theme in question. Teams are selected on the basis of an open call for tenders; there are two such calls a year. Tenders are subject to a thorough review process, as are the reports produced. (Full details are available on the IEA website.)

This report focuses on one of the greatest existential issues of our time, namely, the protection of the natural environment. Environmental challenges grow ever more urgent, and the pervasive degradation of the planet's environment risks becoming this generation's legacy to our children and grandchildren.

It behooves us all to do what we can to halt this damage and mitigate its worst effects. Our competence is education and one of our contributions must be to assist schools and school systems to promote responsible environmental behavior and maximize the likelihood that young people leave school with pro-environmental attitudes and behavior.

IEA studies have amassed a good deal of relevant information to assist in this task. Both the Trends in International Mathematics and Science Study (TIMSS) and the International Civic and Citizenship Education Study (ICCS) have gathered data on students' environmental knowledge, attitudes, and behavior as well as on classroom practices and other contextual factors that are associated with young people's environmental awareness and propensity to act in ways that help sustain the environment. Thus, TIMSS gathers information on students' opportunities to learn about the environmental and on relevant instructional practices and can relate these to students' knowledge of environmental topics. For its part, ICCS has since 2016 made environmental sustainability a focus area of its measurement. It collects information on student-level, instructional, and school factors and displays how these are associated with students' intended pro-environmental behavior as adults.

As with all our publications in the series, volume 17 draws on IEA data from many countries, subjecting them to detailed, in-depth analysis and leading to an enhanced understanding of the underlying issues. Differences in the contextual factors between and within countries provide a platform for acquiring a deeper understanding of education for sustainable development and pointing to ways in which young people can be better equipped to deal with the environmental challenges they will inherit.

Future volumes in the series include a volume focusing on the Dinaric region that presents a collection of analyses of reading literacy factors and also a volume on teaching practices, school environments, and socioeconomic factors associated with reading literacy and learning achievement for im/migrant students.

University of Warwick
Coventry, UK
Seamus Hegarty

Indiana University
Bloomington, IN, USA
Leslie Rutkowski

Foreword: International Large-Scale Assessment for Environmental Sustainability Education in the Twenty-first Century

The challenge of sustainability—defined by the United Nations Brundtland Commission (1987) as "meeting the needs of the present without compromising the ability of future generations to meet their own needs"—is arguably the most critical issue of our time. Economist Kate Raworth (2017) offers the "doughnut" as a compelling metaphor for what it means for humanity to achieve sustainability. The Doughnut consists of two concentric rings: the inner ring represents a social foundation that ensures no one falls short of life's essentials (e.g., food, water, health, and education), while the outer ring represents an ecological ceiling that prevents humanity from overshooting the planetary boundaries that safeguard Earth's life-support systems (e.g., climate change, biodiversity, fresh water, and clean air). The space between these boundaries forms a doughnut-shaped zone that is both ecologically safe and socially just—a space where humanity can truly flourish.

Education, in its broadest sense, is increasingly recognized as a crucial long-term strategy for advancing sustainability. Over the past six decades, we have witnessed the emergence and growth of global educational movements dedicated to this cause, such as Environmental Education (EE), Education for Sustainable Development (ESD), and Climate Change Education (CCE). These movements, whether working within established institutional frameworks or challenging them from the outside, seek to either contest or reinforce existing authority. Importantly, they advocate for education that goes beyond merely transmitting knowledge about sustainability. Instead, they emphasize the importance of teaching and learning through outdoor and real-world experiences, fostering awareness and cultivating pro-sustainability attitudes. This approach aims to motivate and empower students to participate in collective efforts to address both local and global sustainability challenges. Consequently, these movements present a blueprint (or a script) that is a fundamental challenge to the traditional logics and routines embedded in the organization of school curricula, urging a rethinking of how education is structured and delivered.

The complexity of the EE/ESD/CCE blueprint becomes particularly apparent when assessing how educational systems engage with it. International Large-Scale Assessments (ILSAs), for example, break down this blueprint into various components, as noted by Pizmony-Levy (2011, 2019). For instance, the Trends in

International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA) offer extensive data on the knowledge domain of sustainability education. In contrast, the International Civic and Citizenship Education Study (ICCS) provides valuable insights into attitudes and expected or planned behaviors related to sustainability. However, no single ILSA encompasses all the domains of the global EE/ESD/CCE blueprint. This fragmentation presents a significant challenge for the international community as it seeks to comprehensively measure and track progress on this critical issue.

In this book, Maria Magdalena Isac, Andres Sandoval-Hernandez, Wanda Sass, and their collaborators tackle the challenge of fragmentation in the evaluation of sustainability education by examining both the cognitive and affective domains simultaneously. By harnessing data from TIMSS 2019 and ICCS 2016, they provide a comprehensive exploration of what students know about sustainability and how they perceive their roles as citizens in addressing sustainability challenges. This dual focus allows the authors to paint a more holistic picture of sustainability education, bridging the gap between knowledge and action. The book exemplifies the value of theory-driven secondary analysis of ILSA data, offering fresh insights into how educational systems are preparing students for the complexities of the twenty-first century. By addressing key questions about the role of education in fostering not just informed but also engaged and responsible citizens, the authors demonstrate how existing large-scale data can be leveraged to advance our understanding of sustainability education and its impact on future generations.

The current climate crisis has influenced the development of International Large-Scale Assessments (ILSAs) on sustainability. As the global discourse around environmental issues has intensified, so too has the need for educational assessments that address these critical topics. For instance, TIMSS 2019 responded to this growing urgency by retroactively adding a special environmental scale, reflecting the increasing attention to environmental education in the international arena. However, ICCS 2016 was ahead of its time, incorporating a strong focus on sustainability well before the issue had reached its current prominence. ICCS 2016 recognized the importance of not only understanding students' knowledge about environmental issues but also assessing their attitudes and civic engagement in addressing these challenges. This forward-thinking approach positioned ICCS 2016 as a pioneer in integrating sustainability into educational assessments, setting a precedent for how ILSAs could evolve in response to the pressing needs of our time.

The structure of this book is designed to facilitate ease of consumption and effective learning. It begins with an introduction spread across two chapters: one providing a general overview of the book project and the other delving into theoretical frameworks, setting a solid foundation for the reader. The analysis in the book is anchored in the action competence in sustainable development (ACiSD) framework that includes the following core components: relevant knowledge and skills, willingness to contribute, capacity expectations, and outcome expectancy. The core of the book is divided into two main sections, each dedicated to a major ILSA. The TIMSS 2019 section comprises four chapters—two focused on the TIMSS framework itself and two presenting empirical findings—offering a thorough exploration of this assessment. TIMSS 2019 includes data from 46 educational systems (at the eighth grade). Similarly, the ICCS 2016 section follows a parallel structure, with four chapters split between methodological insights and empirical analysis. ICCS 2016 includes data from 24 educational systems. The book concludes with a synthesis chapter that integrates the findings from both assessments, offering a cohesive overview and drawing meaningful conclusions. This organized layout not only ensures a comprehensive understanding of the subject matter but also allows readers to easily navigate through theoretical concepts and empirical evidence.

This book offers a rich array of comparisons that deepen our understanding of sustainability education across diverse contexts. By examining data from two ILSAs, it provides insights into different parts of the global blueprint for sustainability education. The analysis spans multiple countries, allowing for both within-country and between-country comparisons, which highlight the variations and commonalities in how sustainability is integrated into education systems worldwide. Moreover, the book delves into the different dimensions of the curriculum—intended, implemented, and attained—offering a comprehensive view of how sustainability goals are envisioned, carried out in practice, and ultimately achieved. These layered comparisons make the book a valuable resource for understanding the complexities of sustainability education on a global scale.

This book is a significant contribution to the literature on education, particularly in the specialized areas of international comparative education and sustainability education. It offers a nuanced exploration of critical issues, including disparities in access to sustainability education, the influence of national contextual conditions, and the long-standing debate over the effectiveness of teaching "about" the environment versus teaching "for" it. By addressing these interconnected topics, the book provides a comprehensive understanding of how global movements and local contexts shape educational opportunities and experiences. Its insights are both academically rigorous and practically relevant, making it an essential resource for scholars, educators, policymakers, and anyone dedicated to advancing education's role in promoting a sustainable future.

Center for Sustainable Futures, Teachers College
Columbia University
New York, NY, USA

Oren Pizmony-Levy

References

Brundtland, G. H. (1987). *Report of the world commission on environment and development: Our common future*. Geneva, UN-Document A/42/427.

Pizmony-Levy, O. (2011). Bridging the global and local in understanding curricula scripts: The case of environmental education. *Comparative Education Review*, *55*(4), 600–633. https://doi.org/10.1086/66163

Pizmony-Levy, O. (2019). *Comparative and international perspectives on environmental education*. Keynote presentation at the North American Association for Environmental Education (NAAEE). https://academiccommons.columbia.edu/doi/10.7916/d8-qywn-xc30

Raworth, K. (2017). *Doughnut economics: Seven ways to think like a 21st-century economist*. Chelsea Green Publishing.

Contents

Chapter 1
Knowledge and Willingness to Act Pro-environmentally. Perspectives from IEA TIMSS 2019 and ICCS 2016 Data: An Introduction

Maria Magdalena Isac, Wanda Sass, and Andrés Sandoval-Hernández

1.1 Introduction

In the contemporary world, the urgency of environmental challenges such as the climate crisis, loss of biodiversity, pollution, and pandemic diseases cannot be overstated. The situation has catalyzed a growing consensus on the critical importance of preparing citizens to act sustainably and pro-environmentally (Hadjichambis et al., 2020; Sass et al., 2022). Policymakers, researchers, and educationalists are increasingly engaged in dialogue about what competencies should be developed to address environmental challenges and how these can be integrated and fostered in educational systems worldwide.

Indeed, the integration of environmental, economic, and social sustainable development aspects into school education has gained international significance, reinforced by the initiatives of several global organizations. A prime example is the United Nations Educational, Scientific and Cultural Organization (UNESCO), which has actively promoted sustainability in educational systems. Initiatives such as the UN Decade of Education for Sustainable Development (2005–2014) and the

M. M. Isac (✉)
Centre for Political Science Research, KU Leuven, Leuven, Belgium

Department of Education, University of Bath, Bath, UK
e-mail: mariamagdalena.isac@gmail.com

W. Sass
Freudenthal Institute, Utrecht University, Utrecht, The Netherlands

Department of Training and Education Sciences, University of Antwerp, Antwerp, Belgium

Department of Environmental and Life Sciences, Karlstad University, Karlstad, Sweden

A. Sandoval-Hernández
Department of Education, University of Bath, Bath, UK

M. M. Isac et al. (eds.), *Knowledge and Willingness to Act Pro-Environmentally*,
IEA Research for Education 16, https://doi.org/10.1007/978-3-031-76033-4_1

ongoing Education 2030 Agenda are instrumental in encouraging educational systems worldwide to embed education for sustainable development (ESD) as a core component across all levels of education and in fostering competencies that enable young people to take action for sustainability (UNESCO, 2020). In Europe, this emphasis is mirrored in the Strategic Framework for European Cooperation in Education and Training towards the European Education Area (2021–2030) (Council of the European Union, 2021) and the European Commission's, 2022 proposal on learning for environmental sustainability (European Commission, Directorate-General for Education, Youth, Sport and Culture, 2022). Additionally, the European GreenComp framework focuses on competences regarding environmental sustainability (Bianchi et al., 2022). These initiatives have provided new momentum for implementing education related to the environment and sustainability, marking an important step in the evolution of educational policies toward a more sustainable future.

However, despite the significant global increase in ESD policies and practices, ESD is not yet a systemic feature in many educational systems. Several studies have highlighted challenges in various countries in formulating learning goals and appropriate ESD learning opportunities, as well as in collecting data and developing adequate measurement tools for assessing and monitoring ESD learning outcomes and processes (European Commission, Directorate-General for Education, Youth, Sport and Culture, 2022; Evans et al., 2012; Stepanek Lockhart, 2018; Taylor et al., 2019). Furthermore, there is a recognized lack of comparative data that would enable empirical monitoring and evaluation of the impact of these educational strategies on a cross-national scale (Buckler & Creech, 2014).

Against this backdrop, this book aims to highlight the value of international large-scale assessments in understanding key ESD learning outcomes and processes. Specifically, it utilizes data from the Trends in International Mathematics and Science Study (TIMSS) and the International Civic and Citizenship Education Study (ICCS), both conducted by the International Association for the Evaluation of Educational Achievement (IEA). Although the main aims of international large-scale assessments such as TIMSS and ICCS are not primarily concerned with ESD and its learning outcomes, in their last cycles, these studies created an important space for incorporating and addressing such topics in their frameworks and assessments. As detailed later in this book (see Chaps. 3, 4, 5, and 6), TIMSS 2019 included relevant measurement subscales in the achievement assessment. The environmental awareness subscale proved particularly relevant to analyze what we will further refer to as environmental knowledge, the learning outcome of interest in Chaps. 3, 4, 5, and 6. When looking into factors related to the intended and implemented curriculum, the context questionnaires offered valuable information on opportunities to learn environmental topics and classroom practices related to ESD principles such as pluralistic and action-oriented approaches to teaching.

Similarly, ICCS 2016 introduced environmental sustainability as a focus area in its assessment, as detailed in Chaps. 7, 8, 9, and 10. A specific item in the student questionnaire, providing information on students' intended pro-environmental behavior as adults, allowed for measurement of their willingness to act pro-environmentally. This willingness, serving as the dependent variable, is extensively analyzed in these chapters. The study's investigation into school factors that may promote this willingness, especially in terms of ESD opportunities to learn, utilized several relevant indicators found in the ICCS 2016 student, teacher, and school questionnaires. Moreover, the ICCS data allowed for the consideration and control of other student-level factors, such as current behavior, prescriptive social norms, and environmental threat awareness.

These developments enable us to utilize the frameworks and data from TIMSS 2019 and ICCS 2016 to provide educational systems with pertinent data and empirical findings concerning ESD learning outcomes and processes. Focusing specifically on the environmental aspects of sustainable development and ESD, this book aims to examine the extent to which the learning outcomes of environmental knowledge (as measured in TIMSS 2019) and a willingness to act pro-environmentally (as measured in ICCS 2016) are achieved and fostered in various educational systems.[1] Building on this primary aim, three specific research questions guide our investigation:

1. To what extent are there variations in environmental knowledge and willingness to act pro-environmentally across different countries? This comparative perspective is essential for understanding the global landscape of ESD learning outcomes and can provide valuable insights for educational systems worldwide.
2. To what extent do disparities among students within countries, associated with various background characteristics, relate to learning outcomes? This analysis aims to reveal how different sources of potential inequality shape students' environmental knowledge and their willingness to act pro-environmentally.
3. To what extent are specific educational opportunities for learning about sustainable development issues implemented in lower-secondary schools, and how do these opportunities relate to young people's learning outcomes? We aim to identify relevant ESD practices through this analysis.

In the subsequent sections, we delve into the main concepts underpinning this book and provide an overview of each chapter.

1.2 Concepts Underpinning This Book

1.2.1 Sustainable Development

The concept of sustainable development is complex as it involves interrelated environmental, social, and economic perspectives (United Nations, 2015) that may induce conflicting interests (Boström et al., 2018). Still, the international community has pledged to build a just, peaceful, and livable future for current and future

[1] TIMSS and ICCS include both countries and benchmarking participants within countries. As well as the term "educational systems," the term "countries" is sometimes used in this chapter to refer to both, for ease of reading.

generations (United Nations, 2015). While initial understandings of sustainable development saw the three perspectives as being of equal importance for living up to this aim, more current views foreground environmental considerations (Gericke et al., 2019). Indeed, with disruption due to climate change increasingly being felt across the globe, the environmental component of sustainable development may gain momentum. Next to the promotion of individuals' environmentally-friendly lifestyle choices, climate activists of all ages demand greater political consideration of the disruptive effects of human behavior on the planet (Morton, 2022; Niranjan, 2023). However, in the end, any educational approach that intends to prepare future generations for making well-informed decisions when faced with sustainability challenges will need to acknowledge the interconnectedness of environmental, social, and economic aspects in striving for sustainability (UNESCO, 2017; United Nations, 2015). In the next section we give a brief view on what this means for education.

1.2.2 Education for Sustainable Development and Environmental Education

Policymakers have proposed ESD as an approach to teaching and learning suitable for preparing current and future generations to take on sustainability challenges. Action competence—that is, competence to act with regard to the environment or sustainability—was put forward as a desired ESD learning outcome (UNESCO, 2017). Recently, research into the effectiveness of ESD for fostering action competence found empirical evidence that appears to confirm this claim (Olsson et al., 2022; Boeve-de Pauw et al., 2015; Sass et al., 2023). ESD is considered a holistic (Berglund & Gericke, 2022), pluralistic and participatory (Öhman & Östman, 2019), and action-oriented (Sinakou et al., 2019; Varela-Losada et al., 2016) educational approach. *Holism* acknowledges the mutual interconnectedness of environmental, social, and economic sustainability dimensions in order to facilitate students' understanding of the complexity and conflict-prone character of sustainability problems through an interdisciplinary approach (Berglund & Gericke, 2022). *Pluralism* and *participation* refer to a democratic educational approach, inviting different perspectives and highlighting a shared responsibility in the teaching-learning process (Öhman & Östman, 2019). An *orientation toward action* refers to transdisciplinary teaching and learning, situated within the societal context, by encouraging students to engage with authentic, i.e., real-world, sustainability challenges (Sinakou et al., 2019; Varela-Losada et al., 2016).

While ESD integrates the three main sustainability dimensions, environmental education focuses primarily on the environmental component. However, both terms are often used interchangeably, or combined as environmental and sustainability education. Still, the focus of the following chapters of this book is on the environmental component of sustainability, more specifically, on environmental knowledge and willingness to behave pro-environmentally.

1.2.3 Learning Goals of Education for Sustainable Development

As explained above, ESD aims to empower students so that they are better prepared to face sustainability challenges. A desired learning outcome is action competence (UNESCO, 2017). *Action* refers to a voluntary behavior directed toward finding solutions to complex problems, characterized by conflict regarding how to solve them (Mogensen & Schnack, 2010; Sass et al., 2020). *Action competence*, rather than highlighting a specific aptitude to perform a certain task, refers to the development of students with attention to cognitive (knowledge and skills), motivational (willingness in terms of commitment and passion), and self-efficacy (confidence in one's own capacities and in positive impact) components. In sum, action-competent individuals are "committed and passionate about solving a societal issue, have the relevant knowledge about the issue at stake as well as about democratic processes, take a critical but positive stance toward different ways for solving it, and have confidence in their own skills and capacities for changing the conditions for the better" (Sass et al., 2020, p. 300).

Despite political and theoretical claims concerning the potential of ESD for fostering students' action competence (Mogensen & Schnack, 2010; UNESCO, 2017), empirical evidence had long been lacking. However, as mentioned, recent studies are beginning to underscore these claims with evidence, pointing toward action-oriented ESD as a fruitful educational approach for facilitating students' action competence development (Boeve-de Pauw et al., 2015; Olsson et al., 2022; Sass et al., 2023).

1.3 The Structure of the Book

Beginning with the current introductory chapter (Chap. 1), which provides an overview of and sets the context for the subsequent in-depth exploration of the topic, the book is structured into distinct chapters, each focusing on specific aspects of ESD learning outcomes and processes. Following the introduction, Chap. 2 establishes the theoretical and conceptual groundwork underpinning the discussions in later chapters. Chapters 3, 4, 5, and 6 are dedicated to analyzing insights into students' environmental knowledge based on TIMSS 2019 data. Chapters 7, 8, 9, and 10 are focused on the insights gleaned from ICCS 2016 data into students' willingness to act pro-environmentally. The book concludes with Chap. 11, which synthesizes and discusses the key findings from all chapters. In the remainder of this section, we provide a more detailed description of each chapter, highlighting their unique contributions and insights into ESD.

Chapter 2 delves into the main conceptual framework utilized throughout the book. Initially, the chapter anchors the book's work in the concept of action competence, a key observable learning outcome of ESD. This framework posits that an action-competent individual possesses relevant knowledge about sustainable development issues, demonstrates strong motivation and willingness to contribute to solving these issues, and has confidence in their capacity to induce change. The chapter explains how competencies such as environmental knowledge (as captured by TIMSS 2019 data) and willingness to act pro-environmentally (as captured by ICCS 2016 data) are reflected in this framework. Furthermore, Chap. 2 introduces the teaching approaches and learning opportunities that define ESD and are capable of fostering action competence. Delving into ESD principles like holism, pluralism and participation, and an action-oriented approach, this chapter elaborates on how these teaching methodologies and learning opportunities are operationalized within the TIMSS 2019 and ICCS 2016 data. Chapter 2 sets the groundwork for subsequent chapters by detailing the extent to which the conceptual framework is represented in the data and how it contributes to the overall narrative of the book.

Chapters 3, 4, 5, and 6 focus on different aspects of the TIMSS 2019 data. Chapter 3 outlines the objectives of TIMSS 2019, including details on the participating entities, sampling design, assessment instruments, and contextual questionnaires. It also provides an overview of the variables and the main analytical approach used in the subsequent chapters (4, 5, and 6). Chapter 4 explores the conceptualization and measurement of environmental knowledge within the TIMSS science assessment. It begins with a review of the TIMSS science assessment framework and its psychometric scaling procedures. The chapter then outlines the development of the TIMSS 2019 environmental knowledge scale, starting from the definition of the construct and identification of relevant environmental items to the scaling of the data. The chapter presents a summary of average environmental knowledge achievements and scale score distributions across countries. It also evaluates the dimensionality of the TIMSS 2019 science assessment, testing whether the data support a unidimensional item response theory model or a bifactor model. The analysis indicates the presence of a strong general science factor. The chapter concludes with a discussion of the implications of these findings for TIMSS subscale reporting. Chaptre 5 examines the social inequalities in environmental knowledge within countries. It analyzes the achievement gaps in environmental knowledge based on socioeconomic status, gender, and urban–rural differences. The findings highlight significant socioeconomic status-related disparities in environmental knowledge across all countries, while gender and urbanicity gaps vary more by country context. The chapter underscores the challenges in addressing environmental crises from a global perspective, considering these sociodemographic disparities. Chapter 6 provides a comparative overview of the intended and implemented ESD curriculum. Utilizing responses from the TIMSS 2019 curriculum, school leader, and teacher questionnaires, the chapter reveals a widespread misalignment between intended and implemented curricula across countries. It also identifies variations in teaching approaches and resource availability that influence effective instruction in environmental knowledge. The analysis suggests the need for countries to reassess and enforce their intended curriculum for environmental sustainability, promote teaching methods that encourage scientific inquiry and action-oriented classroom practices, and address equipment shortages.

Chapters 7, 8, 9, and 10 focus on different aspects of the ICCS 2016 data. Chapter 7 offers an overview of the ICCS operationalization and methodology. It summarizes ICCS's main purpose and design, provides an overview of the variables and main analytical strategy used, and introduces the way in which results are presented in the subsequent chapters (8, 9, and 10). Chapter 8 examines the conceptualization and measurement of willingness to act pro-environmentally within the ICCS 2016 data. It begins with a review of the concepts of sustainable development and citizenship, relating those with the motivational action competence component of willingness to act pro-environmentally. After outlining how ICCS 2016 data were used to analyze students' future intentions to act pro-environmentally, the chapter presents a summary of the main trends across and differences between countries. It also compares intended pro-environmental behavior with other intentions regarding citizen action, highlighting similarities and differences between countries. The chapter continues describing connections between willingness to act pro-environmentally and factors such as richness or pollution levels. Results indicate that, while overall a majority of the students show positive intentions to perform individual actions for the environment, there are large differences between countries. Rather than yield clearly interpretable results at the national level, a further initial exploration opened new avenues for research into the drivers of and connections between young people's current and future environmental and civic engagement. The chapter concludes with a discussion of the possible implications of these findings for further research. Chapter 9 examines the social inequalities in students' willingness to make personal efforts for environmental protection. The three main factors considered are gender, parental education, and family scholarly culture. Immigration background was also taken into account as some literature indicates that socialization in the country of origin may relate to a reduced sensitivity to the pro-environmental social norms of the current context of the student. The findings highlight significant gaps in students' intended future pro-environmental behavior in terms of gender, familial educational level, and academic orientation. The chapter unveils challenges in addressing environmental crises from a global perspective, considering these disparities. Chapter 10 investigates the association of different school factors to students' pro-environmental behavioral intentions, focusing on opportunities to learn offered by the school as reported by school principals, teachers, and students. Additionally, student covariates such as their current behavior, norms endorsement, and threat awareness are taken into account in the analyses. Results seem to confirm the potential of exposure to action-oriented and pluralistic teaching practices for enhancing students' intended future engagement toward protecting the environment. Inviting students to participate in pro-environmental activities and open classroom discussions may provide opportunities to learn beneficial to students' motivation toward the environment. The finding that this potential may be shaped by national contextual conditions raises questions about the effectiveness of teaching "about" as opposed to teaching "for" the environment and how cultural and historical differences may influence differences between countries. International large-scale assessments may provide excellent opportunities for further research of such differential results regarding ESD.

Chapter 11 consolidates and discusses the key findings from all the empirical chapters. This consolidation closely aligns with the primary objective and the three research questions of the book, offering valuable insights into the disparities in students' environmental knowledge and their willingness to act pro-environmentally. It sheds light on how these aspects vary across countries and underlines differences stemming from various background characteristics. Moreover, the chapter highlights key educational strategies in lower-secondary schools that effectively address environmental issues and identifies specific teaching and learning opportunities that are instrumental in developing young people's action competence. The chapter concludes by reflecting on the limitations of the research process and contemplating future research directions in this field.

This introductory chapter outlined the conceptual foundations and structure for a thorough exploration of ESD using TIMSS and ICCS data in the subsequent chapters. By reflecting on the holistic, pluralistic and participatory, and action-oriented principles that underpin ESD, we acknowledge the complex interrelationship of environmental, social and economic dimensions inherent in sustainability issues. In later chapters, we aim to illuminate the multifaceted challenges posed by these issues through diverse perspectives, while also highlighting the critical role of education in empowering current and future generations to address them.

The empirical findings presented in the various chapters provide valuable comparative insights into the global landscape of key ESD learning outcomes, namely environmental knowledge and willingness to engage in pro-environmental actions among secondary school students. The analyses highlight disparities both between and within countries, based on different sociodemographic backgrounds. In addition, studies of intended and implemented curricula, including analyses of teaching approaches, classroom practices and resource availability, provide pertinent insights into the relevance of ESD opportunities in facilitating learning outcomes.

We encourage readers to explore the subsequent chapters, where diverse analytical perspectives enhance the discussion on monitoring, evaluating, and advancing ESD policies and practices. Ultimately, the aim is to foster the development of sustainability-literate global citizens capable of creating a just and sustainable future for all.

References

Berglund, T., & Gericke, N. (2022). Diversity in views as a resource for learning? Student perspectives on the interconnectedness of sustainable development dimensions. *Environmental Education Research, 28*(3), 354–381. https://doi.org/10.1080/13504622.2021.1980501

Bianchi, G., Pisiotis, U., & Cabrera Giraldez, M. (2022). *GreenComp – The European sustainability competence framework*. Publications Office of the European Union. https://doi.org/10.2760/13286

Boeve-de Pauw, J., Gericke, N., Olsson, D., & Berglund, T. (2015). The effectiveness of education for sustainable development. *Sustainability, 7*(11), 15693–15717. https://doi.org/10.3390/su71115693

Boström, M., Andersson, E., Berg, M., Gustafsson, K., Gustavsson, E., Hysing, E., Lidskog, R., Löfmarck, E., Ojala, M., Olsson, J., Singleton, B. E., Svenberg, S., Uggla, Y., & Öhman, J. (2018). Conditions for transformative learning for sustainable development: A theoretical review and approach. *Sustainability, 10*(12), 4479. https://doi.org/10.3390/su10124479

Buckler, C., & Creech, H. (2014). *Shaping the future we want. UN Decade of Education for Sustainable Development (2005–2014).* Final report. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000230171

Council of the European Union. (2021). Council resolution on a strategic framework for European cooperation in education and training towards the European education area and beyond (2021-2030). *Official Journal of the European Union, C, 66*, 1–21. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021G0226(01)

European Commission, Directorate-General for Education, Youth, Sport and Culture. (2022). *Proposal for a council recommendation on learning for environmental sustainability, COM/2022/11 final*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022DC0011

Evans, N., Whitehouse, H., & Gooch, M. (2012). Barriers, successes and enabling practices of education for sustainability in far North Queensland schools: A case study. *The Journal of Environmental Education, 43*(2), 121–138. https://doi.org/10.1080/00958964.2011.621995

Gericke, N., Boeve-de Pauw, J., Berglund, T., & Olsson, D. (2019). The sustainability consciousness questionnaire: The theoretical development and empirical validation of an evaluation instrument for stakeholders working with sustainable development. *Sustainable Development, 27*(1), 35–49. https://doi.org/10.1002/sd.1859

Hadjichambis, A. C., Reis, P., Paraskeva-Hadjichambi, D., Činčera, J., Boeve-de Pauw, J., Gericke, N., & Knippels, M. C. (Eds.). (2020). *Conceptualizing environmental citizenship for 21st century education*. (Environmental discourses in science education, Vol. 4). Springer. http://link.springer.com/10.1007/978-3-030-20249-1

Mogensen, F., & Schnack, K. (2010). The action competence approach and the 'new' discourses of education for sustainable development, competence and quality criteria. *Environmental Education Research, 16*(1), 59–74. https://doi.org/10.1080/13504620903504032

Morton, A. (2022, October 2). 'I'm tired of the lies': The young activists leading the way on climate action. *The Guardian*. https://www.theguardian.com/environment/2022/oct/02/climate-crisis-young-people-activism-around-world

Niranjan, A. (2023, December 27). 'We have a responsibility': The older women suing Switzerland to demand climate action. *The Guardian*. https://www.theguardian.com/environment/2023/dec/27/we-have-a-responsibility-the-older-women-suing-switzerland-to-demand-climate-action

Öhman, J., & Östman, L. (2019). Different teaching traditions in environmental and sustainability education. In K. Van Poeck, L. Östman, & J. Öhman (Eds.), *Sustainable development teaching: Ethical and political challenges* (pp. 70–82). Routledge. https://doi.org/10.4324/9781351124348

Olsson, D., Gericke, N., & Boeve-de Pauw, J. (2022). The effectiveness of education for sustainable development revisited – A longitudinal study on secondary students' action competence for sustainability. *Environmental Education Research, 28*(3), 405–429. https://doi.org/10.1080/13504622.2022.2033170

Sass, W., Boeve-de Pauw, J., Olsson, D., Gericke, N., De Maeyer, S., & Van Petegem, P. (2020). Redefining action competence: The case of sustainable development. *The Journal of Environmental Education, 51*(4), 292–305. https://doi.org/10.1080/00958964.2020.1765132

Sass, W., Claes, E., Boeve-de Pauw, J., De Maeyer, S., Schelfhout, W., Van Petegem, P., & Isac, M. M. (2022). Measuring professional action competence in education for sustainable development (PACesd). *Environmental Education Research, 28*(2), 260–275. https://doi.org/10.1080/13504622.2021.1976731

Sass, W., De Maeyer, S., Boeve-de Pauw, J., & Van Petegem, P. (2023). Effectiveness of education for sustainability: The importance of an action-oriented approach. *Environmental Education Research, 30*(4), 479–498. https://doi.org/10.1080/13504622.2023.2229543

Sinakou, E., Donche, V., Boeve-de Pauw, J., & Van Petegem, P. (2019). Designing powerful learning environments in education for sustainable development: A conceptual framework. *Sustainability, 11*(21), 5994. https://doi.org/10.3390/su11215994

Stepanek Lockhart, A. (2018). Monitoring ESD: Lessons learned and ways forward. In A. Leicht, J. Heiss, & W. J. Byun (Eds.), *Issues and trends in education for sustainable development* (pp. 215–231). UNESCO. https://doi.org/10.54675/YELO2332

Taylor, N., Quinn, F., Jenkins, K., Miller-Brown, H., Rizk, N., Prodromou, T., Serow, P., & Taylor, S. (2019). Education for sustainability in the secondary sector – A review. *Journal of Education for Sustainable Development, 13*(1), 102–122. https://doi.org/10.1177/0973408219846675

UNESCO. (2017). *Education for sustainable development goals: Learning objectives.* https://unesdoc.unesco.org/ark:/48223/pf0000247444

UNESCO. (2020). *Education for sustainable development: A roadmap*. https://unesdoc.unesco.org/ark:/48223/pf0000374802

United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development.* https://sdgs.un.org/sites/default/files/publications/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

Varela-Losada, M., Vega-Marcote, P., Pérez-Rodríguez, U., & Álvarez-Lires, M. (2016). Going to action? A literature review on educational proposals in formal environmental education. *Environmental Education Research, 22*(3), 390–421. https://doi.org/10.1080/13504622.2015.1101751

Chapter 2
Theoretical Approaches: Operationalizing Action Competence as a Learning Outcome of Education for Sustainable Development Using International Large-Scale Assessments

Wanda Sass, Jelle Boeve-de Pauw, Daniel Olsson, Niklas Gericke, and Peter Van Petegem

2.1 Introduction

Since the publication of the first reports of the Intergovernmental Panel on Climate Change (IPCC) in the 1990s, consensus has been growing about the human-induced nature of climate change (Myers et al., 2021). The latest IPCC synthesis report again confirmed the urgency of increased climate action for human living conditions and ecosystems alike (IPCC, 2023). Based on findings regarding the inadequacy of efforts made so far, there is a growing call for increased action (United Nations Environment Programme, 2022). Meanwhile, sustainable development and how to empower future citizens to mitigate and adapt to sustainability challenges through education for sustainable development (ESD) have become prominent

W. Sass (✉)
Freudenthal Institute, Utrecht University, Utrecht, The Netherlands

Department of Training and Education Sciences, University of Antwerp, Antwerp, Belgium

Department of Environmental and Life Sciences, Karlstad University, Karlstad, Sweden
e-mail: w.p.y.sass@uu.nl

J. Boeve-de. Pauw
Freudenthal Institute, Utrecht University, Utrecht, The Netherlands

D. Olsson · N. Gericke
Department of Environmental and Life Sciences, Karlstad University, Karlstad, Sweden

P. Van Petegem
Department of Training and Education Sciences, University of Antwerp, Antwerp, Belgium

M. M. Isac et al. (eds.), *Knowledge and Willingness to Act Pro-Environmentally*,
IEA Research for Education 16, https://doi.org/10.1007/978-3-031-76033-4_2

issues on the agendas of citizens (Pizmony-Levy et al., 2023), policymakers (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2017), practitioners, and scholars (Leicht et al., 2018).

As a transformative educational approach, ESD poses challenges for monitoring processes and measuring learning outcomes. Yet this is crucial if countries are to contribute to students' empowerment through education, and educational policymakers need tools to do so (Leicht et al., 2018).

Educational effectiveness research typically focuses on cognitive outcomes in traditional school subjects such as mathematics, sciences, and native languages. However, there has been a growing and increasingly vocal movement calling for the inclusion of less traditional subjects and affective and social educational learning outcomes (Muijs, 2006; Muijs et al., 2014; Reynolds et al., 2016; Townsend et al., 2016; Verhelst et al., 2022). In line with this and the calls for preparing future generations for the sustainability challenges that lie ahead, it has also been recommended that educational effectiveness research should take a specific focus on sustainability issues (Kelly & Clarke, 2016).

Conceptual frameworks have been suggested to guide teaching-learning processes in order to better prepare future generations for sustainability challenges. Among these, action competence in sustainable development (ACiSD) (Mogensen & Schnack, 2010; Sass et al., 2020) emerges as a notable framework that may not only be able to guide teaching-learning processes but also allow for conceptualizing the learning outcomes of action-oriented ESD (Mogensen & Schnack, 2010; Olsson et al., 2022; Sass et al., 2020; UNESCO, 2017). Recent evidence has supported policy claims regarding the effectiveness of ESD for fostering ACiSD (Boeve-de Pauw et al., 2015; Olsson et al., 2022; Saleem & Dare, 2023; Sass et al., 2023; UNESCO, 2017; Verhelst et al., 2022).

The current chapter introduces the main components of the ACiSD-ESD conceptual framework that focus on the development of the relevant knowledge and skills, willingness, and self-efficacy of (groups of) people to contribute to sustainability. As this conceptual framework focuses on more than cognitive outcomes, the risk of ILSAs inducing a push toward accountability is reduced when utilizing ACiSD and related educational approaches. Additionally, it also answers the calls for including more affective and social educational goals to complement the predominantly cognitive orientation of effectiveness research (Reynolds et al., 2016; Townsend et al., 2016) and ILSAs (Sinnes & Eriksen, 2016).

In the following chapters of this book, we initiate an operationalization of the ACiSD-ESD conceptual framework with a focus on environmental knowledge, using TIMSS 2019 data, and willingness to act pro-environmentally, using ICCS 2016 data. Additionally, there is a focus on aspects of ESD as opportunities to learn for both the knowledge and willingness components of ACiSD. In what follows here, we will first discuss action competence. Then, we zoom in on ESD and its facilitation of action competence development. We end this chapter with the role ILSAs can play in advancing ESD implementation internationally.

2.2 Conceptual Framework: Action Competence as a Learning Outcome of Education for Sustainable Development

The concept of action competence was first developed by scholars at the Danish School of Education in the 1980s. They developed it as an educational ideal and underscored an orientation toward action as one of the central notions in an effective teaching approach (Mogensen & Schnack, 2010). Given the need for monitoring efforts to implement ESD in schools (UNESCO, 2017), Sass et al. (2020) redefined action competence as a generic competence of individuals or groups, introducing the concept of ACiSD. This redefined action competence conceptual framework facilitated the development of measurement instruments focusing on students in primary and secondary education (aged between 10 and 19), such as the Self-Perceived Action Competence for Sustainability Questionnaire (SPACS-Q) by Olsson et al. (2020).

In the following section, we further elaborate on the notions of *action* and *action competence*. Additionally, we introduce the SPACS-Q as a suitable generic ACiSD measurement instrument. Its items may inspire variables to be added to ILSA (e.g., TIMSS and ICCS) student questionnaires in order to include measurements of their self-perceived ACiSD.

2.2.1 Action Competence

Action is a voluntary behavior, meaning it is a choice decided on by the person taking the action. Furthermore, it is a voluntary behavior that aims to solve complex issues defined by controversy about how to solve them (Hungerford & Volk, 1990; Jensen & Schnack, 2006; Mogensen & Schnack, 2010; Sass et al., 2020). Sustainable development refers to mutually interacting environmental, social, and economic aspects that involve past, present, and future generations in their local, regional, and global contexts (United Nations, 2015). As sustainable development issues are often characterized by conflicting interests, i.e., environmental, social, and economic viewpoints from several generations across the globe (United Nations, 2015), different solutions may be preferable to different stakeholders involved. Therefore, sustainability problems qualify as complex and controversial issues that call for action in view of their urgent nature (Sass et al., 2020).

Action competence is defined by the acquisition of relevant knowledge and skills, willingness to contribute to finding a solution, and self-efficacy regarding a controversial problem. When the action taker's goal is to solve a sustainability problem, this implies relevant knowledge about sustainability and sustainability action possibilities. Skills then include, for example, critical, systems, and future thinking, as well as problem-solving and communication skills. Willingness refers to a strong motivation, or passion, and commitment to contribute to sustainability (Jensen & Schnack, 2006; Mogensen & Schnack, 2010; Sass et al., 2020). It allows

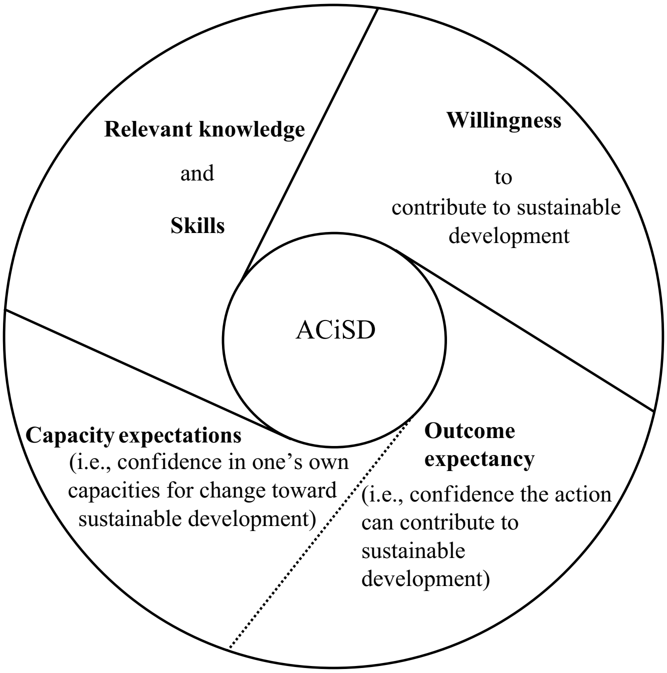


Fig. 2.1 Core components of action competence in sustainable development (ACiSD). (Source Adapted from Sass et al. 2020)

the action taker to persevere in the face of difficulties (Moeller, 2013). Self-efficacy consists of confidence in one's own capacities, i.e., capacity expectations, and confidence in a positive impact of the action, i.e., outcome expectancy (Sass et al., 2020). For a graphic representation of ACiSD, see Fig. 2.1.

Answering UNESCO's (2017) call for monitoring and informing ESD implementation efforts, instruments were developed to measure the learning outcomes of ESD. Examples of such instruments include the, already mentioned, SPACS-Q (Olsson et al., 2020) and ACiSD-Q (Sass et al., 2021), as well as the Sustainability Consciousness Questionnaire (SCQ) (Gericke et al., 2019). Whereas the SCQ and ACiSD-Q are based on specific sustainability actions such as *avoiding buying goods from companies with a bad reputation for looking after their employees and the environment* (SCQ) or *saving electricity and water at home* (ACiSD-Q), the SPACS-Q is a more generically conceived instrument. This quality makes it suitable for use with a broad international population. It consists of 12 items that tap into the core components of ACiSD, with four items on respondents' knowledge of action possibilities, four items on willingness to act sustainably, and four items on confidence in the impact of one's own behavior or actions. Therefore, the operationalization that can be made with TIMSS and ICCS may be similar to the knowledge, confidence, and willingness components included in the SPACS-Q.

2.2.2 *Education for Sustainable Development*

Recent empirical evidence has underscored the value of action-oriented ESD for students' ACiSD development (Boeve-de Pauw et al., 2015; Olsson et al., 2022; Sass et al., 2023), as is also suggested in policy documents (UNESCO, 2017). ESD is characterized by holism (Varela-Losada et al., 2016; Wiek et al., 2015), pluralism and participation (Berglund & Gericke, 2022; Mogensen & Schnack, 2010; Öhman & Östman, 2019; Rudsberg & Öhman, 2010), and an orientation toward action (Sass et al., 2023; Sinakou et al., 2019; Varela-Losada et al., 2016).

Holism relates to an integrated approach to the different aspects of sustainability (i.e., environmental, social, economic, generational, and spatial). This involves an interdisciplinary view on sustainability (Boström et al., 2018; Ke et al., 2020; Sass et al., 2023). Consequently, teachers of different disciplines need to cooperate if students are to achieve a holistic perspective (Gericke et al., 2020; Ke et al., 2020; Mogensen & Schnack, 2010).

Pluralism involves an openness to contrasting perspectives, views, and opinions (Öhman & Östman, 2019), whereas *participation* refers to a shared responsibility between teachers and students regarding decision-making and the teaching-learning process (Öhman & Östman, 2019; Sass et al., 2023). A pluralistic and participative approach to teaching requires a democratic style of education. Students are invited to engage with different values, insights, opinions, and perspectives, while taking responsibility for the teaching-learning process in cooperation with the teachers (Mogensen & Schnack, 2010; Öhman & Östman, 2019; Rudsberg & Öhman, 2010). Even though pluralism and a participative approach seem to be two different aspects of a democratic approach to teaching and learning, they have often been considered together under the single term of "pluralism." However, recent research seems to indicate it may be prudent to describe (and measure) these two aspects separately (Sass et al., 2023).

Finally, an *orientation toward action* means that students, teachers, and partners in the local community learn together by engaging with authentic sustainability problems in the real global and local society (Sinakou et al., 2019; Varela-Losada et al., 2016).

In the past decade, few empirical studies have looked into the effectiveness of ESD regarding students' ACiSD development. Still, their findings point toward the relevance of action-oriented, holistic, participative, and pluralistic educational approaches, such as ESD. Next to the value of a holistic, pluralistic and participatory approach to teaching (Boeve-de Pauw et al., 2015; Olsson et al., 2022), a recent study in Flanders (Belgium) found that an action-oriented ESD approach in particular supports students' action competence development (Sass et al., 2023). This finding was confirmed in a Malaysian study (Saleem & Dare, 2023). Further international research is required to verify these findings. ILSA data are well-suited to inform such a verification and cross-cultural comparison.

2.3 Operationalizing the Conceptual Framework

Educational policymakers need instruments for monitoring ESD teaching-learning processes and measuring ACiSD as desired learning outcomes. This is an essential first step if countries are to contribute to students' empowerment through education (UNESCO, 2017). Due to the possibility of offering rankings of countries' achievements, international large-scale assessments (ILSAs) appear to have a larger impact on curriculum and educational policy decisions than international agreements (Sinnes & Eriksen, 2016). However, they tend to steer countries toward a more cognitive focus, measuring students' knowledge through multiple choice tests that presuppose there is certainty about wrong and correct answers (Sinnes & Eriksen, 2016). Contrary to this, ESD acknowledges that sustainability issues are characterized by uncertainty, the search for knowledge that is not (yet) available, and the value of different perspectives (Öhman & Östman, 2019). Still, ILSAs such as the International Civic and Citizenship Education Study (ICCS) and Trends in International Mathematics and Science Study (TIMSS) from the International Association for the Evaluation of Educational Achievement (IEA), and the Programme for International Student Assessment (PISA) from the Organization for Economic Cooperation and Development (OECD) have taken the lead in tackling the challenge of providing nations with such tools by beginning to establish an important space for incorporating and addressing ESD topics and learning outcomes in their frameworks and assessments (Stepanek Lockhart, 2018; UNESCO, 2017). These initiatives are applauded, although they go hand in hand with the responsibility for a continued search into ways to embrace the transformative nature of ESD, as it is "vital to remember that only what is measured gets counted" (Stepanek Lockhart, 2018, p. 228). ILSAs may provide a promising tool for monitoring the development of ESD learning outcomes and processes, offering a comparison between and within countries (Rieckmann, 2018; Sandoval-Hernández & Miranda, 2018; UNESCO, 2017). Such comparisons have proven to be influential regarding countries' educational policy settings (Sinnes & Eriksen, 2016). Furthermore, as sustainability issues typically involve populations and ecosystems worldwide, we posit that ILSAs may provide interesting insights across national educational settings. They may facilitate exchanges of insights and knowledge acquired by educational systems across the globe, supporting an acceleration in ESD implementation efforts. Conversely, they may also go against the ESD rationale, which emphasizes its transformational and democratic character, by generating too much emphasis on accountability within participating national settings (Pizmony-Levy & Gan, 2021). Due to their focus on measuring students' knowledge *about* rather than their preparedness *for* sustainability, alignment between ILSA student achievement measures and ESD practices has been found to be insufficient to capture students' opportunities to develop ACiSD (Sinnes & Eriksen, 2016). Consequently, Sinnes and Eriksen (2016) call on international initiatives to develop measures that can inform countries regarding their educational system's ability to foster ACiSD. Regarding this endeavor, we recommend caution when attempting to measure multifaceted concepts such as ACiSD and ESD through ILSAs. However, the various context questionnaires that complement achievement measures in ILSAs may show promise for looking into the crucial alignment between the transformative nature of ESD and ACiSD as its desired learning outcome. Moreover, these questionnaires should be further developed with attention to non-cognitive attributes, contextual differences, and cultural variations in the expression of sustainability actions, which are difficult to quantify. We therefore call for such adaptations, as they will both contribute to valid and reliable information that can feed a learning culture regarding ESD within and across educational systems, while also addressing the critique that ILSAs are ignoring the complex nature of this field.

Following this introduction to the ACiSD–ESD conceptual framework and looking into the role ILSAs may play in encouraging countries to foster ACiSD through ESD implementation, the remaining chapters in this book proceed with an operationalization of two ACiSD components, i.e., knowledge and willingness, using ILSAs. Specifically, the subsequent chapters provide an operationalization of environmental knowledge through secondary analyses of TIMSS 2019 data (Chaps. 3, 4, 5, and 6), followed by an operationalization of willingness to act pro-environmentally through secondary analyses of ICCS 2016 data (Chap. 7, 8, 9, and 10). Additionally, we include different ESD components in the variables, selected from both the TIMSS and ICCS measurements.

For an operationalization of environmental knowledge, the environmental awareness scale that was (re)introduced in the TIMSS performance tests of the 2019 assessment (see Chap. 4 for details) was used. Teacher practices that may promote students' environmental knowledge were based on *teachers' emphasis on science investigation* as a proxy for an action-oriented approach (see Chap. 6).

Willingness to act pro-environmentally, as operationalized in Chap. 7, made use of an ICCS 2016 question regarding young people's future intentions to act pro-environmentally. The ICCS 2016 measure of *open classroom discussion* (Knowles et al., 2018), was used as an indicator of pluralistic ESD teaching practices. This measure looks into the extent to which controversial issues are discussed in the classroom, guided by the teachers, promoting facts and controversies to be understood and remembered by the students (Carrasco & Pavón Mediano, 2021), as is further explained in Chap 10.

References

Berglund, T., & Gericke, N. (2022). Diversity in views as a resource for learning? Student perspectives on the interconnectedness of sustainable development dimensions. *Environmental Education Research, 28*(3), 354–381. https://doi.org/10.1080/13504622.2021.1980501

Boeve-de Pauw, J., Gericke, N., Olsson, D., & Berglund, T. (2015). The effectiveness of education for sustainable development. *Sustainability, 7*(11), 15693–15717. https://doi.org/10.3390/su71115693

Boström, M., Andersson, E., Berg, M., Gustafsson, K., Gustavsson, E., Hysing, E., Lidskog, R., Löfmarck, E., Ojala, M., Olsson, J., Singleton, B. E., Svenberg, S., Uggla, Y., & Öhman, J. (2018). Conditions for transformative learning for sustainable development: A theoretical review and approach. *Sustainability, 10*(12), 4479. https://doi.org/10.3390/su10124479

Carrasco, D., & Pavón Mediano, A. (2021). Tolerance of corruption among students in Latin America. In E. Treviño, D. Carrasco, E. Claes, & K. J. Kennedy (Eds.), *Good citizenship for the next generation. A global perspective using IEA ICCS 2016 data* (IEA research for education) (Vol. 12, pp. 107–125). Springer. https://doi.org/10.1007/978-3-030-75746-5

Gericke, N., Boeve-de Pauw, J., Berglund, T., & Olsson, D. (2019). The sustainability consciousness questionnaire: The theoretical development and empirical validation of an evaluation instrument for stakeholders working with sustainable development. *Sustainable Development, 27*(1), 35–49. https://doi.org/10.1002/sd.1859

Gericke, N., Huang, L., Knippels, M. C., Christodoulou, A., Van Dam, F., & Gasparovic, S. (2020). Environmental citizenship in secondary formal education: The importance of curriculum and subject teachers. In A. C. Hadjichambis, P. Reis, D. Paraskeva-Hadjichambi, J. Činčera, J. Boeve-de Pauw, N. Gericke, & M. C. Knippels (Eds.), *Conceptualizing environmental citizenship for 21st century education* (Environmental discourses in science education) (Vol. 4, pp. 193–212). Springer. https://doi.org/10.1007/978-3-030-20249-1_13

Hungerford, H. R., & Volk, T. L. (1990). Changing learner behavior through environmental education. *The Journal of Environmental Education, 21*(3), 8–21. https://doi.org/10.1080/00958964.1990.10753743

IPCC. (2023). *IPCC, 2023: Climate change 2023: Synthesis report.* Contribution of working groups I, II and III to the sixth assessment report of the intergovernmental panel on climate change [Core Writing Team, H. Lee & J. Romero (Eds.)]. https://doi.org/10.59327/IPCC/AR6-9789291691647.

Jensen, B. B., & Schnack, K. (2006). The action competence approach in environmental education. *Environmental Education Research, 12*(3–4), 471–486. https://doi.org/10.1080/13504620600943053

Ke, L., Sadler, T. D., Zangori, L., & Friedrichsen, P. J. (2020). Students' perceptions of socio-scientific issue-based learning and their appropriation of epistemic tools for systems thinking. *International Journal of Science Education, 42*(8), 1339–1361. https://doi.org/10.1080/09500693.2020.1759843

Kelly, A., & Clarke, P. (2016). The challenges of globalisation and the new policy paradigms for educational effectiveness and improvement research. In C. Chapman, D. Muijs, D. Reynolds, P. Sammons, & C. Teddlie (Eds.), *The Routledge international handbook of educational effectiveness and improvement* (pp. 365–379). Routledge. https://doi.org/10.4324/9781315679488

Knowles, R. T., Torney-Purta, J., & Barber, C. (2018). Enhancing citizenship learning with international comparative research: Analyses of IEA civic education datasets. *Citizenship Teaching and Learning, 13*(1), 7–30. https://doi.org/10.1386/ctl.13.1.7_1

Leicht, A., Heiss, J., & Byun, W. J. (Eds.). (2018). *Issues and trends in education for sustainable development*. UNESCO. https://doi.org/10.54675/YELO2332

Moeller, J. (2013). *A review of passion concepts and their overlaps with commitment: Opening a can of worms*. Doctoral dissertation, Universität Erfurt.

Mogensen, F., & Schnack, K. (2010). The action competence approach and the 'new' discourses of education for sustainable development, competence and quality criteria. *Environmental Education Research, 16*(1), 59–74. https://doi.org/10.1080/13504620903504032

Muijs, D. (2006). Measuring teacher effectiveness: Some methodological reflections. *Educational Research and Evaluation, 12*(1), 53–74. https://doi.org/10.1080/13803610500392236

Muijs, D., Kyriakides, L., van der Werf, G., Creemers, B., Timperley, H., & Earl, L. (2014). State of the art – Teacher effectiveness and professional learning. *School Effectiveness and School Improvement, 25*(2), 231–256. https://doi.org/10.1080/09243453.2014.885451

Myers, K. F., Doran, P. T., Cook, J., Kotcher, J. E., & Myers, T. A. (2021). Consensus revisited: Quantifying scientific agreement on climate change and climate expertise among Earth scientists 10 years later. *Environmental Research Letters, 16*(10). https://doi.org/10.1088/1748-9326/ac2774

Öhman, J., & Östman, L. (2019). Different teaching traditions in environmental and sustainability education. In K. Van Poeck, L. Östman, & J. Öhman (Eds.), *Sustainable development teaching: Ethical and political challenges* (pp. 70–82). Routledge. https://doi.org/10.4324/9781351124348

Olsson, D., Gericke, N., Sass, W., & Boeve-de Pauw, J. (2020). Self-perceived action competence for sustainability: The theoretical grounding and empirical validation of a novel research instrument. *Environmental Education Research, 26*(5), 742–760. https://doi.org/10.1080/13504622.2020.1736991

Olsson, D., Gericke, N., & Boeve-de Pauw, J. (2022). The effectiveness of education for sustainable development revisited – A longitudinal study on secondary students' action competence for sustainability. *Environmental Education Research, 28*(3), 405–429. https://doi.org/10.1080/13504622.2022.2033170

Pizmony-Levy, O., & Gan, D. (2021). Introduction to special issue: Learning assessments for sustainability? Exploring the interaction between two global movements. *Education Policy Analysis Archives, 29*(August–December), 121. 10.14507/epaa.29.7171.

Pizmony-Levy, O., Koch, P. A., & Rivet, A. E. (2023). *Green light for comprehensive climate change education*. Teachers College, Columbia University. https://doi.org/10.7916/jmzp-ay10

Reynolds, D., Chapman, C., Clarke, P., Muijs, D., Sammons, P., & Teddlie, C. (2016). The future of educational effectiveness and improvement research, and some suggestions and speculations. In C. Chapman, D. Muijs, D. Reynolds, P. Sammons, & C. Teddlie (Eds.), *The Routledge international handbook of educational effectiveness and improvement* (pp. 408–439). Routledge. https://doi.org/10.4324/9781315679488

Rieckmann, M. (2018). Learning to transform the world: Key competencies in education for sustainable development. In A. Leicht, J. Heiss, & W. J. Byun (Eds.), *Issues and trends in education for sustainable development* (pp. 61–84). UNESCO, 10.54675/YELO2332.

Rudsberg, K., & Öhman, J. (2010). Pluralism in practice – Experiences from Swedish evaluation, school development and research. *Environmental Education Research, 16*(1), 95–111. https://doi.org/10.1080/13504620903504073

Saleem, A., & Dare, P. S. (2023). Unmasking the action-oriented ESD approach to acting environmentally friendly. *Sustainability, 15*(2), 1675. https://doi.org/10.3390/su15021675

Sandoval-Hernández, A., & Miranda, D. (2018). *Exploring ICCS 2016 to measure progress toward target 4.7*. Background paper prepared for the 2019 Global Education Monitoring Report. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000266073

Sass, W., Boeve-de Pauw, J., Olsson, D., Gericke, N., De Maeyer, S., & Van Petegem, P. (2020). Redefining action competence: The case of sustainable development. *The Journal of Environmental Education, 51*(4), 292–305. https://doi.org/10.1080/00958964.2020.1765132

Sass, W., Boeve-de Pauw, J., De Maeyer, S., & Van Petegem, P. (2021). Development and validation of an instrument for measuring action competence in sustainable development within early adolescents: The action competence in sustainable development questionnaire (ACiSD-Q). *Environmental Education Research, 27*(9), 1284–1384. https://doi.org/10.1080/13504622.2021.1888887

Sass, W., De Maeyer, S., Boeve-de Pauw, J., & Van Petegem, P. (2023). Effectiveness of education for sustainability: The importance of an action-oriented approach. *Environmental Education Research, 30*(4), 479–498. https://doi.org/10.1080/13504622.2023.2229543

Sinakou, E., Donche, V., Boeve-de Pauw, J., & Van Petegem, P. (2019). Designing powerful learning environments in education for sustainable development: A conceptual framework. *Sustainability, 11*(21), 5994. https://doi.org/10.3390/su11215994

Sinnes, A. T., & Eriksen, C. C. (2016). Education for sustainable development and international student assessments: Governing education in times of climate change. *Global Policy, 7*(1), 46–55. https://doi.org/10.1111/1758-5899.12256

Stepanek Lockhart, A. (2018). Monitoring ESD: Lessons learned and ways forward. In A. Leicht, J. Heiss, & W. J. Byun (Eds.), *Issues and trends in education for sustainable development* (pp. 215–231). UNESCO. https://doi.org/10.54675/YELO2332

Townsend, T., MacBeath, J., & Bogotch, I. (2016). Critical and alternative perspectives on educational effectiveness and improvement research. In C. Chapman, D. Muijs, D. Reynolds, P. Sammons, & C. Teddlie (Eds.), *The Routledge international handbook of educational effectiveness and improvement* (pp. 380–407). Routledge. https://doi.org/10.4324/9781315679488

UNESCO. (2017). *Education for sustainable development goals: Learning objectives.* https://unesdoc.unesco.org/ark:/48223/pf0000247444

United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development.* https://sdgs.un.org/sites/default/files/publications/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

United Nations Environment Programme. (2022). *Emissions gap report 2022. The closing window – Climate crisis calls for rapid transformation of societies.* https://www.unep.org/resources/emissions-gap-report-2022

Varela-Losada, M., Vega-Marcote, P., Pérez-Rodríguez, U., & Álvarez-Lires, M. (2016). Going to action? A literature review on educational proposals in formal environmental education. *Environmental Education Research, 22*(3), 390–421. https://doi.org/10.1080/13504622.2015.1101751

Verhelst, D., Vanhoof, J., De Maeyer, S., Sass, W., & Van Petegem, P. (2022). Enabling effective education for sustainable development: Investigating the connection between the school organization and students' action competence. *The Journal of Environmental Education, 53*(4), 171–185. https://doi.org/10.1080/00958964.2022.2072797

Wiek, A., Bernstein, M. J., Foley, R. W., Cohen, M., Forrest, N., Kuzdas, C., Kay, B., & Withycombe Keeler, L. (2015). Operationalising competencies in higher education for sustainable development. In M. Barth, G. Michelsen, M. Rieckmann, & I. Thomas (Eds.), *Handbook of higher education for sustainable development* (1st ed., pp. 241–260). Routledge. https://doi.org/10.4324/9781315852249

Chapter 3
Operationalization and Methodology in TIMSS

Rolf Strietholt, Purya Baghaei, Yuan-Ling Liaw, Sabine Meinck, and Andrés Strello

3.1 The Trends in International Mathematics and Science Study

International large-scale assessments in education offer deep insights into both individual national educational systems and the broader international educational landscape. The primary focus of the Trends in International Mathematics and Science Study (TIMSS) centers on evaluating the mathematical and scientific competencies of students (Martin et al., 2020; Mullis et al., 2020; Mullis & Martin, 2017). This study has been conducted at four-year intervals since 1995 under the auspices of the International Association for the Evaluation of Educational Achievement (IEA). TIMSS is administered at various stages of students' educational careers: at the fourth and eighth grades, as well as during the last year of secondary school. For the purposes of this report, we only utilize data from the eighth grade TIMSS 2019 assessment with a focus on the environmental knowledge domain.

The objective of TIMSS is to periodically assess the quality of mathematical and scientific education on a global scale while recording long-term developments within participating educational systems. To accomplish this, TIMSS examines students' academic performance in mathematics and science, taking into consideration curriculum requirements and other significant contextual factors within school-based learning environments.

R. Strietholt (✉)
International Association for the Evaluation of Educational Achievement (IEA), Hamburg, Germany

P. Baghaei · Y.-L. Liaw · S. Meinck · A. Strello
Department of Education, University of Bath, Bath, UK

KU Leuven, Leuven, Belgium

M. M. Isac et al. (eds.), *Knowledge and Willingness to Act Pro-Environmentally*, IEA Research for Education 16, https://doi.org/10.1007/978-3-031-76033-4_3

In the context of TIMSS 2019, an assessment framework (Mullis & Martin, 2017) was established, closely aligning with the structure of previous cycles. This framework delineates the theoretical and conceptual underpinnings of the study, collaboratively developed by experts from a diverse range of participating nations. The updates to the framework encompass adjustments in the emphasis placed on subject matter and an increased reliance on digital tools for test administration and surveys. In line with this framework, the achievements of TIMSS students are perceived as the outcomes of a learning process shaped not only by classroom instruction and internal school-related factors but also by extracurricular attributes and circumstances.

As a conceptual framework, IEA draws upon the *opportunity to learn* framework (McDonnell, 1995), which operates on multiple levels. This framework considers, firstly, how educational opportunities are made available to students globally and, secondly, what factors influence the utilization of these opportunities by students. The opportunity to learn model conceptualizes curricula as functioning on three levels: (1) the intended curriculum—what national educational policies intend students to learn and how the educational system is organized to facilitate this learning (e.g., including versus segregating students with special needs); (2) the implemented curriculum—how the educational organizations (e.g., schools) implement the intended curriculum, what is actually taught in individual classrooms, who teaches it, and how it is taught; and (3) the attained curriculum—what students have actually learned (e.g., scores on standardized tests) and what they think about it (e.g., interest) as well as the emergence of educational inequality (e.g., gender gaps).

TIMSS follows an approach that seeks partial alignment of achievement tests with the curricula of participating countries (Rocher & Hastedt, 2020). Student performances are thus interpreted within the specific context of their respective curricula, marking a unique feature of the study that sets it apart from other international large-scale assessments in education like PIRLS or PISA.[1] TIMSS assessment instruments and context questionnaires are developed in collaboration with experts from various participating countries, and the evaluation of what is known as the Test-Curriculum Matching Analysis is conducted to assess the suitability of the tests for each individual country.

3.2 Participants and Sampling

TIMSS is an international project with participation from numerous countries. In the following section, we provide an overview of the participating countries and benchmarking participants, followed by a summary of sampling procedures used to collect internationally comparable data.

[1] PIRLS = Progress in International Reading Literacy Study; PISA = Programme for International Student Assessment.

3.2.1 Countries and Benchmarking Participants in TIMSS 2019

In the TIMSS 2019 assessment, 46 educational systems worldwide participated in evaluating the performance of their eighth-grade students (see Table 3.1). Among these, 39 countries took part, including some with distinct educational systems within country, such as Hong Kong SAR. Furthermore, TIMSS 2019 also featured seven benchmarking participants, which include regional entities like provinces and municipalities. These entities aimed to place their results on the international performance scale. When presenting content domain scores, reliance was placed on reliable and accurate estimation. However, it is important to note that the accurate estimation for science content domain scores in Kuwait and the Kingdom of Saudi Arabia was not feasible. Therefore, this report presents the results of students' performance in the environmental knowledge domain, covering 44 participating countries and benchmarking participants.[2]

Table 3.1 Educational systems in TIMSS 2019, grade eight

Australia	Republic of Kazakhstan	Türkiye United Arab Emirates (UAE)
Bahrain	Korea	United States
Chile	Kuwait[a]	
Chinese Taipei	Lebanon	*Benchmarking participants*
Cyprus	Lithuania	Ontario (Canada)
Egypt	Malaysia	Quebec (Canada)
England	Morocco	Moscow City (Russian Federation)
Finland	New Zealand	Gauteng (South Africa)
France	Norway	Western Cape (South Africa)
Georgia	Oman	Abu Dhabi (United Arab Emirates)
Hong Kong SAR	Portugal	Dubai (United Arab Emirates)
Hungary	Qatar	
Islamic Republic of Iran	Romania	
Ireland	Russian Federation	
Israel	Kingdom of Saudi Arabia[a]	
Italy	Singapore	
Japan	South Africa	
Jordan	Sweden	

Note: [a]Comparable data were not available in Kuwait and the Kingdom of Saudi Arabia because average achievement could not be accurately estimated
Source: Mullis et al. (2020, p. 266)

[2] Note that the terms "educational systems" and "countries" are sometimes used in this chapter to refer to both countries and benchmarking participants, for ease of reading.

3.2.2 Target Population

TIMSS systematically examines the performance of students at specific grade levels, aiming to compare complete cohorts of students. The student population to be investigated (the target population) is defined on the criterion of formal years of schooling. The TIMSS target grade is the grade that represents 8 years of schooling, counting from the first year of ISCED level 1 (UNESCO Institute for Statistics, 2012). This corresponds to students in grade eight in most participating countries. To ensure a developmentally appropriate alignment of the performance tests and testing conditions, in addition to this reference, an age criterion has also been set, requiring the average age of the target population at the time of testing to be at least 13.5 years (Mullis & Martin, 2017).

3.2.3 Sampling Approach

TIMSS does not test all eighth-grade students, but a random sample in each of the participating countries or benchmarking regions. The TIMSS sampling model involves multiple stages, including the selection of schools and classes within schools. In the first stage, a sample of schools is selected from a list of all schools accommodating grade eight in each country. In the second stage, one or multiple intact classes are selected from each selected school. The sampling at each stage is at random, so that it is possible to infer from the distribution of the sample parameters the corresponding characteristics in the population of all grade eight students, after accounting for the complex sampling design features. The process of random sampling is thoroughly documented in the TIMSS 2019 technical report (LaRoche et al., 2020).

3.2.4 Exclusions and Participation

There are two sets of threats to the representativeness of the TIMSS sampling, namely exclusion and non-response (Atasever et al., 2023). Exclusions of entire schools or individual students pose a threat to the representativeness of samples and make it difficult to compare data across countries. To mitigate this risk, IEA permits only a few exceptions for countries to exclude individual schools or students from TIMSS (i.e., remote schools, and students with disabilities). In addition, the TIMSS guidelines for sampling permit countries to exclude not more than 5% of the relevant population of grade eight students. School or student non-response poses another threat to the representativeness of samples. To reduce this risk, TIMSS standards required minimum participation rates of 85% of both schools and students or a combined rate (the product of school and student participation) of 75% to minimize potential bias from non-response.

Most countries had exclusion rates well below 5% but Egypt (9.1%), Kazakhstan (5.8%), the Russian Federation (5.7%), Kingdom of Saudi Arabia (10.0%), Singapore (10.3%), Sweden (6.3%), and Dubai (5.5%) had higher overall exclusion rates and their results should be interpreted with caution. With respect to participation rates, most countries achieved the required rates mentioned above except for the following countries whose results should also be interpreted with caution (combined rates after the inclusion of replacement schools are given in parentheses): Hong Kong SAR (81%), New Zealand (81%), Norway (84%), the United States (79%), and Quebec (73%). LaRoche and Foy (2020) provided more comprehensive information on school and student exclusion as well as participation rates.

3.3 Instruments

To assess student performance in the domains of mathematics and science within the framework of TIMSS, achievement assessments are employed. Comprehensive background information relevant to school learning is collected through contextual questionnaires at the system, school, teacher, and student levels. Several nations opted for the administration of tests and surveys in a paper-based format (paperTIMSS), while others conducted them electronically using computers (eTIMSS).

3.3.1 Achievement Assessment

The assessments used in TIMSS are designed to measure students' achievement levels in mathematics and science. The resulting student performance data allow for international comparisons to investigate variation in performance both across and within countries for the overall performance scales and respective subdomains. In this report, we particularly focus on the subdomain environmental knowledge (as discussed in the following chapter).

The development of test items is a collaborative process involving all participating countries. Proposals for individual tasks are submitted from various participating countries and reviewed by experts from different disciplines and countries. A crucial aspect of developing TIMSS test items is that they should be representative of the content and requirements outlined in the framework concept.

All assessment items are age-appropriate and some of them contain pictures or graphs. About half of the tasks are in multiple-choice format, where students select the correct answer from the provided options. The other half of the test items are characterized by an open response format, allowing students to formulate their answers freely in an open-text field.

3.3.2 Contextual Questionnaire

At the eighth grade, background information relevant to student learning, particularly with regard to the acquisition of mathematical and scientific competencies, is collected through surveys of participating TIMSS students, their schools and teachers who are involved in their learning process.

As described for the performance tests, the development of questionnaire items is a cooperative process among TIMSS participating countries. Proposals for specific questions related to background characteristics are submitted from various participating countries and evaluated by experts from various disciplines and states.

The student questionnaire includes questions related to attitudes, learning behaviors, and home environments among other things. Additionally, questionnaires are distributed among the teachers who instruct the students in mathematics and science, gathering information about their teaching methods, materials used, and other related matters. School principals are also surveyed, offering insights into factors like the school's location and profile. At the system level, national coordinators who implement TIMSS in their respective countries provide additional information about the national context.

3.4 Variables

In this section, we describe the variables used throughout Chaps. 4, 5, and 6. The following descriptions are brief, given we expand on their conceptual interpretations and theoretical justification in each analytical chapter. We first describe the main dependent variable, and then the independent variables, divided into two groups: variables used to measure inequalities among students and variables used to measure schooling factors.

3.4.1 Dependent Variable: Environmental Knowledge

The main dependent variable of this section of the book is the subscale of environmental awareness included in the TIMSS 2019 dataset. From here onwards, we refer to this subscale as environmental knowledge. Chapter 4 focuses on the measurement of environmental knowledge within the TIMSS science assessment. The dependent variable—environmental knowledge—is meticulously reviewed, involving the definition of the construct, identification of environmental items, and scaling of environmental knowledge data. The chapter evaluates its dimensionality and concludes by suggesting the existence of a robust general science factor and nested factors, including environmental knowledge.

3.4.2 Variables Used to Measure Inequalities

Chapter 5 examines social inequalities in environmental knowledge within and between countries. Key variables used include:

- Socioeconomic status—measured by parental education and number of books at home, as reported by students.
- Gender—operationalized as student sex, as reported by students (boy/girl).
- Urbanicity—measured as school location, categorized by principals as remote rural to densely populated urban.

3.4.3 Variables Used to Measure School Practices

Chapter 6 investigates factors related to the intended and implemented curriculum. Relevant variables include:

- Opportunities to learn environmental topics—measured by science teachers' reports on which of six environmental science topics were covered in class.
- Classroom practices affecting environmental awareness—measured as:
  - Teachers' emphasis on science investigation: Frequency of experiment/investigation activities.
  - Teachers' use of pluralistic and action-oriented instruction: Frequency of pluralistic and action-oriented approaches.

3.5 Analytical Approach

In this section, we describe the analytical approach used throughout Chaps. 4, 5, and 6. Similar to the description of variables, this section is brief, given we expand on this information in each analytical chapter.

The analytical approach in Chap. 4 centers on psychometric analysis to investigate the environmental knowledge scale constructed for the TIMSS science assessment. Specific techniques include a comprehensive review of the assessment framework, scaling procedures to develop the environmental knowledge measure, and model testing (unidimensional and bifactor models) to evaluate dimensionality. The interpretation of results focuses on implications for TIMSS subscale reporting given evidence for both overall and subject-specific factors.

Chapter 5 presents an analysis of achievement gaps to explore social inequalities in environmental knowledge between and within countries. The gap analysis entails descriptive statistics to summarize variations in distributions and quantify gaps among demographic subgroups defined by socioeconomic status, gender, and urbanicity. Findings are interpreted to highlight the contextual nature of gaps based on gender and urbanicity versus the consistent significance of socioeconomic status differences.

Finally, the analytical strategy in Chap. 6 includes an analysis of curriculum and instruction-related variables from the TIMSS school and teacher questionnaires. Variables indicating intended and implemented curriculum coverage of environmental topics are analyzed to determine the extent of misalignment. Additionally, differences in instructional approaches are quantified and interpreted to underscore key factors impacting students' environmental knowledge acquisition through a correlational analysis.

References

Atasever, U., Jerrim, J., & Tieck, S. (2023). Exclusion rates from international large-scale assessments: an analysis of 20 years of IEA data. *Educational Assessment, Evaluation and Accountability*, 1–24. https://doi.org/10.1007/s11092-023-09416-3

LaRoche, S., & Foy, P. (2020). Sample implementation in TIMSS 2019. In M. O. Martin, M. von Davier, & I. V. S. Mullis (Eds.), *Methods and procedures: TIMSS 2019 technical report*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/methods/pdf/TIMSS-2019-MP-Technical-Report.pdf

LaRoche, S., Joncas, M., & Foy, P. (2020). Sample design in TIMSS 2019. In M. O. Martin, M. von Davier, & I. V. S. Mullis (Eds.), *Methods and procedures: TIMSS 2019 technical report*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/methods/pdf/TIMSS-2019-MP-Technical-Report.pdf

Martin, M. O., von Davier, M., & Mullis, I. V. S. (Eds.). (2020). *Methods and procedures: TIMSS 2019 technical report*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/methods/pdf/TIMSS-2019-MP-Technical-Report.pdf

McDonnell, L. M. (1995). Opportunity to learn as a research concept and a policy instrument. *Educational Evaluation and Policy Analysis, 17*(3), 305–322. https://doi.org/10.3102/01623737017003305

Mullis, I. V. S., & Martin, M. O. (Eds.). (2017). *TIMSS 2019 assessment frameworks*. TIMSS & PIRLS International Study Center, Boston College. http://timssandpirls.bc.edu/timss2019/frameworks/

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 international results in mathematics and science*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/international-results/

Rocher, T., & Hastedt, D. (2020, September). *International large-scale assessments in education: A brief guide.* IEA Compass: Briefs in Education, No. 10. International Association for the Evaluation of Educational Achievement (IEA). https://www.iea.nl/publications/series-journals/iea-compass-briefs-education-series/september-2020-international-large

UNESCO Institute for Statistics. (2012). *International standard classification of education. ISCED 2011.* https://uis.unesco.org/sites/default/files/documents/international-standard-classification-of-education-isced-2011-en.pdf

Chapter 4
Environmental Knowledge: Conceptualization and Measurement

Yuan-Ling Liaw, Purya Baghaei, Rolf Strietholt, Sabine Meinck, and Andrés Strello

4.1 Introduction

Historically, the Trends in International Mathematics and Science Study (TIMSS) from the International Association for the Evaluation of Educational Achievement (IEA) included a measurement of environmental knowledge for fourth- and eighth-grade students as part of the science assessment. However, the content area *Environmental issues and the nature of science* was present in earlier TIMSS cycles but ceased to be reported after 2003 (Beaton et al., 1996; Martin et al., 2000, 2004).

In response to the environmental crisis and the increasing importance of environmental knowledge and sustainability, TIMSS 2019 reintroduced the so-called *environmental awareness* scale. The scale was referred to by the study designers of TIMSS as environmental awareness, however, we believe that this terminology is potentially misleading since the term "awareness" implies attitudes or behavior, whereas the performance test primarily assesses knowledge. Therefore, in the following, we will use the term *environmental knowledge* to underscore the assessment of students' cognitive understanding of environmental issues. This scale was designed to assess students' understanding of environmental and sustainable development topics. The importance of this concern was evident in the TIMSS 2019 assessment, which actively addressed various environmental issues at both fourth- and eighth-grade levels.

Y.-L. Liaw (✉)
International Association for the Evaluation of Educational Achievement (IEA), Hamburg, Germany

P. Baghaei · R. Strietholt · S. Meinck · A. Strello
Department of Education, University of Bath, Bath, UK

KU Leuven, Leuven, Belgium

M. M. Isac et al. (eds.), *Knowledge and Willingness to Act Pro-Environmentally*, IEA Research for Education 16, https://doi.org/10.1007/978-3-031-76033-4_4

It should be noted that this scale was different from other scales measuring science subdomains, and that it was developed after the TIMSS 2019 data collection and the release of the core TIMSS 2019 results. The post hoc identification of items from the TIMSS 2019 science assessment measuring environmental knowledge allowed for the construction of this cognitive scale, incorporating elements from Earth science, life science, and biology (Yin & Foy, 2021).

The aim of this chapter is to investigate the dimensionality of the TIMSS science assessment, specifically examining the distinctness of the subscale scores with a particular emphasis on the newly developed environmental knowledge scale.

The remainder of the chapter is organized as follows. The next section presents a summary of the TIMSS science assessment framework and its psychometric scaling procedure. We start with the definition of the construct, the identification of environmental items accompanied by examples, and continue with illustrating the scaling approach to derive the environmental knowledge scale. Following this, a summary of the average environmental knowledge achievement and scale score distributions across countries[1] is presented. Finally, an empirical study is reported, systematically comparing competing item response theory (IRT) models.

4.2 Environmental Knowledge

4.2.1 Background

The initial TIMSS 1995 science curriculum framework (Robitaille et al., 1993; Robitaille & Maxwell, 1996) established eight comprehensive content categories: Earth science; life science; physical science; science, technology, and mathematics; history of science and technology; environmental issues; nature of science; and other disciplines. Notably, environmental issues were treated as an independent topic within these categories. In TIMSS 1999, additional items allowed distinct reporting scores of environmental and resource issues, scientific inquiry, and the nature of science.

Five primary content domains remained in TIMSS 2003 to define the science content: life science (30%), chemistry (15%), physics (25%), Earth science (15%), and environmental science (15%) (Mullis et al., 2003). The environmental science category involves understanding the interaction between humans and ecosystems, changes in the environment due to human-made or natural events, and environmental protection. A consistent theme throughout highlights the responsibilities of science, technology, and society in preserving the environment and conserving resources. Key areas of focus encompassed changes in population, use and conservation of natural resources, and changes in environments.

[1] The terms "educational systems" and "countries" are sometimes used in this chapter to refer to both countries and benchmarking participants, for ease of reading.

The TIMSS 2007 assessment frameworks document closely resembled that of TIMSS 2003 (Mullis et al., 2005). However, while environmental science served as a reporting strand in 2003, it was removed for TIMSS 2007. The content of environmental science was integrated into biology and Earth science. This change also included the introduction of a new topic area concentrating on Earth's resources, their utilization, and conservation. In 2007 and subsequent TIMSS cycles, the percentages of science assessment dedicated to content domains at the eighth-grade level remained unchanged: biology (35%), chemistry (20%), physics (25%), and Earth science (20%) (Mullis & Martin, 2017).

4.2.2 Conceptualization

Environmental topics within the TIMSS framework can be differentiated between scientific ecological aspects and environmental sustainability aspects, addressing ecosystem-related matters and human impacts on the environment, respectively (Mullis & Martin, 2017). A clear differentiation exists between topics that describe the relationships and balance in ecosystems and those that depict changes in the environment caused by human activities. While the assessment frameworks are regularly updated to reflect current curricula, standards, and instruction, these two core environmental themes have remained consistent throughout all TIMSS study cycles.

The first theme, which pertains to ecosystems, falls within the life science or biology content domains. Students are expected to acknowledge that the interrelationship between living organisms and their environment is rooted in recognizing the influence of human activity on ecosystems. Understanding the effect of human activity on ecosystems is crucial for comprehending the interdependence of living organisms and their environment.

Fundamental concepts related to ecosystems encompass the flow of energy in ecosystems (identifying different organisms as producers, consumers, and decomposers, and drawing or interpreting food pyramids or food web diagrams); the cycling of water, oxygen, and carbon in ecosystems (describing the roles of living organisms in the cycling of elements and compounds); the interdependence of populations of organisms in an ecosystem in terms of the effects of competition, predation, and symbiosis; and factors affecting population size in an ecosystem (explaining factors influencing plant and animal growth, recognizing population-limiting elements, and predicting how ecosystem changes impact resources and population balance).

In TIMSS 2019, a significantly heightened focus on the human impact on the environment within ecosystems was added (Centurino & Jones, 2017). Students were expected to describe and explain the positive environmental outcomes of human actions, including re-planting forests, reducing air and water pollution, and protecting endangered species. Conversely, they were also required to elaborate on the negative effects of human behaviors, such as allowing factory wastewater to enter water systems and burning fossil fuels that release greenhouse gases and pollutants into the air. Also included were the effects of air, water, and soil pollution on humans, plants, and animals, such as the decline of plant and animal life in water systems due to water pollution.

The second theme, which revolves around (environmental) sustainability and falls within the Earth science category, primarily encompasses Earth's processes, cycles, and history, along with Earth's resources, their use, and conservation. In this context, Earth's processes, cycles, and history encompass geological processes, the Earth's water cycle, and weather and climate. For example, a topic in this area is whether students can differentiate between weather, which involves daily fluctuations in elements like temperature, humidity, precipitation, clouds, and wind, and climate, which relates to persistent weather patterns unique to geographic regions. To measure knowledge in this area, students have to understand and interpret weather pattern data and maps, allowing them to categorize distinct climate types. Additionally, they are asked to explore how global and local factors, such as latitude, altitude, and geographical features, influence climate and seasonal variations in weather patterns. Furthermore, students have to identify and describe evidence of climate changes, from historical transformations during ice ages to contemporary phenomena like global warming. This comprehensive exploration aims to measure if students have a profound understanding of the multifaceted realms of weather and climate, enabling them to discern patterns, causes, and consequences within Earth's dynamic systems.

TIMSS 2019 assessment items covering the topic of Earth's resources, their use, and conservation delve into the management of Earth's resources with an emphasis on renewable and nonrenewable resources. The topic involves examining the benefits and drawbacks of various energy sources, including sunlight, wind, water, geothermal, oil, coal, gas, and nuclear power. Students are expected to demonstrate their knowledge regarding strategies for conserving Earth's resources and managing waste, including recycling methods; the impact and significance of land and water use practices; and the effects of common land-use practices like farming, logging, and mining on land and water resources. Students are also expected to explain the importance of water conservation and describe methods for ensuring the availability of fresh water for human activities, such as desalination and purification.

4.2.3 Environmental Items

TIMSS 2019 assessed a broad spectrum of topics related to environmental issues, as specified above and in the TIMSS science framework. The covered subjects encompass the utilization and conservation of Earth's resources, the interdependence among habitat members within ecosystems, the origins and consequences of pollution, the changes and impacts on habitats due to varying climates, and the diverse cycles that unfold in the natural world (Yin & Foy, 2021). For instance, assessment items prompt students to describe the effects of pollution on farm fields, assess resources employed in electricity generation, expound upon the advantages of tree planting, and identify evidence of climate change over time. For illustration purposes we present examples of environmental items from TIMSS 2019 in the following section.

The construction of the environmental knowledge scale involved identifying all TIMSS 2019 science items related to environmental issues at each grade level. The environmental knowledge scale includes items from Earth science and life science domains at the fourth grade and Earth science and biology domains at the eighth grade. The assessment consisted of 33 environmental items with a maximum score of 33 points at the fourth grade and 41 environmental items with a maximum score of 44 points at the eighth grade. The topics covered in the assessment included natural resource use and conservation, ecosystem interdependence, pollution causes and consequences, climate-induced habitat changes, and natural cycles.

Table 4.1 displays the number of items included in the alternate science content subscales at eighth grade by test administration mode. The numbers are presented separately for eTIMSS and paper TIMSS due to some minor differences between the two modes of administration. The 41 environmental items shown in Table 4.2 belong either to the biology or Earth science content domains.

4.2.4 Examples of Environmental Items

In this section, we present a series of example items to illustrate the measurement of environmental knowledge. It is not possible to disclose all TIMSS items, as they are intended for use in future cycles.

In Fig. 4.1, an environmental item explores the relationship between insects and flowering plants to assess students' knowledge of ecosystems and their understanding of symbiosis. The question inquires about this interaction, with the correct answer expecting students to recognize it as a symbiotic relationship.

In Fig. 4.2, the item asks students to list two ways in which planting trees benefits the environment. It is an open-ended assessment of their biology knowledge related to ecosystems, requiring a constructed response highlighting the ecological advantages of tree planting.

Table 4.1 Numbers of items in the TIMSS 2019 eighth grade alternate science subscales

	eTIMSS		paperTIMSS	
Alternate science content domain	Items	Points	Items	Points
Environmental	41	44	41	44
Non-environmental	76	89	75	88
Chemistry	42	46	43	47
Physics	52	54	52	54
Total	211	233	211	233

Source: Yin and Foy (2021, pp. 8–18)

Table 4.2 Items for the TIMSS 2019 eighth grade environmental knowledge scale

Item block	Item ID	Content domain	Content area
SE01	SE52021	Biology	Ecosystems
SE01	SE52095Z	Biology	Ecosystems
SE02	SE72072	Biology	Ecosystems
SE02	SE72902	Biology	Ecosystems
SE02	SE72721	Earth science	Earth's processes, cycles, and history
SE02	SE72335	Earth science	Earth's processes, cycles, and history
SE03	SE62116A	Biology	Ecosystems
SE03	SE62116B	Biology	Ecosystems
SE03	SE62116C	Biology	Ecosystems
SE03	SE62233	Earth science	Earth's structure and physical features
SE03	SE62171	Earth science	Earth's processes, cycles, and history
SE04	SE72066	Biology	Ecosystems
SE04	SE72063	Biology	Ecosystems
SE04	SE72345	Earth science	Earth's resources, their use and conservation
SE04	SE72349	Earth science	Earth's resources, their use and conservation
SE05	SE52272	Biology	Ecosystems
SE05	SE52113	Earth science	Earth's processes, cycles, and history
SE06	SE62090	Earth science	Earth's processes, cycles, and history
SE06	SE62175	Earth science	Earth's resources, their use and conservation
SE06	SE62173A	Earth science	Earth's processes, cycles, and history
SE06	SE62173B	Earth science	Earth's processes, cycles, and history
SE07	SE52273	Biology	Ecosystems
SE07	SE52099	Earth science	Earth's resources, their use and conservation
SE08	SE72462	Biology	Ecosystems
SE08	SE72347	Earth science	Earth's resources, their use and conservation
SE08	SE72351	Earth science	Earth's resources, their use and conservation
SE09	SE62190	Earth science	Earth's resources, their use and conservation
SE10	SE72086	Biology	Ecosystems
SE10	SE72720	Earth science	Earth's processes, cycles, and history
SE11	SE62089	Biology	Ecosystems
SE11	SE62177	Earth science	Earth's processes, cycles, and history
SE11	SE62211A	Earth science	Earth's processes, cycles, and history
SE11	SE62211B	Earth science	Earth's processes, cycles, and history
SE12	SE72460	Biology	Ecosystems
SE13	SE62091A	Biology	Ecosystems
SE13	SE62091B	Biology	Ecosystems
SE13	SE62180	Earth science	Earth's processes, cycles, and history
SE13	SE62022	Earth science	Earth's structure and physical features
SE13	SE62243	Earth science	Earth's processes, cycles, and history
SE14	SE72074	Biology	Ecosystems
SE14	SE72323	Earth science	Earth's processes, cycles, and history

Source: Yin and Foy (2021, Chp. 18)

Insects that feed on nectar pollinate flowering plants as they move from flower to flower.

What kind of relationship is this?

(A) predation

(B) parasitism

(C) competition

(D) symbiosis

Fig. 4.1 Relationship between insects and flowering plants

How is planting trees beneficial for the environment?

Write **two** ways planting trees benefits the environment.

Fig. 4.2 Ways of planting trees to benefit the environment

Figure 4.3 focuses on identifying the human activities that can cause algal blooms, presenting a multiple-choice question. This item assesses students' biology knowledge about ecosystems and their ability to apply it. Algal blooms in freshwater ponds are explained, and students are tasked with recognizing the specific human activity that can lead to these harmful occurrences, one of the options being farming with excessive fertilizer.

Algal blooms can occur in freshwater ponds when there are too many nutrients in the water. These blooms can be harmful to other wildlife.

The picture shows an algal bloom in a pond.

What human activity can cause too many nutrients to enter a pond and cause an algal bloom?

(A) farming with a lot of fertilizer

(B) burning chemicals in factories

(C) using aerosol spray cans

(D) planting lots of trees around a pond

Fig. 4.3 Human activity causing algal blooms

Figure 4.4 presents an item that asks students to explain how roof gardens in cities contribute to the reduction of carbon dioxide in the air. This assessment evaluates students' biology knowledge about ecosystems and their reasoning skills through a constructed response, wherein students are prompted to explain how the increase in green spaces, such as roof gardens, aids in reducing carbon dioxide levels in the atmosphere.

In Fig. 4.5, a multiple-choice question examines students' Earth science knowledge regarding the water cycle in a forest ecosystem. The accompanying figure illustrates rain, tree water uptake, and leaf evaporation, requiring students to comprehend this cycle in a forest environment.

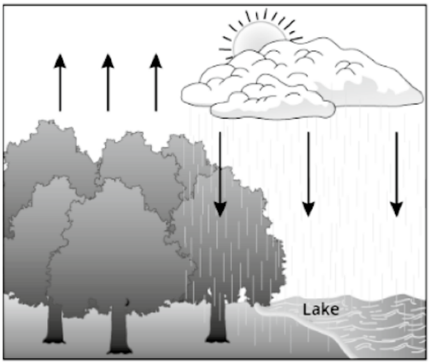
Figure 4.6 shifts the focus towards climate and geography, serving as an assessment of students' understanding of Earth's processes, cycles, and history, as well as their application and reasoning skills. In this item, students are presented with a map displaying the geographical locations of London and Astana, along with accompanying graphs that illustrate their average monthly temperatures. The assessment begins by prompting students to establish the correlation between temperature and geography during different months and then continues with subsequent questions that delve into the relationship between climate and geography throughout the year.

In some large cities, owners of large buildings and houses have installed gardens on the roofs. Having more gardens helps reduce the amount of carbon dioxide in the air.

How does increasing the number of gardens help reduce the amount of carbon dioxide in the air?

Fig. 4.4 Roof gardens in cities help reduce the amount of carbon dioxide in the air

The figure below shows how water cycles through a forest ecosystem.



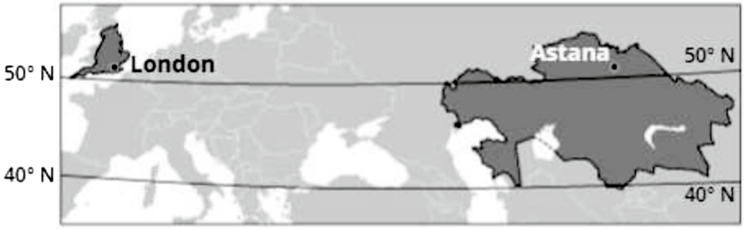
The arrows pointing down show rain falling on the forest. Some of this water is taken up by trees from the soil.

What process in the water cycle is shown by the arrows pointing up?

(A) absorption of water by tree roots
(B) production of carbon dioxide by the trees
(C) evaporation of water from tree leaves into the air
(D) release of carbon dioxide into the air by animals living in the trees

Fig. 4.5 Water cycle in forest ecosystem

Look at the map below. The cities of London and Astana are marked.



The two graphs show the average monthly temperatures (˚C) for London and Astana.

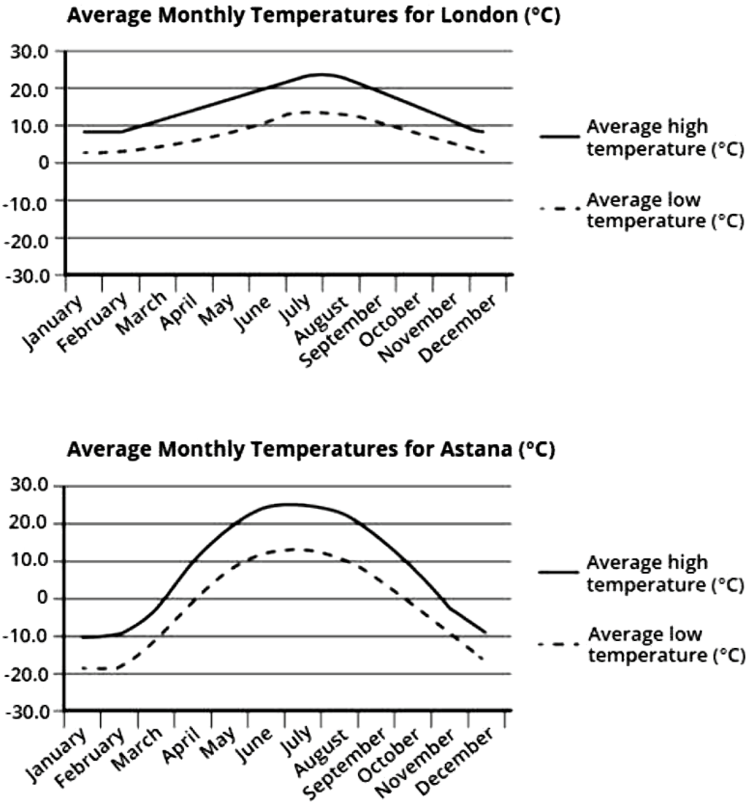


Fig. 4.6 Climate and geography

A. Fill in one circle to answer each of the following questions.

(Click one circle in each row.)

	London	Atana
Which city is warmer in March?	A	B
Which city is cooler in October?	A	B
Which city is warmer from December to February?	A	B
Which city has a larger range in average temperature?	A	B

B. What about the geographies of the cities explains the differences in their climates throughoutthe year?

(A) London's climate is less variable because itis near the ocean.

(B) London's climate is less variable because itis farther westthan Astana.

(C) Astana's climate is warmer in the summer because it receives warm ocean breezes.

(D) Astana's climate is colder in the winter because itis farther north than London.

Fig. 4.6 (continued)

In Fig. 4.7, students are tasked with recognizing how the melting of permafrost influences the Earth's climate. This multiple-choice item functions as an assessment of their understanding of Earth's processes, cycles, and history, all while evaluating their ability to apply this knowledge. The item begins by providing an explanation, which clarifies that permafrost is frozen soil primarily found in the Arctic, consisting of ice, rocks, and methane. Subsequently, students are asked to contemplate how the thawing of permafrost can impact the Earth's climate. The correct response emphasizes that releasing more methane into the air can lead to global warming.

Lastly, in Fig. 4.8, students are asked to consider geographic factors related to power plants. The possible answers include factors such as the seismic stability of an area, the likelihood of extreme weather events like tornadoes or floods, and the proximity to population centers. Students have a range of options to consider, In the Arctic, we can find frozen soil called permafrost, which contains ice, rocks, and methane (a greenhouse gas).

How can the melting of permafrost affect the Earth's climate?

(A) Increased methane in the atmosphere can contribute to global warming.

(B) Increased water in the atmosphere can cause more rain in the Arctic.

(C) Areas of melted permafrost can be now used as farmland.

(D) Methane can react with oxygen in the air to produce smog.

Fig. 4.7 Melting of permafrost affects the Earth's climate

Describe one important geographic factor that a country must consider when selecting the safest location for a new nuclear power plant.

Fig. 4.8 Power plant geographic factor

such as the location of major cities, the prevalence of earthquakes in the region, the risk of tsunamis, areas prone to natural disasters, the necessity of selecting remote locations, the importance of avoiding proximity to residential areas in case of explosions and ensuring a safe distance from populated regions to mitigate the risk of radiation leaks.

4.2.5 Scaling of Achievement Data

The responses provided by students to individual test items are aggregated into scores through the application of models derived from IRT. The TIMSS scaling process involves four key tasks: calibrating achievement items, creating principal components for survey data, generating plausible values for mathematics and science using both test and survey data, and aligning these values with reporting metrics. Each of these steps incorporates quality control measures to ensure the accuracy of the results.

When creating the environmental knowledge scale an alternative approach was adopted, following the method detailed in Chap. 12 of the TIMSS 2019 technical report (Foy et al., 2020) used for building TIMSS science content domain subscales. To estimate plausible values for the alternate science content domains at the eighth grade, a five-dimensional IRT model was used, utilizing the item parameters that were estimated for the overall mathematics and science scales, along with the same set of conditioning variables.

As an example, when considering the eighth grade, biology and Earth science items were reorganized to create two scales: an environmental scale and a non-environmental scale. Meanwhile, the original chemistry and physics scales remained unchanged and aligned with the TIMSS 2019 science framework. It is important to note that the non-environmental scale is not used for reporting due to several reasons, including its lack of coverage of a well-defined science subdomain.

4.3 Environmental Knowledge Across Countries

Environmental knowledge, like other educational outcomes, varies significantly among the countries and benchmarking participants participating in the study. The TIMSS 2019 encyclopedia (Kelly et al., 2020) illustrates the diversity of these educational systems. Different educational systems have their own unique curriculums, varying levels of teacher professional development, accountability systems, school stratification, economic resources, and cultural factors.

Figure 4.9 visually displays the mean achievement scores of environmental knowledge, along with the interquartile range, as well as the 10th and 90th percentiles. This figure is similar to the one published by Mullis et al. (2020a). For detailed values, please refer to Appendix, which includes the standard deviation. Similar to other achievement scales in TIMSS, the environmental knowledge scale is reported on a scale with an international mean of 500 and a standard deviation of 100.

The visual display highlights substantial disparities across countries. The five highest-achieving countries have averages well above 550 points, which is more than half a standard deviation above the TIMSS scale center point (i.e., 500). In contrast, the four lower-achieving countries fall short of even reaching a mean of 400 points, equivalent to one standard deviation below the scale center, and three additional countries do not reach at least 450 points, representing half a standard deviation below. Furthermore, the score distribution also varies across countries. Eleven participants have an interquartile range of more than 150 points, meaning substantial differences between low and high achieving students. In all countries the

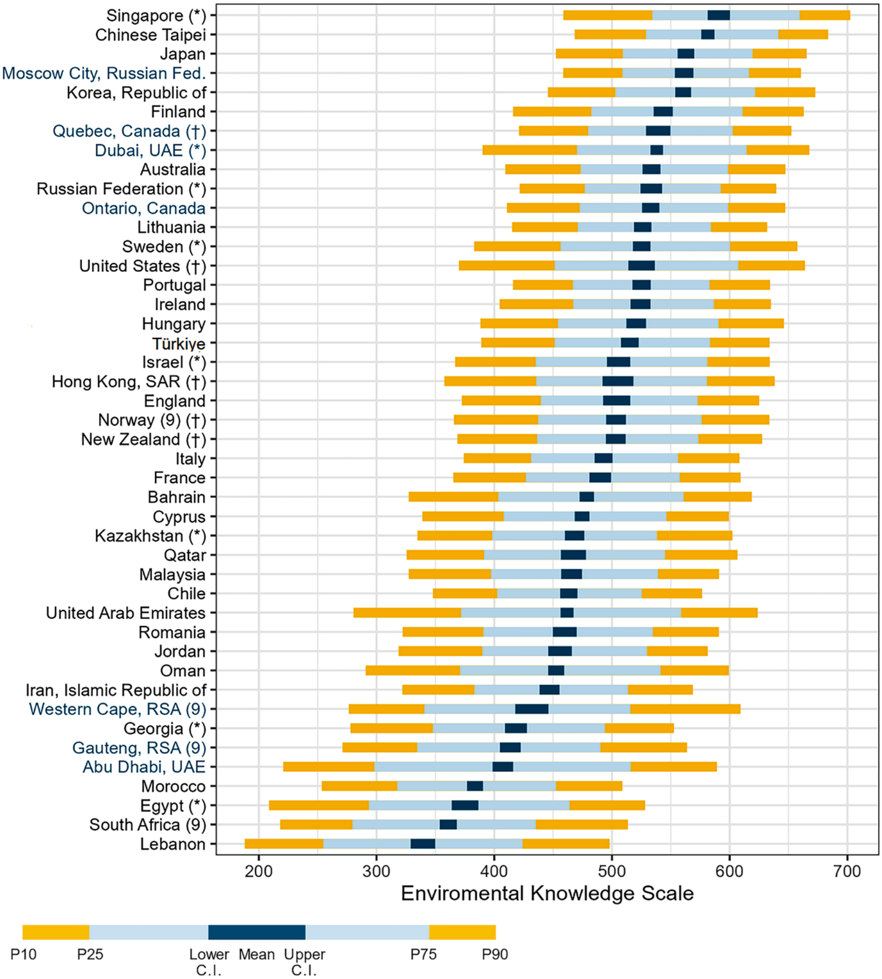


Fig. 4.9 Mean and interquartile achievement of environmental knowledge across educational systems

Notes: Benchmarking participants are highlighted in blue. RSA = South Africa, UAE = United Arab Emirates. (*) denotes Population coverages notes, see Appendix B.7 in Mullis et al. (2020b). (†) denotes Sampling participation rates notes, see Appendix B.10 in Mullis et al. (2020b). (9) indicates that the Country deviated from international defined population and surveyed adjacent upper grade. *C.I.* denotes Confidence Interval

interquartile range is at least of 100 points, with just eight countries having a range of fewer than 120 points of difference. These differences become more obvious when looking at the standard deviation (see Appendix), that ranges from 78 points (below the international standard deviation of 100 points) to 139 points. This variation can be partially explained in the results on achievement gaps in Chap. 5.

4.4 Examination of the Dimensionality of the Environmental Knowledge Scale

4.4.1 Domain Score

TIMSS reports an overall score for science (and mathematics) along with scores for subdomains. The reports of subdomain scores aim to inform countries about their relative academic strengths and weaknesses in specific learning domains. In order to address countries' preferences with regard to the content domains that would characterize mathematics and science in the assessment and the specific topics in each domain, the previous assessment frameworks were redefined. For example, although the environmental science domain was a reporting strand in 2003 at eighth grade, this strand was eliminated for TIMSS 2007 and its topics moved to biology and Earth science, where a new topic area was added—Earth's resources, their use, and conservation (Olson et al., 2008). A consequence of this change in allocation of topics to subdomains is a high degree of correlation among distinct content subdomains.

TIMSS acknowledges the existence of a strong general science factor, which leads to the calibration of item parameters based on unidimensional IRT models. For the computation of scores for the different content and cognitive domains, multidimensional IRT models are used. Multidimensional scaling uses the item parameters derived from the concurrent calibration of the overall assessment, along with the same set of conditioning variables (Foy et al., 2020). This approach enhances the robustness of item parameter estimation. However, the definition of subdomains and the assignment of corresponding items are based on theoretical considerations. An empirical analysis of the dimensionality of the TIMSS test has not been published to date. It is also important to note that using item parameters from a unidimensional model estimation implies that if performance excels in one subdomain, it will correspondingly lag in at least one other, while average achievement across the subdomains generally aligns with the achievement in the overall scale. This methodology facilitates a more comprehensive understanding of student performance across various dimensions of the assessment.

Although scores in subdomains are very useful from a conceptual perspective, there are important factors to consider before deciding whether to report them at the individual or group level. According to the *Standards for Educational and Psychological Testing* (American Educational Research Association, American Psychological Association, & National Council on Measurement in Education, 2014) scores for subdomains should not be reported unless their validity, comparability, and reliability have been demonstrated. Additionally, the *Standards* require that if a test provides multiple scores, the distinctiveness of each score should be established. However, the distinctiveness and added values of the TIMSS subdomain scores is discussed less frequently. In the following section, the added values of subscores at eighth grade will be examined.

4.4.2 Models

To examine the dimensionality of the TIMSS 2019 science assessment, two models were fitted to the data: a unidimensional two-parameter logistic (2PL) IRT model (Birnbaum, 1968) and a 2PL bifactor IRT model (Gibbons & Hedeker, 1992). In the unidimensional model, all the items were modeled to load on a general science dimension. In the bifactor model, all the items loaded on a general science dimension while simultaneously loading on their specific factors, namely, physics, chemistry, environmental knowledge, and non-environmental knowledge. The non-environmental scale was comprised of the biology and earth sciences items that were not included in the environmental knowledge scale. The mirt package (Chalmers, 2012) in R (R Core Team, 2022) was used to estimate the models. The Metropolis-Hastings Robbins-Monro algorithm (Cai, 2010) was used to estimate the model parameters.

4.4.3 Data

Publicly available data from TIMSS 2019 eighth grade science were used for this analysis. The 2019 cycle of TIMSS involved 39 countries and seven benchmarking participants. Items with partial credit were recoded to binary items (correct = 1; incorrect or partially correct = 0) to simplify the analysis. Omitted responses were coded as incorrect responses. The sample sizes varied, with the largest and smallest per country being 22,334 and 3178, respectively. For a comprehensive categorization of science items, please refer to the TIMSS 2019 assessment framework and technical report (Martin et al., 2020; Mullis & Martin, 2017).

4.4.4 Results

The comparison between the two models across countries was facilitated by employing the log-likelihood and specific information criteria, namely the Akaike information criterion (AIC) (Akaike, 1974) and the Bayesian information criterion (BIC) (Schwarz, 1978). Table 4.3 shows these values for the two models across countries. Based on likelihood function, the bifactor model has a better fit than the unidimensional model in all countries. However, when BIC, which penalizes for overparameterization, is considered, the unidimensional model has a better fit in all countries, while AIC does not yield consistent results.

Table 4.4 shows the reliabilities for each scale across the models and countries. As is shown in the table, the general dimension has a high reliability in both models but the specific dimensions in the bifactor model have low reliability coefficients.

Table 4.3 Global fit values for the two competing models in each educational system

Country	Mode	Unidimensional			Bifactor		
		-2LogLik	AIC	BIC	-2LogLik	AIC	BIC
Australia	Paper	308623	309467	312465	308259	309525	314023
Bahrain	Paper	194176	195020	197827	193682	194948	199158
Chile	Computer	132505	133349	136015	132190	133456	137456
Chinese Taipei	Computer	154856	155700	158443	154487	155753	159867
Cyprus	Paper	118337	119181	121784	117873	119139	123042
Egypt	Paper	214182	215022	217913	213694	214954	219290
England	Computer	113088	113928	116498	112748	114008	117863
Finland	Computer	163485	164329	167066	163094	164360	168465
France	Computer	129703	130547	133189	129336	130602	134565
Georgia	Computer	105383	106227	108803	104968	106234	110098
Hong Kong SAR	Computer	109488	110332	112900	109078	110344	114198
Hungary	Computer	154428	155272	157984	154133	155399	159466
Islamic Republic of Iran	Paper	186649	187489	190301	186296	187556	191774
Ireland	Paper	143154	143998	146664	142770	144036	148036
Israel	Computer	125649	126493	129118	125304	126570	130509
Italy	Computer	121353	122197	124811	121048	122314	126235
Japan	Paper	144820	145656	148331	144488	145742	149754
Jordan	Paper	229751	230591	233480	229348	230608	234942
Kazakhstan	Paper	155222	156066	158768	154538	155804	159856
Republic of Korea	Computer	127087	127931	130572	126724	127990	131952
Kuwait	Paper	148174	149018	151730	147839	149105	153174
Lebanon	Paper	131564	132408	135133	–	–	–
Lithuania	Computer	130535	131379	134016	130198	131464	135420
Malaysia	Computer	236592	237436	240332	236223	237489	241833
Morocco	Paper	–	–	–	–	–	–
New Zealand	Paper	205573	206417	209246	205124	206390	210633
Norway	Computer	151964	152808	155518	151634	152900	156964
Oman	Paper	220336	221180	224056	219868	221134	225449
Portugal	Computer	114893	115737	118319	114560	115826	119700
Qatar	Computer	129591	130435	133078	129185	130451	134416
Romania	Paper	151873	152717	155422	151233	152499	156556
Russian Federation	Computer	135172	136016	138662	134701	135967	139935
Kingdom of Saudi Arabia	Paper	179428	180256	183007	178927	180169	184295
Singapore	Computer	152931	153775	156512	152536	153802	157908
South Africa	Paper	–	–	–	598052	599312	604316
Sweden	Computer	135114	135958	138611	134725	135991	139971
Türkiye	Computer	135839	136683	139347	135489	136755	140751
United Arab Emirates	Computer	734078	734922	738304	733102	734368	739440
United States	Computer	293231	294075	297058	292720	293986	298461

(continued)

Table 4.3 (continued)

Country	Mode	Unidimensional			Bifactor		
		-2LogLik	AIC	BIC	-2LogLik	AIC	BIC
Benchmarking participant							
Ontario (Canada)	Computer	130338	131182	133813	129968	131234	135180
Quebec (Canada)	Computer	111631	112475	115033	111276	112542	116379
Moscow City (Russian Federation)	Computer	127382	128226	130858	127045	128311	132260
Gauteng (South Africa)	Paper	169655	170495	173282	169301	170561	174741
Western Cape (South Africa)	Paper	164208	165048	167813	163854	165114	169261
Abu Dhabi (United Arab Emirates)	Computer	252572	253416	256375	252093	253359	257797
Dubai (United Arab Emirates)	Computer	197907	198751	201558	197416	198682	202893

Notes: -2LogLik = Negative twice the log-likelihood, AIC = Akaike information criterion, BIC = Bayesian information criterion
(-) denotes that the model could not be identified or accurately estimated

Table 4.4 Scale reliabilities across the models and educational systems

Country	Unidimensional	Bifactor				
	G	G	C	P	NEK	EK
Australia	0.852	0.847	0.102	0.151	0.161	0.122
Bahrain	0.853	0.848	0.175	0.180	0.242	0.112
Chile	0.793	0.788	0.183	0.179	0.219	0.146
Chinese Taipei	0.852	0.847	0.175	0.201	0.223	0.172
Cyprus	0.823	0.817	0.180	0.243	0.294	0.200
Egypt	0.782	0.777	0.165	0.170	0.183	0.127
England	0.851	0.845	0.175	0.242	0.246	0.160
Finland	0.844	0.838	0.181	0.195	0.225	0.163
France	0.798	0.795	0.197	0.181	0.266	0.171
Georgia	0.771	0.760	0.219	0.264	0.254	0.200
Hong Kong SAR	0.842	0.838	0.203	0.258	0.267	0.193
Hungary	0.838	0.834	0.178	0.199	0.179	0.15
Islamic Republic of Iran	0.811	0.802	0.183	0.173	0.181	0.115
Ireland	0.831	0.824	0.192	0.215	0.259	0.178
Israel	0.857	0.852	0.186	0.218	0.243	0.189
Italy	0.802	0.796	0.198	0.214	0.229	0.172
Japan	0.823	0.818	0.180	0.164	0.229	0.135
Jordan	0.815	0.810	0.107	0.150	0.202	0.132
Kazakhstan	0.800	0.794	0.253	0.223	0.298	0.207
Republic of Korea	0.854	0.849	0.183	0.199	0.281	0.157
Kuwait	0.819	0.816	0.137	0.170	0.229	0.159
Lebanon	0.741	0.726	0.193	0.197	0.237	0.127
Lithuania	0.835	0.830	0.152	0.180	0.249	0.177

(continued)

Table 4.4 (continued)

	Unidimensional	Bifactor				
Country	G	G	C	P	NEK	EK
Malaysia	0.837	0.830	0.145	0.119	0.213	0.107
Morocco	–	–	–	–	–	–
New Zealand	0.859	0.851	0.135	0.197	0.191	0.153
Norway	0.842	0.836	0.167	0.157	0.218	0.150
Oman	0.842	0.838	0.147	0.161	0.205	0.127
Portugal	0.806	0.795	0.215	0.230	0.237	0.182
Qatar	0.847	0.841	0.214	0.220	0.256	0.175
Romania	0.831	0.822	0.237	0.229	0.272	0.165
Russian Federation	0.817	0.805	0.217	0.225	0.268	0.191
Kingdom of Saudi Arabia	0.797	0.790	0.175	0.192	0.215	0.147
Singapore	0.854	0.848	0.185	0.183	0.248	0.136
South Africa	–	0.764	0.080	0.100	0.128	0.069
Sweden	0.858	0.851	0.179	0.220	0.258	0.179
Türkiye	0.866	0.862	0.230	0.197	0.220	0.152
United Arab Emirates	0.864	0.859	0.099	0.121	0.171	0.096
United States	0.862	0.857	0.133	0.125	0.210	0.135
Benchmarking participant						
Ontario (Canada)	0.796	0.791	0.189	0.223	0.274	0.248
Quebec (Canada)	0.821	0.815	0.194	0.199	0.281	0.146
Moscow City (Russian Federation)	0.808	0.798	0.176	0.195	0.234	0.203
Gauteng (South Africa)	0.789	0.784	0.139	0.166	0.203	0.144
Western Cape (South Africa)	0.827	0.823	0.125	0.173	0.219	0.139
Abu Dhabi (United Arab Emirates)	0.853	0.849	0.140	0.154	0.177	0.087
Dubai (United Arab Emirates)	0.861	0.855	0.165	0.154	0.259	0.117

Notes: G = general dimension, C = chemistry, P = physics, EK = environmental knowledge, NEK = non-environmental knowledge
(-) denotes that the model could not be identified or accurately estimated

Table 4.5 shows the explained common variance (ECV) (Bentler, 2009) values for the general dimension and the specific group factors from the bifactor model. ECV for the general dimension is the percentage of the common variance that is explained by the general factor. It is a measure that quantifies the proportion of common variance that is explained by the general dimension. If ECV is one, the test is unidimensional and values smaller than one indicate deviation from unidimensionality. ECV can also be computed for specific group factors. It refers to the proportion of common variance explained by a latent specific factor. Dueber and Toland (2023) suggest that for low subscore reliabilities ($\omega = 0.60$), ECV should be 0.45 to have added value (the highest ω reliability we observed for the subscales was 0.18). As Table 4.5 shows, the ECV values indicate a strong general factor of science as ECV_G is >0.7 in all countries and benchmarking entities, while the subscale ECVs are relatively small. We interpret this as strong evidence for a general factor that explains roughly 80% of the variance in all items but there is also evidence for the

Table 4.5 Explained common variance (ECV) for each dimension in the bifactor model across educational systems

Country	ECV_G	ECV_C	ECV_P	ECV_EK	ECV_NEK
Australia	0.893	0.102	0.114	0.123	0.096
Bahrain	0.866	0.141	0.128	0.113	0.144
Chile	0.794	0.275	0.171	0.204	0.191
Chinese Taipei	0.857	0.146	0.147	0.155	0.132
Cyprus	0.786	0.211	0.233	0.220	0.199
Egypt	0.817	0.173	0.194	0.178	0.185
England	0.840	0.142	0.187	0.166	0.148
Finland	0.840	0.157	0.147	0.159	0.172
France	0.783	0.263	0.162	0.184	0.249
Georgia	0.736	0.238	0.271	0.302	0.255
Hong Kong SAR	0.816	0.180	0.206	0.175	0.175
Hungary	0.853	0.176	0.158	0.152	0.118
Islamic Republic of Iran	0.839	0.184	0.166	0.133	0.159
Ireland	0.824	0.178	0.171	0.190	0.172
Israel	0.843	0.154	0.153	0.166	0.156
Italy	0.784	0.260	0.230	0.182	0.202
Japan	0.838	0.189	0.145	0.147	0.168
Jordan	0.843	0.136	0.168	0.151	0.164
Kazakhstan	0.757	0.297	0.212	0.231	0.238
Republic of Korea	0.842	0.156	0.128	0.150	0.189
Kuwait	0.840	0.119	0.186	0.170	0.167
Lebanon	0.764	0.248	0.213	0.201	0.266
Lithuania	0.835	0.159	0.144	0.201	0.163
Malaysia	0.868	0.134	0.105	0.108	0.163
Morocco	–	–	–	–	–
New Zealand	0.872	0.122	0.133	0.137	0.122
Norway	0.855	0.161	0.132	0.127	0.157
Oman	0.869	0.159	0.140	0.124	0.114
Portugal	0.779	0.251	0.272	0.197	0.185
Qatar	0.834	0.174	0.174	0.169	0.153
Romania	0.800	0.214	0.207	0.185	0.194
Russian Federation	0.777	0.269	0.203	0.229	0.208
Kingdom of Saudi Arabia	0.819	0.182	0.205	0.190	0.160
Singapore	0.866	0.146	0.127	0.124	0.138
South Africa	0.895	0.105	0.099	0.099	0.112
Sweden	0.845	0.153	0.153	0.146	0.164
Türkiye	0.866	0.078	0.085	0.091	0.083
United Arab Emirates	0.916	0.122	0.133	0.137	0.122
United States	0.890	0.161	0.132	0.127	0.157

(continued)

Table 4.5 (continued)

Country	ECV_G	ECV_C	ECV_P	ECV_EK	ECV_NEK
Benchmarking participant					
Ontario (Canada)	0.800	0.249	0.182	0.160	0.207
Quebec (Canada)	0.761	0.233	0.228	0.244	0.246
Moscow City (Russian Federation)	0.794	0.234	0.188	0.224	0.193
Gauteng (South Africa)	0.823	0.183	0.195	0.193	0.153
Western Cape (South Africa)	0.867	0.128	0.137	0.144	0.126
Abu Dhabi (United Arab Emirates)	0.901	0.126	0.105	0.087	0.085
Dubai (United Arab Emirates)	0.873	0.130	0.105	0.116	0.145

Notes: G = general dimension, C = chemistry, P = physics, EK = environmental knowledge, NEK = non-environmental knowledge
(-) denotes that the model could not be identified or accurately estimated

subdomains that explain each roughly 5% of the variance. Solving TIMSS science individual items primarily requires general knowledge as measures with all science items, but there is also limited evidence for specific knowledge facets within the subdomains.

4.5 Discussion and Conclusion

TIMSS reports subdomain scores to inform countries about their relative academic strengths and weaknesses in specific learning domains. After almost 20 years, TIMSS 2019 provided again an opportunity to study environmental knowledge. For this purpose, TIMSS post hoc identified items that are conceptually related to various environmental issues to establish a new subscale on environmental knowledge. In this chapter, we first reviewed the conceptual framework and illustrated how environmental knowledge was measured by presenting several test items. Thereafter, we examined the latent structure of the TIMSS assessment in grade eight by means of model comparisons of various IRT models.

For the exploration of the latent structure of the TIMSS test, we compared a unidimensional 2PL IRT model with a bifactor 2PL IRT model that contains nested factors for the TIMSS subdomains including environmental knowledge. Specifically, the IRT models were fitted to the test data of 39 countries and seven benchmarking participants at eighth grade separately. The log-likelihood of the models consistently supported the superiority of the bifactor model across all the countries. However, when BIC was considered for model comparison, the unidimensional model turned out to be the superior model in all countries, while the AIC provided mixed evidence across countries. We interpret these results as evidence for a strong general science factor along with more nested factors for the subdomains.

Next, we examined the ECVs for the general factor and group factors in the bifactor model. These analyses suggest that the general factor explains roughly 80% of the variance in the test while each subdomain (including environmental knowledge) explains roughly another 5% of the variance. These additional results provide further evidence for a general factor along with more narrowly defined factors for the subdomains. Interestingly, the decomposition of the variance varies across countries, suggesting variation in the importance of the different subscores across countries.

Lastly, we observe high reliabilities for the general factor, which explains more variance and is measured by more items, and lower reliabilities for the nested factors, each of which explains less variance and is measured by fewer items. The small reliability coefficients question the precision and consistency of the subscale scores.

We would like to conclude by issuing a cautionary note. While the use of subscale scores is widespread and garners interest from various educational stakeholders seeking insights into strengths and weaknesses within different content areas instead of relying solely on a total score, it is crucial to heed the advice of the psychometric community. Unless the validity and reliability of subscale scores are rigorously established (Feinberg & Jurich, 2017; Wainer et al., 2001), it is a matter of debate to consider reporting them or not. In line with Sinharay et al. (2011), who stated, "Whenever subscores are provided, provide evidence of adequate reliability, validity, and distinctness of the subscores" (p. 36), our objective is to contribute evidence to this topic. When interpreting subscores in environmental knowledge, it is important to consider that a significant portion of the variance in the subscores is attributable to the general factor.

The issue of the little utility of subscores in the context of TIMSS mathematics has been discussed before by Camilli and Dossey (2019). To address this issue, they suggest obtaining empirical subscores by extracting profiles from the test data using factor analysis. They demonstrated that factor scores yielded by IRT factor analysis of TIMSS 2007 and TIMSS 2011 mathematics assessment data at fourth and eighth grade, were less correlated than the subscores that were constructed based on some predefined assessment frameworks. They also showed that subscores obtained with this method revealed some previously unknown information about the rankings of countries and their achievement profiles.

When interpreting subscores in TIMSS, it is important to consider that a significant portion of the variance in the subscores is attributable to the general factor. Differences in subscores can be attributed to subdomains that, in comparison, explain relatively little variance in the items. However, this concern might be mitigated by the fact that the final subscale scores are augmented by using principal components from students' contextual information and the item responses from other scales including the mathematics scale. As explained by Foy et al. (2020), students' item responses to all the items, the correlations between subscales, and contextual information are used in a sophisticated multidimensional latent regression model to improve the reliability of each subscale.

The present study highlights the presence of a robust general science factor in the TIMSS 2019 science assessment across 39 countries and seven benchmarking participants, alongside the existence of very weak specific dimensions. The low reliability of these subdimensions raises concerns about their practical significance. This calls into question the added value of these subdimensions, both for educational assessment and for informing science education policies. There is little doubt that multidimensional profiles can offer a more profound insight into national and international student achievements and subscores can serve as valuable supplementary information for comprehending performance. However, these subscores are often very imprecise and end up being strongly related to each other, essentially giving the same information (Puhan et al., 2010; Stone et al., 2009; Wainer & Feinberg, 2015).

Our analyses and findings encourage further investigation into the optimal approach for measuring and interpreting students' science abilities in educational assessments and the development of policies to support science education on a global scale. Future research in the field of educational assessment should consider whether a single general science factor is sufficient for capturing the essential aspects of students' science performance.

Appendix: Environmental Knowledge Score Mean and Distribution Across Educational Systems

Country	Mean	Mean SE	SD	P10	P25	P75	P90
Australia	533.6	3.4	92.3	410.3	474.1	597.7	646.5
Bahrain	478.6	2.7	111.5	328.2	404.2	560.1	617.8
Chile	463.3	3.3	88.4	348.8	403.3	524.6	575.7
Chinese Taipei	581.5	2.4	84.8	469.2	529.6	640.4	682.7
Cyprus	474.6	2.8	101.4	339.8	408.8	545.4	598.5
Egypt	375.2	5.3	122.7	209.6	294.3	463.1	527.3
England	504.0	5.4	97.9	373.3	440.4	571.9	624.1
Finland	543.5	3.7	96.8	416.9	483.3	610.2	662.0
France	490.0	4.2	95.0	366.3	427.7	556.8	608.3
Georgia	418.4	4.3	106.8	278.8	348.8	493.1	551.8
Hong Kong SAR	505.1	6.2	106.3	358.5	436.4	579.8	637.4
Hungary	520.6	3.8	99.8	389.2	455.0	589.7	645.2
Islamic Republic of Iran	447.0	3.9	95.4	322.9	384.0	512.7	567.8
Ireland	524.2	3.8	89.4	405.4	467.9	585.8	634.1
Israel	505.6	4.6	104.0	367.7	436.1	580.1	633.2
Italy	492.8	3.4	91.4	375.0	432.2	555.3	607.5
Japan	562.8	3.2	82.8	453.3	510.1	618.7	664.5
Kazakhstan	468.2	3.7	103.8	335.7	399.1	537.3	601.4
Jordan	455.9	4.7	102.2	319.6	390.7	528.9	580.4

(continued)

Country	Mean	Mean SE	SD	P10	P25	P75	P90
Republic of Korea	560.5	3.0	88.6	446.4	503.7	620.8	671.8
Kuwait	–	–	–	–	–	–	–
Lebanon	339.4	4.8	118.3	189.0	255.6	423.2	497.1
Lithuania	526.1	3.3	84.7	416.1	471.7	583.3	630.9
Malaysia	465.7	4.0	101.1	328.2	398.1	538.2	590.1
Morocco	383.6	3.0	98.5	254.4	318.3	451.7	508.0
Oman	452.6	3.0	118.6	291.6	371.8	540.5	598.5
New Zealand	503.2	3.8	100.3	369.5	437.3	572.6	626.7
Norway	503.4	3.8	103.2	366.6	438.1	575.3	632.8
Portugal	525.1	3.5	85.1	416.8	467.6	582.1	633.4
Qatar	467.3	5.0	106.4	326.4	392.1	544.2	605.7
Romania	459.9	4.7	104.6	323.1	391.6	533.8	589.9
Russian Federation	533.4	4.2	85.0	422.5	477.7	591.5	638.7
Singapore	590.7	4.4	95.2	459.6	535.1	658.6	701.5
Kingdom of Saudi Arabia	–	–	–	–	–	–	–
South Africa	360.9	3.3	114.8	219.0	280.4	434.5	512.6
Sweden	525.2	3.3	106.5	383.9	457.2	599.4	656.6
Türkiye	515.2	3.4	95.5	389.8	452.2	582.5	633.0
United Arab Emirates	461.8	2.4	130.1	281.4	372.7	558.0	622.9
United States	525.1	5.3	113.8	370.8	452.2	606.5	663.1
Benchmarking participant							
Ontario (Canada)	532.9	3.3	93.1	411.7	473.4	597.8	646.3
Quebec (Canada)	539.3	4.8	89.5	421.9	480.6	601.8	651.5
Moscow City (Russian Federation)	561.3	3.5	78.0	459.4	509.7	615.6	659.6
Gauteng (South Africa)	413.5	4.0	111.4	272.0	335.4	489.3	562.8
Western Cape (South Africa)	432.0	6.7	125.9	277.4	341.5	514.8	608.3
Abu Dhabi (United Arab Emirates)	407.3	4.0	139.1	221.6	299.1	515.1	588.2
Dubai (United Arab Emirates)	538.0	2.3	107.6	390.9	471.1	613.6	666.8

Notes: P = percentile, SD = standard deviation, SE = standard error
In Kuwait and the Kingdom of Saudi Arabia, average achievement in science content domains could not be accurately estimated

References

Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control, 19*(6), 716–723. https://doi.org/10.1109/TAC.1974.1100705

American Educational Research Association, American Psychological Association, & National Council on Measurement in Education. (2014). Standards for educational and psychological testing. American Educational Research Association. https://www.testingstandards.net/uploads/7/6/6/4/76643089/standards_2014edition.pdf.

Beaton, A. E., Mullis, I. V. S., Martin, M. O., Gonzalez, E. J., Kelly, D. L., & Smith, T. A. (1996). *Mathematics achievement in the middle school years: IEA's Third International Mathematics and Science Study (TIMSS)*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss1995i/MathB.html

Bentler, P. M. (2009). Alpha, dimension-free, and model-based internal consistency reliability. *Psychometrika, 74*(1), 137–143. https://doi.org/10.1007/s11336-008-9100-1

Birnbaum, A. (1968). Some latent trait models and their use in inferring an examinee's ability. In F. M. Lord & M. R. Novick (Eds.), *Statistical theories of mental test scores* (pp. 395–479). Addison-Wesley.

Cai, L. (2010). High-dimensional exploratory item factor analysis by a Metropolis-Hastings Robbins-Monro algorithm. *Psychometrika, 75*, 33–57. https://doi.org/10.1007/s11336-009-9136-x

Camilli, G., & Dossey, J. A. (2019). Multidimensional national profiles for TIMSS 2007 and 2011 mathematics. *Journal of Mathematical Behavior, 55*, 100693. https://doi.org/10.1016/j.jmathb.2019.02.001

Centurino, V. A. S., & Jones, L. (2017). TIMSS 2019 science framework. In I. V. S. Mullis & M. O. Martin (Eds.), *TIMSS 2019 assessment frameworks* (pp. 27–55). TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/frameworks/

Chalmers, R. P. (2012). mirt: A multidimensional item response theory package for the R environment. *Journal of Statistical Software, 48*(6), 1–29. https://doi.org/10.18637/jss.v048.i06

Dueber, D. M., & Toland, M. D. (2023). A bifactor approach to subscore assessment. *Psychological Methods, 28*(1), 222–241. https://doi.org/10.1037/met0000459

Feinberg, R. A., & Jurich, D. P. (2017). Guidelines for interpreting and reporting subscores. *Educational Measurement: Issues and Practice, 36*(1), 5–13. https://doi.org/10.1111/emip.12142

Foy, P., Fishbein, B., von Davier, M., & Yin, L. (2020). Implementing the TIMSS 2019 scaling methodology. In M. O. Martin, M. von Davier, & I. V. S. Mullis (Eds.), *Methods and procedures: TIMSS 2019 technical report* (pp. 12.1–12.146). TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/methods/chapter-12.html

Gibbons, R. D., & Hedeker, D. R. (1992). Full-information item bi-factor analysis. *Psychometrika, 57*, 423–436. https://doi.org/10.1007/BF02295430

Kelly, D. L., Centurino, V. A. S., Martin, M. O., & Mullis, I. V. S. (Eds.). (2020). *TIMSS 2019 encyclopedia: Education policy and curriculum in mathematics and science*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/encyclopedia/

Martin, M. O., Gregory, K. D., & Stemler, S. E. (Eds.). (2000). *TIMSS 1999 technical report*. TIMSS & PIRLS International Study Center, Boston College. https://timss.bc.edu/timss1999i/tech_report.html

Martin, M. O., Mullis, I. V. S., & Chrostowski, S. J. (Eds.). (2004). *TIMSS 2003 technical report*. TIMSS & PIRLS International Study Center, Boston College. https://timss.bc.edu/timss2003i/technicald.html

Martin, M. O., von Davier, M., & Mullis, I. V. S. (Eds.). (2020). *Methods and procedures: TIMSS 2019 technical report*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/methods

Mullis, I. V. S., & Martin, M. O. (Eds.). (2017). *TIMSS 2019 assessment frameworks*. TIMSS & PIRLS International Study Center, Boston College. http://timssandpirls.bc.edu/timss2019/frameworks/

Mullis, I. V. S., Martin, M. O., Smith, T. A., Garden, R. A., Gregory, K. D., Gonzalez, E. J., Chrostowski, S. J., & O'Connor, K. M. (2003). *TIMSS assessment frameworks and specifications 2003* (2nd ed.). TIMSS & PIRLS International Study Center, Boston College. https://timss.bc.edu/timss2003i/frameworks.html

Mullis, I. V. S., Martin, M. O., Ruddock, G. J., O'Sullivan, C. Y., Arora, A., & Erberber, E. (2005). *TIMSS 2007 assessment frameworks*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/TIMSS2007/frameworks.html

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020a). *TIMSS 2019 environmental awareness results*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/TIMSS_2019_Environmental_Results.pdf

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020b). *TIMSS 2019 international results in mathematics and science*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/international-results/

Olson, J. F., Martin, M. O., & Mullis, I. V. S. (Eds.). (2008). *TIMSS 2007 technical report*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2007/techreport.html

Puhan, G., Sinharay, S., Haberman, S., & Larkin, K. (2010). The utility of augmented subscores in a licensure exam: An evaluation of methods using empirical data. *Applied Measurement in Education, 23*(3), 266–285. https://doi.org/10.1080/08957347.2010.486287

R Core Team. (2022). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. https://www.R-project.org/

Robitaille, D. F., & Maxwell, B. (1996). The conceptual framework and research questions for TIMSS. In D. F. Robitaille & R. A. Garden (Eds.), *Research questions and study design. TIMSS Monograph No. 2* (pp. 34–43). Pacific Educational Press.

Robitaille, D. F., Schmidt, W. H., Raizen, S., McKnight, C., Britton, E., & Nicol, C. (1993). *Curriculum frameworks for mathematics and science. TIMSS Monograph No. 1*. Pacific Educational Press.

Schwarz, G. (1978). Estimating the dimension of a model. *Annals of Statistics, 6*(2), 461–464. https://doi.org/10.1214/aos/1176344136

Sinharay, S., Puhan, G., & Haberman, S. J. (2011). An NCME instructional module on subscores. *Educational Measurement: Issues and Practice, 30*(3), 29–40. https://doi.org/10.1111/j.1745-3992.2011.00208.x

Stone, C. A., Ye, F., Zhu, X., & Lane, S. (2009). Providing subscale scores for diagnostic information: A case study when the test is essentially unidimensional. *Applied Measurement in Education, 23*(1), 63–86. https://doi.org/10.1080/08957340903423651

Wainer, H., & Feinberg, R. (2015). For want of a nail: Why unnecessarily long tests may be impeding the progress of western civilisation. *Significance, 12*(1), 16–21. https://doi.org/10.1111/j.1740-9713.2015.00797.x

Wainer, H., Vevea, J. L., Camacho, F., Reeve, B. B., III, Rosa, K., Nelson, L., Swygert, K. A., & Thissen, D. (2001). Augmented scores-"Borrowing strength" to compute score based on small numbers of items. In D. Thissen & H. Wainer (Eds.), *Test scoring* (pp. 343–388). Erlbaum. https://doi.org/10.4324/9781410604729

Yin, L., & Foy, P. (2021). Constructing the TIMSS 2019 environmental awareness scales. In I. V. S. Mullis, M. von Davier, & M. O. Martin (Eds.), *Methods and procedures: TIMSS 2019 technical report* (pp. 18.1–18.30). TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/methods/chapter-18.html

Chapter 5
Inequalities on Environmental Knowledge

Andrés Strello, Rolf Strietholt, Yuan-Ling Liaw, Purya Baghaei, and Sabine Meinck

5.1 Introduction

The previous chapters conceptualized environmental knowledge and explained the construction of the environmental knowledge scale and its psychometric properties. In this chapter, using the subscore provided by the Trends in International Mathematics and Science Study (TIMSS) 2019 international study center, we report on the distributions of the environmental knowledge scale within each educational system from an equity perspective.

Inequality in education is not a new topic. Since the Coleman report in the 1960s (Coleman et al., 1966), there has been an important focus on the extent to which educational systems are capable of reaching all students, regardless of their origin. In the context of environmental knowledge, the discussion reaches new dimensions. In the world-threatening context of climate change, the understanding of environmental-related phenomena acquires greater importance because it builds a foundation for developing pro-environmental attitudes and behavior (Steg & Vlek, 2009).

A. Strello (✉)
International Association for the Evaluation of Educational Achievement (IEA), Hamburg, Germany

R. Strietholt · Y.-L. Liaw · P. Baghaei · S. Meinck
Department of Education, University of Bath, Bath, UK

KU Leuven, Leuven, Belgium

M. M. Isac et al. (eds.), *Knowledge and Willingness to Act Pro-Environmentally*, IEA Research for Education 16, https://doi.org/10.1007/978-3-031-76033-4_5

5.1.1 Environmental Knowledge Score

In Chap. 4, we introduced environmental knowledge and its distribution across countries[1] (see Fig. 4.9 in Chap. 4 or see Appendix in this chapter for the tabular format). As with other educational outcomes, environmental knowledge varies drastically among the participating countries. The TIMSS 2019 encyclopedia (Kelly et al., 2020) shows the diversity of the educational systems that participated in the study. Different educational systems have different curriculums, levels of professional development among their teachers, accountability systems, levels of school stratification, economic resources and cultural aspects. The variation of scores across countries reflected the diversity in educational contexts.

The five highest achieving countries average well above 550 points, i.e., more than half a standard deviation above the scale center point. Meanwhile, the four lower achieving countries do not even reach a mean of 400 points (i.e., one standard deviation below the scale center), and three other countries do not reach at least 450 points (0.5 standard deviation below). In context, 1 year of schooling is associated with a range from 18 to 60 score points (Luyten, 2006; Steinmann & Olsen, 2022), meaning that the high achieving countries present, on average, gains equivalent to three to 5 years of schooling. In equally striking inequalities, the 75th percentile of students in the four lowest achieving countries have roughly similar performances than the students in the 10th percentile of the high achieving countries. In addition, the score distribution also varies across countries. Eleven participants have an interquartile range of more than 150 points, meaning large differences between low and high achieving students. In all countries the interquartile range is of at least 100 points, with just eight countries having a range of fewer than 120 points of difference. These differences become more obvious when looking at the standard deviation (see Appendix A), that ranges from 78 points (below the international standard deviation of 100 points) to 139 points. This variation can be partially explained in the following results on achievement gaps.

Scores on environmental knowledge vary according to each country's geographical region and economic development. Figure 5.1 suggests that the highest scores are concentrated in East Asia, Europe, and North America, while the lowest scores are concentrated in Africa, West Asia, and South America. In other words, we can observe a gap between the so-called Global North and the Global South on environmental knowledge (United Nations Conference on Trade and Development [UNCTAD], 2022).

[1] TIMSS participating educational systems can consist of countries (e.g., Russian Federation) and regions as benchmarking participants (e.g., Moscow City in the Russian Federation). For the sake of simplicity, in this chapter, we sometimes refer to both as "countries."

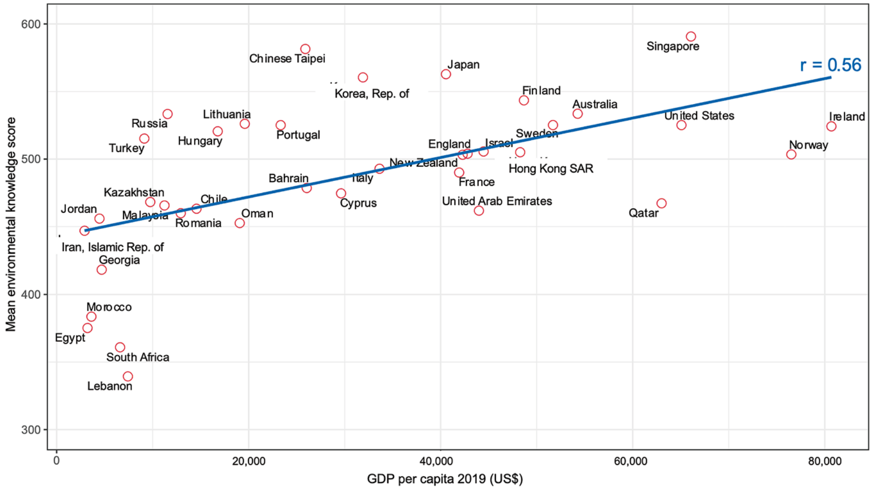


Fig. 5.1 Mean environmental knowledge achievement and gross domestic product (GDP) per capita in 2019
Source: GDP data for 2019 from the International Monetary Fund (2023)

In addition, achievement is associated with the economic wealth of each country. This is shown in Fig. 5.1, which plots each country's environmental knowledge mean achievement against their respective gross domestic product (GDP) per capita in 2019 (International Monetary Fund, 2023).[2] We excluded benchmarking participants from the analyses due to the difficulty of estimating GDP for them. The horizontal axis of the figure shows the heterogeneity of the economic wealth of the participating countries, with few countries from different continents reaching well over US$ 60,000 per capita and many others not reaching the US$ 10,000 per capita mark. The blue line represents the linear correlation between GDP per capita and the mean environmental knowledge achievement, showing a strong correlation ($r = 0.56$), i.e., countries with higher GDP per capita tend to perform better in environmental knowledge. The line also enables us to compare how much some countries are under- or overperforming in relation to their economic wealth. Many East Asian countries seem to outperform given their economic status, while several African countries appear to underperform. This suggests that the economy of each country can explain some of this variation, but there are also some unique factors within each educational system that affect the environmental knowledge performance, unrelated to the country's economic wealth.

[2] GDP per capita is a common indicator of the economic wealth of each country and consists of the total monetary value of all the finished goods and services within a country, divided by the population size.

5.2 Social Inequality Within Countries

In the following sections, we investigate within-country variation of environmental knowledge, with a specific focus on social inequality. Social inequality refers to the equalitarian ideal where differences on student performance should not be related to their family background or other deterministic characteristics they cannot control. In each of these sections we test the achievement gaps between groups determined by students' socioeconomic status (SES), gender, and the urbanicity of their schools.[3]

5.3 Socioeconomic Inequality in Environmental Knowledge

5.3.1 Background

SES may be referred to as the individual's position within a society, understanding that within societies people or groups are marked by their access to or control over wealth, power, or status (Mueller & Parcel, 1981). The differences in achievement between different SES groups has been an important topic of research in education for decades. Evidence of significant achievement gaps by SES groups have been present since the very first international large-scale assessments (see Chmielewski, 2019).

The difference in achievement between students from different SES families can be explained by the fewer resources for education that students of lower SES backgrounds may receive. This difference in resources accumulates along students' development trajectory, explaining the disparities in achievement between them. Following Bourdieu's theory, these resources are manifested as economic resources (e.g., families with higher incomes can send their children to private schools or afford private tutoring) and in the families' cultural and social capital (Bourdieu, 1986; Broer et al., 2019; Coleman, 1988, 1990).

In addition, educational systems also play a role in the generation of disparities. Besides what Boudon (1974) named as primary effects, the differentials in achievement due to SES, these differences may be exacerbated during educational transitions, i.e., secondary effects (Jackson et al., 2007). This means that in addition to the presence or absence of achievement gaps between SES groups, the features of educational systems have an influence on the magnitude and importance of these gaps (Strietholt et al. 2019; Van de Werfhorst & Mijs 2010; Volante et al. 2019).

[3] For information on how the achievement gap was calculated, see Chap. 4.

5.3.2 Variables

Indicators such as parental income, occupation or educational level are seen as proxies of students' SES (Duncan et al., 1972; Gottfried, 1985; Hauser, 1994; Mueller & Parcel, 1981; Sirin, 2005; White, 1982). Due to the difficulties in obtaining reliable information from students and the difficulties in constructing internationally comparable indicators (see Jerrim et al., 2019; Jerrim & Micklewright, 2014), other indicators such as the number of books at home have been used, where evidence has shown its association with the achievement level of students (Brese & Mirazchiyski, 2013; Hanushek & Woessmann, 2011). However, this indicator also has its own share of problems, as it may suffer from endogeneity bias and be confounded with achievement itself—that is, low achievers accrue fewer books and are more likely to underestimate the number of books reported (Engzell, 2019). On more conceptual terms, parental education and number of books at home also may represent different constructs. While both are related to Bourdieu's concept of cultural capital, parental education is an institutionalized capital that can further be transferred into economic capital, while the number of books would be a rough representation of the embodied culture of home. Moreover, previous analyses have shown that SES based on parental education and on number of books at home are highly correlated, but not a perfect correlation (Strietholt & Strello, 2021). Therefore, as proxy of student SES, we decided to use two different measures: parental education and number of books at home, both measures as reported by the students.

- **Parental education** If the response for both parents is available, we kept the value of highest education. Parental education in TIMSS is reported by students and later standardized in ISCED levels (UNESCO Institute for Statistics, 2012) within the international dataset to keep the categories comparable across countries. For the sake of simplicity, we dichotomized parental education into two values: parents without a university degree (that is, lower than ISCED 6) and parents with a university degree (that is, ISCED 6 or higher).
- **Number of books at home** We categorized the values into two groups: fewer than 100 books and 100 books or more.

Table 5.1 shows the percentage of students whose parents have a university degree and percentage of students reporting more than 100 books at home. As can be seen, countries show similar patterns for both variables (i.e., countries with higher percentages of students with highly educated parents also tend to have more students reporting more than 100 books at home). The correlation between those variables is strong ($r = 0.60$).

In addition, the variation in SES is evident across the participating educational systems in TIMSS 2019, demonstrating the heterogeneity of the countries participating in this study. Ten participating countries, from a wide range of geographical contexts, had 50% of students with parents holding a university degree. On the other hand, the lower levels of parental education are concentrated in the African, West Asian and even some European countries. Regarding the number of books, this

Table 5.1 Size of sociodemographic groups (percent of students)

Country	Parental education (% university)	Number of books (% >100 books)	Gender (% girls)	Urbanicity (% urban area)
Australia	49	41	50	84
Bahrain	50	17	49	86
Chile	30	12	49	88
Chinese Taipei	43	28	50	84
Cyprus	59	30	49	78
Egypt	36	10	55	51
England	49	29	53	69
Finland	54	39	48	53
France	34	26	49	70
Georgia	36	37	48	74
Hong Kong SAR	33	26	46	97
Hungary	36	39	50	59
Islamic Republic of Iran	23	15	47	74
Ireland	45	33	49	59
Israel	62	32	52	78
Italy	28	34	50	38
Japan	49	31	52	87
Jordan	33	9	48	80
Kazakhstan	43	13	49	55
Republic of Korea	65	59	48	87
Lebanon	38	13	49	59
Lithuania	46	26	50	74
Malaysia	15	12	51	70
Morocco	14	6	50	70
New Zealand	45	33	49	81
Norway	69	40	49	50
Oman	36	16	48	72
Portugal	33	25	50	82
Qatar	62	16	50	89
Romania	27	23	51	51
Russian Federation	50	20	48	74
Singapore	51	27	49	100
South Africa	23	6	52	38
Sweden	59	32	49	55
Türkiye	16	23	50	83
United Arab Emirates	58	21	48	89
United States	56	29	49	73
Benchmarking participants				
Ontario (Canada)	52	40	50	87
Quebec (Canada)	53	26	51	78
Moscow City (Russian Federation)	76	43	48	99
Gauteng (South Africa)	32	8	55	78
Western Cape (South Africa)	23	11	55	76
Abu Dhabi (United Arab Emirates)	55	19	47	81
Dubai (United Arab Emirates)	68	28	50	98

indicator seems to be more distinctive, as some countries show particularly low levels: in three countries, less than 10% of the students are categorized into the high SES group, based on the number of books in their home. Other countries with relatively few such students are concentrated in the Middle East, Africa, and South America. In most countries, between 20% and 40% of the students report having more than 100 books at home.

5.3.3 Results with Parental Education

The socioeconomic achievement gap based on parental education, i.e., the mean difference between students with parents with university degree and without university degree, is reported in Fig. 5.2. The figure shows that in all countries there are significant knowledge gaps between socioeconomic groups based on parental education and in all countries the higher socioeconomic groups have advantages. However, across countries there is large variation in the size of these gaps. Some countries, such as the Republic of Korea or Kazakhstan, present less than 40 points in mean difference between the different socioeconomic groups. In contrast, for participants such as Abu Dhabi or Western Cape the gap reaches 100 points, and in countries such as Lebanon, United Arab Emirates, Hungary and Qatar this achievement gap is close to 90 points, i.e., differences of around one standard deviation between socioeconomic groups.

In addition, there are some geographic patterns related to the magnitude of the achievement gap. Many of the countries with the highest gap between socioeconomic groups by parental education seem to be from the Middle East, plus countries such as Hungary and New Zealand. In contrast, many of the countries with the lowest gaps between socioeconomic groups by parental education seem to be from East Asia, plus countries such as Kazakhstan, the Russian Federation, and Norway.

5.3.4 Results with Number of Books at Home

Figure 5.3 reports the SES achievement gap based on the number of books at home, i.e., the achievement gaps between students with 100 or more books versus equal or lower than 100 books at home. While similar to the results based on parental education, the gaps are not identical, although it is difficult to compare as the differences may be due to the cutoff point used. Sweden and the United States present an example of these differences, with the second and third highest gaps, respectively. In addition, in Jordan the achievement gap is not statistically significant, while Egypt even presents a negative direction in achievement gap (i.e., students with fewer books have higher scores); however, it is important to remember that in these two countries most of the student population reported a very low number of books.

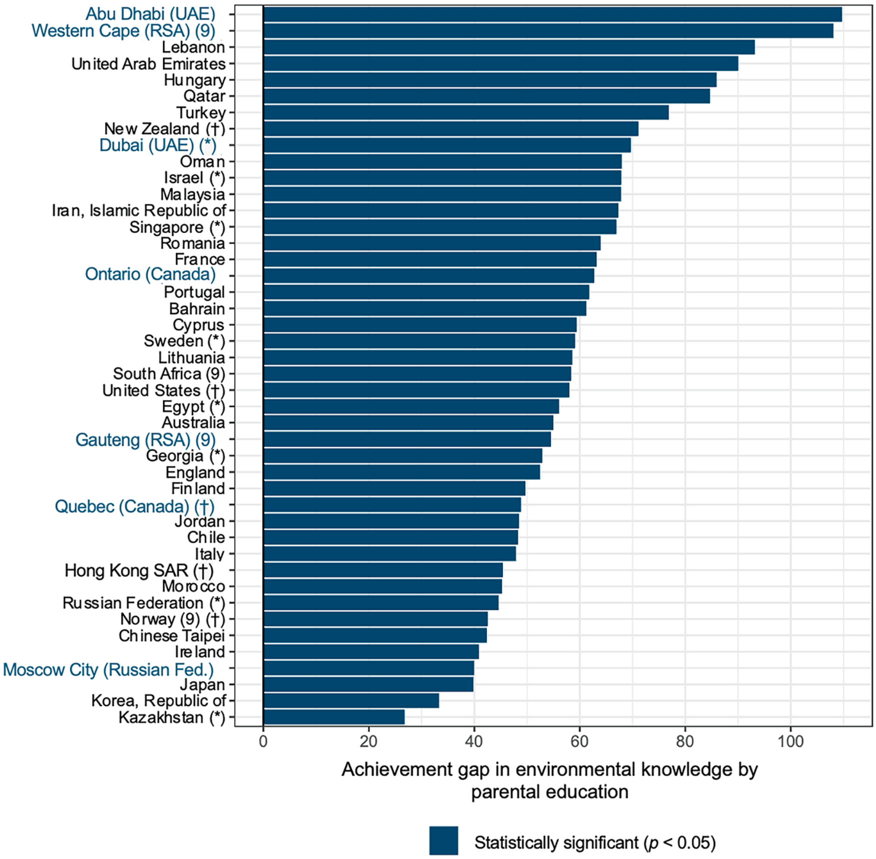


Fig. 5.2 Environmental knowledge gap between students with parents with university degree versus without university degree
Notes: Benchmarking participants are marked in blue. RSA = South Africa, UAE = United Arab Emirates. (*) Population coverages notes, see Appendix B.7 in Mullis et al. (2020). (†) Sampling participation rates notes, see Appendix B.10 in Mullis et al. (2020). (9) Country deviated from international defined population and surveyed adjacent upper grade

5.4 Gender Achievement Gap

5.4.1 Background

Gender inequality in education has been a historically contentious topic. Until recently, there were important differences in school enrollment, that have now been neutralized in the Western world and reduced in most other countries (Steinmann & Rutkowski, 2023). Current gender inequalities studies are centered around career

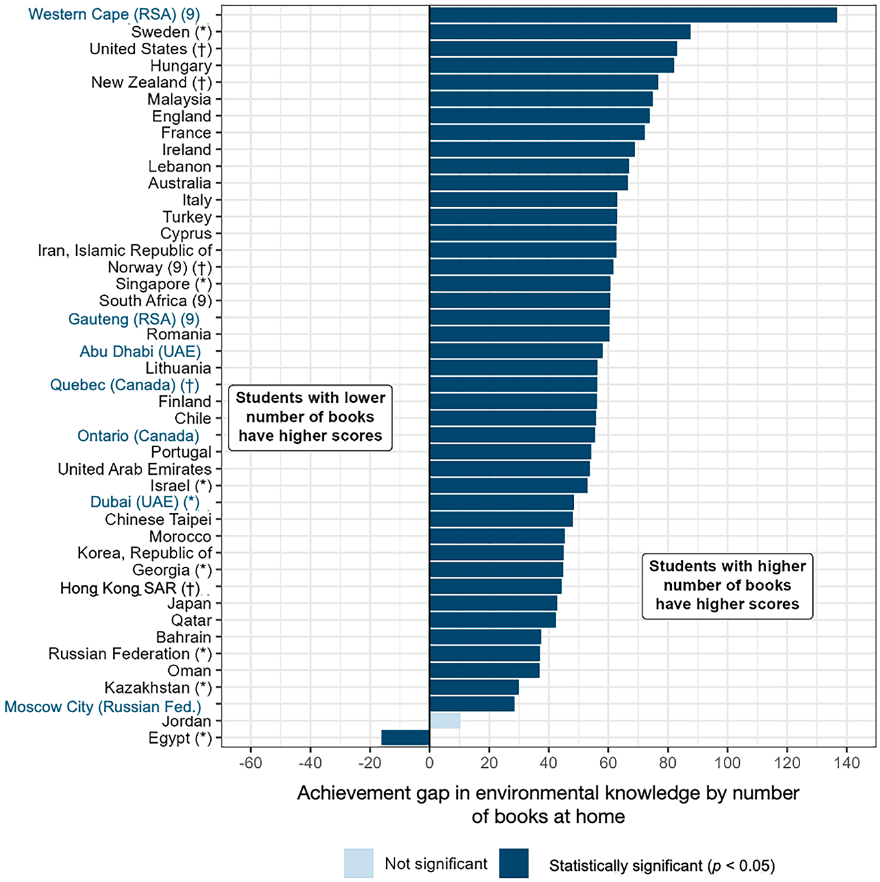


Fig. 5.3 Environmental knowledge gap between students reporting more than 100 books versus equal or less than 100 books at home
Notes: Benchmarking participants are marked in blue. RSA = South Africa, UAE = United Arab Emirates. (*) Population coverages notes, see Appendix B.7 in Mullis et al. (2020). (†) Sampling participation rates notes, see Appendix B.10 in Mullis et al. (2020). (9) Country deviated from international defined population and surveyed adjacent upper grade

preferences, such as the underrepresentation of women in STEM[4] careers, and still show systematic differences in performance between boys and girls that are differentiated between domains (Leder, 2019). Based on international evidence, in the reading domain girls have outperformed boys since the very first studies in the 1970s until the latest editions of PIRLS and PISA,[5] with variations in the magnitude

[4] STEM = science, technology, engineering and mathematics.

[5] PIRLS = Progress in International Reading Literacy Study; PISA = Programme for International Student Assessment.

between countries and a slight decrease from 2001 onwards (see Steinmann et al., 2023). In mathematics and science domains, the gender gap has been less clear, as there is variation in the size and direction of the gender achievement gap between countries (Leder, 2019; Rosén et al., 2022; Steinmann & Rutkowski, 2023).

The likely causes of the gender gap can be divided into two broad explanations: nature and nurture (see overviews by Halpern, 2012; Hyde, 2014). The nature theories assume innate differences between boys and girls on their learning process; however, the evidence has shown that boys and girls score mostly the same on cognitive ability tests (see *gender similarity hypothesis* in Hyde, 2014; Zell et al., 2015). The nurture theories focus on the environmental influences that differ between boys and girls. Nurture-related theoretical perspectives all suggest that societal gender norms and existing gender differences in education transmit to students, perpetuating educational gender inequalities, such as the overrepresentation of men in STEM careers (Eccles et al., 1990; Halpern, 2012; Neuville & Croizet, 2007). In the present study, we cannot distinguish between nature and nurture but rather measure the accumulated differences of sex and gender.

5.4.2 Results

The gender achievement gap, i.e., the mean difference between girls and boys, is illustrated in Fig. 5.4. There are significant gaps between girls and boys in less than half of the countries. In addition, in countries where the achievement gap is significant, roughly half of the participants present achievement gaps in favor of boys and roughly half in favor of girls.

There are some clear geographic patterns regarding the magnitude and direction of the achievement gap. Most countries with positive gaps, i.e., where girls have an advantage, are in the Middle East or Africa, with Finland being the only exception. In contrast, the countries presenting negative gaps, i.e., where boys have an advantage, seem to be a heterogeneous group of educational systems. South Africa presents an interesting case, as the results in Western Cape show a gap favoring boys, while we find a non-significant gap favoring girls in Gauteng and in the full-country sample. In addition, in the countries where boys have an advantage, the achievement gaps are significant but relatively small, around 20 points; in contrast, in Oman, Bahrain, and Jordan the achievement gaps in favor of girls are around 40 points. Since all these countries are from the Arab world, the clear gap in favor of girls in these countries may be explained with factors such as the predominance of gender segregated schools and the disparity in school enrollment by gender (Fryer & Levitt, 2010; Smits & Huisman, 2013).

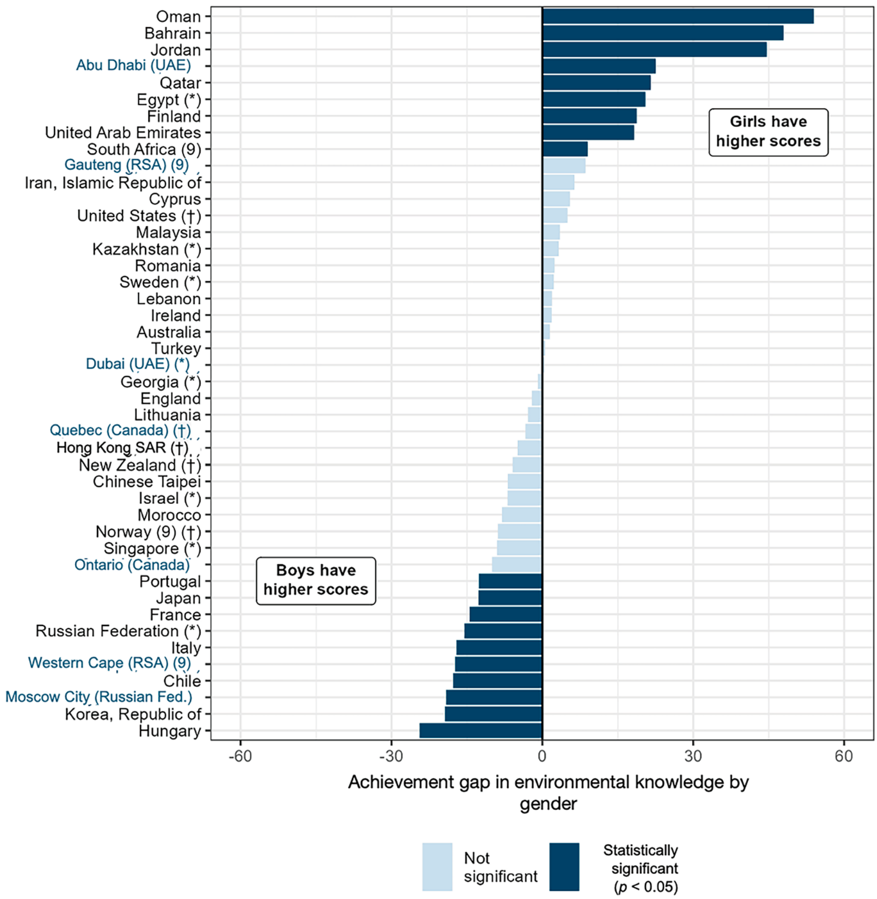


Fig. 5.4 Environmental knowledge gap between female and male students
Notes: Benchmarking participants are marked in blue. RSA = South Africa, UAE = United Arab Emirates. (*) Population coverages notes, see Appendix B.7 in Mullis et al. (2020). (†) Sampling participation rates notes, see Appendix B.10 in Mullis et al. (2020). (9) Country deviated from international defined population and surveyed adjacent upper grade

5.4.3 Variables

We used the variable reported by students as the indicator of gender. In TIMSS 2019, two genders are available in the international dataset: boy and girl.

In Table 5.1 we reported the percentage of girls by country. Most participants report around 50% of girls, with a minimum of 46% and maximum of 55%, meaning that there are no notable differences between countries in the enrollment of each gender.

5.5 Urbanicity Achievement Gap

5.5.1 Background

School location has been part of the school contextual questionnaires since the earliest international large-scale assessments, such as the first International Association for the Evaluation of Educational Achievement (IEA) International Mathematics Study in 1964 and its following second edition in 1980–1982 (Noonan, 1976; Westbury & Travers, 1990). The results of the first edition of TIMSS in 1995 (Martin et al., 2000) showed that the urbanicity of the school location was a relevant predictor in several educational systems.

In the context of climate change and the challenges it brings to the population, discussion of levels of environmental knowledge by urbanicity acquires new meanings. We advocate for a renewed focus on the urban–rural divide within the context of environmental concerns. Evidently, the global climate crisis affects rural and urban areas differently, as urban areas are more likely to suffer higher temperatures as a consequence of global warming (Chapman et al., 2017). On the other hand, rural areas may be affected in aspects such as agricultural production, with the added consequences on their economy and demographic changes within a population that, in many cases, is already more vulnerable (due to lower SES and access to services) (Bi & Parton, 2008; Fahad & Wang, 2020; Lal et al., 2011; Olesen & Bindi, 2002). In this context, it becomes important to investigate whether levels of environmental knowledge vary between urban and rural areas. In this section, we explore how environmental knowledge scores distribute across groups of urbanicity.

We found very few comparative studies that measured the gap between urban and rural areas and none which focused on environmental knowledge. The only exception we found was Echazarra and Radinger's (2019) working paper. Using TALIS[6] 2013 and PISA 2015 data, the authors found that rural schools tended to perform worse in science than urban schools in most countries, with rural students having a lower socioeconomic background in most cases. In addition, students from rural areas had lower further education expectations than students from urban areas even after controlling by SES, but with notorious heterogeneity between countries on the resources rural schools receive. Reviewing further non-comparative evidence, the urban and rural disparity seems to heavily depend on the context of each country. For example, it has been found that in many countries there are wide gaps between urban and rural areas, since the latter receive less resources than their urban counterparts; these countries include Nigeria (Alordiah et al., 2015; Owoeye & Yara, 2011), Australia (Murphy, 2019), China (Wang et al., 2014), and Thailand (Lounkaew, 2013), as well as countries within sub-Saharan Africa (Zhang, 2006)

[6] TALIS = Teaching and Learning International Survey.

and several ex-soviet countries (Kryst et al., 2015). In contrast, in countries such as the United States, it has been found that students in urban areas do worse than their rural and suburban counterparts, possibly due to the segregation logics that are found in large urban areas (Lankford et al., 2002; Miller & Votruba-Drzal, 2015; Sirin, 2005).

5.5.2 Variables

For the indicator of urbanicity, we used the information reported by school principals in the school questionnaire. The principals were asked to categorize their school location by type of area: from remote rural area to a densely populated urban area. To facilitate the analyses, we dichotomized the urbanicity into two categories: urban areas (densely populated urban areas plus medium sized cities and suburban areas) and rural areas (small towns and rural areas).

Table 5.1 shows the percentage of students who study in urban areas. In some countries, for example, Chile, Türkiye, the Republic of Korea and Israel, a considerable majority of students attend schools located in urban areas. In Singapore and Hong Kong SAR most or almost all students go to schools in urban areas. However, other countries show very different patterns; for example, the percentage of students attending schools in urban areas is approximately 40% in Norway, South Africa and Italy.

5.5.3 Results

The urbanicity achievement gap, i.e., the mean score difference between students living in urban areas (medium cities or larger) versus those living in rural areas (small towns or smaller), are shown in Fig. 5.5. In 26 countries there is a positive achievement gap, i.e., students in urban areas perform better than their rural counterparts. In most countries, the magnitude of the achievement gap is not as high as the socioeconomic gap seen above, but there are outliers such as United Arab Emirates and Abu Dhabi with over 100 points of difference between urban and rural areas, and other countries such as South Africa, Türkiye, and the Islamic Republic of Iran whose gaps reach over 60 points. In most other countries, the gap is lower than 40 score points. In contrast, in France and Bahrain, the achievement gap is negative. This means that students in rural areas outperform their counterparts, scoring approximately 15 points higher on average than students studying in urban areas. Lastly, in 13 countries there are no statistically significant differences between urban and rural areas.

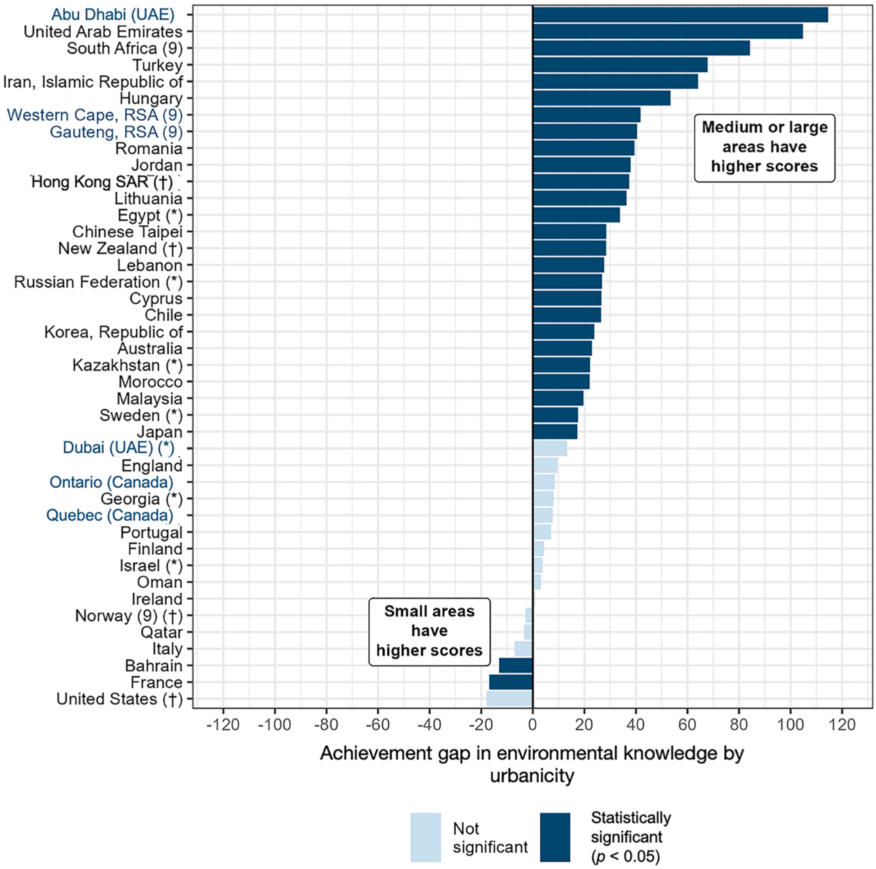


Fig. 5.5 Environmental knowledge gap between urban (medium cities or larger) and rural (small town or smaller) areas
Notes: Benchmarking participants are marked in blue. RSA = South Africa, UAE = United Arab Emirates. Moscow City (Russian Federation) is omitted due the low number of respondents in rural areas; Singapore is omitted due all respondents being located in urban areas. (*) Population coverages notes, see Appendix B.7 in Mullis et al. (2020). (†) Sampling participation rates notes, see Appendix B.10 in Mullis et al. (2020). (9) Country deviated from international defined population and surveyed adjacent upper grade

5.6 Discussion and Conclusion

In this chapter, we studied the variation in environmental knowledge from an equity perspective. The overall results indicate important variation in the levels of environmental knowledge among the TIMSS 2019 participating educational systems and students.

We further discussed in this chapter the results shown in the previous chapter, where we found that there are important differences in the levels of mean achievement in environmental knowledge between countries, and that the high-achieving students in lower performing countries reached similar levels of performance compared to the low-achieving students in the highest performing countries. In the same vein, there were important differences in the distribution of environmental knowledge across countries, with some presenting large gaps between high and low performers while others had reduced differences. It is worrying, but sadly not surprising, to observe a strong correlation between countries' wealth (measured as GDP) and the performance level of their students. Richer countries tended to perform significantly better than poorer countries.

Additionally, we studied the within-country variation on environmental knowledge through measuring the achievement gap between sociodemographic groups as a measure of social inequality. We found that environmental knowledge is very highly associated with the SES of students' families, both by parental education and by number of books at home. In the context of climate change, students who have a poorer understanding of how the environment functions and how it is affected by human actions are likely to have fewer resources in their future lives. In contrast, in almost half of the countries, the gender achievement gap was non-significant, and in the other half, there were small gender achievement gaps. Finally, many countries presented important gaps by levels of urbanicity, showing that students from big or mid-sized urban areas systematically perform better on environmental knowledge than their rural or suburban counterparts, while for many others this gap was non-significant.

Overall, this chapter has shown that there is important work to do in terms of environmental knowledge. Environmental knowledge has been conspicuously under-researched to date. To fill this research gap, our research offers new insights on which groups of students have not yet obtained the necessary knowledge to understand, evaluate and act upon the challenges to come. Environmental crises, including climate change, biodiversity loss, pollution, water scarcity, and more, are all global phenomena, but currently young people in the TIMSS participating countries show vastly differing, and often low, levels of knowledge on environmental topics. Moreover, within countries there are also important differences on how well their future citizens understand the phenomena. Considering the pressing nature of ongoing environmental challenges, this finding is cause for concern, and highlights the urgent need for action. It is imperative for policymakers and educators to equip our students for the future, enabling them to contribute to a more sustainable environment.

Appendix: Environmental Knowledge Score Mean and Distribution Across Educational Systems

Country	Mean	Mean SE	SD	P10	P25	P75	P90
Australia	533.6	3.4	92.3	410.3	474.1	597.7	646.5
Bahrain	478.6	2.7	111.5	328.2	404.2	560.1	617.8
Chile	463.3	3.3	88.4	348.8	403.3	524.6	575.7
Chinese Taipei	581.5	2.4	84.8	469.2	529.6	640.4	682.7
Cyprus	474.6	2.8	101.4	339.8	408.8	545.4	598.5
Egypt	375.2	5.3	122.7	209.6	294.3	463.1	527.3
England	504	5.4	97.9	373.3	440.4	571.9	624.1
Finland	543.5	3.7	96.8	416.9	483.3	610.2	662
France	490	4.2	95	366.3	427.7	556.8	608.3
Georgia	418.4	4.3	106.8	278.8	348.8	493.1	551.8
Hong Kong SAR	505.1	6.2	106.3	358.5	436.4	579.8	637.4
Hungary	520.6	3.8	99.8	389.2	455	589.7	645.2
Islamic Republic of Iran	447	3.9	95.4	322.9	384	512.7	567.8
Ireland	524.2	3.8	89.4	405.4	467.9	585.8	634.1
Israel	505.6	4.6	104	367.7	436.1	580.1	633.2
Italy	492.8	3.4	91.4	375	432.2	555.3	607.5
Japan	562.8	3.2	82.8	453.3	510.1	618.7	664.5
Jordan	455.9	4.7	102.2	319.6	390.7	528.9	580.4
Kazakhstan	468.2	3.7	103.8	335.7	399.1	537.3	601.4
Republic of Korea	560.5	3	88.6	446.4	503.7	620.8	671.8
Lebanon	339.4	4.8	118.3	189	255.6	423.2	497.1
Lithuania	526.1	3.3	84.7	416.1	471.7	583.3	630.9
Malaysia	465.7	4	101.1	328.2	398.1	538.2	590.1
Morocco	383.6	3	98.5	254.4	318.3	451.7	508
New Zealand	503.2	3.8	100.3	369.5	437.3	572.6	626.7
Norway	503.4	3.8	103.2	366.6	438.1	575.3	632.8
Oman	452.6	3	118.6	291.6	371.8	540.5	598.5
Portugal	525.1	3.5	85.1	416.8	467.6	582.1	633.4
Qatar	467.3	5	106.4	326.4	392.1	544.2	605.7
Romania	459.9	4.7	104.6	323.1	391.6	533.8	589.9
Russian Federation	533.4	4.2	85	422.5	477.7	591.5	638.7
Singapore	590.7	4.4	95.2	459.6	535.1	658.6	701.5
South Africa	360.9	3.3	114.8	219	280.4	434.5	512.6
Sweden	525.2	3.3	106.5	383.9	457.2	599.4	656.6
Türkiye	515.2	3.4	95.5	389.8	452.2	582.5	633
United Arab Emirates	461.8	2.4	130.1	281.4	372.7	558	622.9
United States	525.1	5.3	113.8	370.8	452.2	606.5	663.1

(continued)

Country	Mean	Mean SE	SD	P10	P25	P75	P90
Benchmarking participants							
Ontario (Canada)	532.9	3.3	93.1	411.7	473.4	597.8	646.3
Quebec (Canada)	539.3	4.8	89.5	421.9	480.6	601.8	651.5
Moscow City (Russian Federation)	561.3	3.5	78.0	459.4	509.7	615.6	659.6
Gauteng (South Africa)	413.5	4.0	111.4	272.0	335.4	489.3	562.8
Western Cape (South Africa)	432.0	6.7	125.9	277.4	341.5	514.8	608.3
Abu Dhabi (United Arab Emirates)	407.3	4.0	139.1	221.6	299.1	515.1	588.2
Dubai (United Arab Emirates)	538.0	2.3	107.6	390.9	471.1	613.6	666.8

Notes: P = percentile, SD = standard deviation, SE = standard error

References

Alordiah, C. O., Akpadaka, G., & Oviogbodu, C. O. (2015). The influence of gender, school location and socio-economic status on students' academic achievement in mathematics. *Journal of Education and Practice, 6*(17), 130–136. https://files.eric.ed.gov/fulltext/EJ1079759.pdf

Bi, P., & Parton, K. A. (2008). Effect of climate change on Australian rural and remote regions: What do we know and what do we need to know? *Australian Journal of Rural Health, 16*(1), 2–4. https://doi.org/10.1111/j.1440-1584.2007.00945.x

Boudon, R. (1974). *Education, opportunity, and social inequality: Changing prospects in Western society*. Wiley.

Bourdieu, P. (1986). The forms of capital. In J. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241–258). Greenwood.

Brese, F., & Mirazchiyski, P. (2013). *Measuring students' family background in large scale international education studies* (IERI Monograph Series, Special Issue 2. Issues and Methodologies in Large-Scale Assessments). https://eric.ed.gov/?id=ED561898

Broer, M., Bai, Y., & Fonseca, F. (2019). *Socioeconomic inequality and educational outcomes* (IEA Research for Education) (Vol. 5). Springer. https://doi.org/10.1007/978-3-030-11991-1

Chapman, S., Watson, J. E. M., Salazar, A., Thatcher, M., & McAlpine, C. A. (2017). The impact of urbanization and climate change on urban temperatures: A systematic review. *Landscape Ecology, 32*(10), 1921–1935. https://doi.org/10.1007/s10980-017-0561-4

Chmielewski, A. K. (2019). The global increase in the socioeconomic achievement gap, 1964 to 2015. *American Sociological Review, 84*(3), 000312241984716. https://doi.org/10.1177/0003122419847165

Coleman, J. S. (1988). Social capital in the creation of human capital. *American Journal of Sociology, 94*, S95–S120. http://www.jstor.org/stable/2780243

Coleman, J. S. (1990). *Foundations of social theory*. The Belknap of Harvard University Press.

Coleman, J. S., Campbell, E. Q., Hobson, C. J., McPartland, J., Mood, A. M., Weinfeld, F. D., & York, R. L. (1966). *Equality of educational opportunity*. U.S. Department of Health, Education, and Welfare. https://eric.ed.gov/?id=ED012275

Duncan, O. D., Featherman, D. L., & Duncan, B. (1972). *Socio-economic background and achievement*. Seminar Press.

Eccles, J. S., Jacobs, J. E., & Harold, R. D. (1990). Gender role stereotypes, expectancy effects, and parents' socialization of gender differences. *Journal of Social Issues, 46*(2), 183–201. https://doi.org/10.1111/j.1540-4560.1990.tb01929.x

Echazarra, A., & Radinger, T. (2019). *Learning in rural schools: Insights from PISA, TALIS and the literature* (OECD Education Working Papers, No. 196). OECD Publishing. https://doi.org/10.1787/8b1a5cb9-en.

Engzell, P. (2019). What do books in the home proxy for? A cautionary tale. *Sociological Methods and Research, 50*(4), 1–28. https://doi.org/10.1177/0049124119826143

Fahad, S., & Wang, J. (2020). Climate change, vulnerability, and its impacts in rural Pakistan: A review. *Environmental Science and Pollution Research, 27*(2), 1334–1338. https://doi.org/10.1007/s11356-019-06878-1

Fryer, R. G., Jr., & Levitt, S. D. (2010). An empirical analysis of the gender gap in mathematics. *American Economic Journal: Applied Economics, 2*(2), 210–240. https://doi.org/10.1257/app.2.2.210

Gottfried, A. W. (1985). Measures of socioeconomic status in child development research: Data and recommendations. *Merrill-Palmer Quarterly, 31*(1), 85–92. https://www.jstor.org/stable/23086136

Halpern, D. F. (2012). *Sex differences in cognitive abilities* (4th ed.). Psychology Press. https://doi.org/10.4324/9780203816530

Hanushek, E. A., & Woessmann, L. (2011). The economics of international differences in educational achievement. In E. A. Hanushek, S. Machin, & L. Woessmann (Eds.), *Handbook of the economics of education* (Vol. 3, pp. 89–200). Elsevier. https://doi.org/10.1016/B978-0-444-53429-3.00002-8

Hauser, R. M. (1994). Measuring socioeconomic status in studies of child development. *Child Development, 65*(6), 1541–1545. https://doi.org/10.1111/j.1467-8624.1994.tb00834.x

Hyde, J. S. (2014). Gender similarities and differences. *Annual Review of Psychology, 65*(1), 373–398. https://doi.org/10.1146/annurev-psych-010213-115057

International Monetary Fund. (2023). *GDP per capita, current prices. 2019.* https://www.imf.org/external/datamapper/NGDPDPC@WEO/OEMDC/ADVEC/WEOWOD?year=2019

Jackson, M., Erikson, R., Goldthorpe, J. H., & Yaish, M. (2007). Primary and secondary effects in class differentials in educational attainment: The transition to A-level courses in England and Wales. *Acta Sociologica, 50*(3), 211–229. https://doi.org/10.1177/0001699307080926

Jerrim, J., & Micklewright, J. (2014). Socio-economic gradients in children's cognitive skills: Are cross-country comparisons robust to who reports family background? *European Sociological Review, 30*(6), 766–781. https://doi.org/10.1093/esr/jcu072

Jerrim, J., Volante, L., Klinger, D. A., & Schnepf, S. V. (2019). Socioeconomic inequality and student outcomes across education systems. In L. Volante, S. V. Schnepf, J. Jerrim, & D. A. Klinger (Eds.), *Socioeconomic inequality and student outcomes: Cross-national trends, policies, and practices* (pp. 3–16). Springer. https://doi.org/10.1007/978-981-13-9863-6_1

Kelly, D. L., Centurino, V. A. S., Martin, M., & Mullis, I. (Eds.). (2020). *TIMSS 2019 encyclopedia: Education policy and curriculum in mathematics and science*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/encyclopedia/

Kryst, E. L., Kotok, S., & Bodovski, K. (2015). Rural/urban disparities in science achievement in post-socialist countries: The evolving influence of socioeconomic status. *Global Education Review, 2*(4), 60–77. https://ger.mercy.edu/index.php/ger/article/view/179

Lal, P., Alavalapati, J. R. R., & Mercer, E. D. (2011). Socio-economic impacts of climate change on rural United States. *Mitigation and Adaptation Strategies for Global Change, 16*(7), 819–844. https://doi.org/10.1007/s11027-011-9295-9

Lankford, H., Loeb, S., & Wyckoff, J. (2002). Teacher sorting and the plight of urban schools: A descriptive analysis. *Educational Evaluation and Policy Analysis, 24*(1), 37–62. https://doi.org/10.3102/01623737024001037

Leder, G. C. (2019). Gender and mathematics education: An overview. In G. Kaiser & N. Presmeg (Eds.), *Compendium for early career researchers in mathematics education* (ICME-13 Monographs) (pp. 289–308). https://doi.org/10.1007/978-3-030-15636-7_13

Lounkaew, K. (2013). Explaining urban–rural differences in educational achievement in Thailand: Evidence from PISA literacy data. *Economics of Education Review, 37*, 213–225. https://doi.org/10.1016/j.econedurev.2013.09.003

Luyten, H. (2006). An empirical assessment of the absolute effect of schooling: Regression-discontinuity applied to TIMSS-95. *Oxford Review of Education, 32*(3), 397–429. https://doi.org/10.1080/03054980600776589

Martin, M. O., Mullis, I. V. S., Gregory, K. D., Hoyle, C., & Shen, C. (2000). *Effective schools in science and mathematics*. International Study Center, Lynch School of Education, Boston College. https://timssandpirls.bc.edu/timss1995i/effective_schools.html

Miller, P., & Votruba-Drzal, E. (2015). Urbanicity moderates associations between family income and adolescent academic achievement. *Rural Sociology, 80*(3), 362–386. https://doi.org/10.1111/ruso.12067

Mueller, C. W., & Parcel, T. L. (1981). Measures of socioeconomic status: Alternatives and recommendations. *Child Development, 52*(1), 13. https://doi.org/10.2307/1129211

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 international results in mathematics and science*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/international-results/

Murphy, S. (2019). School location and socioeconomic status and patterns of participation and achievement in senior secondary mathematics. *Mathematics Education Research Journal, 31*(3), 219–235. https://doi.org/10.1007/s13394-018-0251-9

Neuville, E., & Croizet, J. C. (2007). Can salience of gender identity impair math performance among 7–8 years old girls? The moderating role of task difficulty. *European Journal of Psychology of Education, 22*(3), 307–316. https://doi.org/10.1007/BF03173428

Noonan, R. D. (1976). *School resources, social class, and student achievement*. Almqvist & Wiksell International. https://www.iea.nl/publications/study-reports/international-reports-iea-studies/school-resources-social-class-and

Olesen, J. E., & Bindi, M. (2002). Consequences of climate change for European agricultural productivity, land use and policy. *European Journal of Agronomy, 16*(4), 239–262. https://doi.org/10.1016/S1161-0301(02)00004-7

Owoeye, J. S., & Yara, P. O. (2011). School location and academic achievement of secondary school in Ekiti State, Nigeria. *Asian Social Science, 7*(5), 170–175. https://doi.org/10.5539/ass.v7n5p170

Rosén, M., Steinmann, I., & Wernersson, I. (2022). Gender differences in school achievement. In T. Nilsen, A. Stancel-Piątak, & J. E. Gustafsson (Eds.), *International handbook of comparative large-scale studies in education* (pp. 1–48). Springer. https://doi.org/10.1007/978-3-030-38298-8_46-1

Sirin, S. R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of Educational Research, 75*(3), 417–453. https://doi.org/10.3102/00346543075003417

Smits, J., & Huisman, J. (2013). Determinants of educational participation and gender differences in education in six Arab countries. *Acta Sociologica, 56*(4), 325–346. https://doi.org/10.1177/0001699313496259

Steg, L., & Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology, 29*(3), 309–317. https://doi.org/10.1016/j.jenvp.2008.10.004

Steinmann, I., & Olsen, R. V. (2022). Equal opportunities for all? Analyzing within-country variation in school effectiveness. *Large-Scale Assessments in Education, 10*(1), 2. https://doi.org/10.1186/s40536-022-00120-0

Steinmann, I., & Rutkowski, L. (2023). The link between gender gaps in school enrollment and school achievement. *Comparative Education Review, 67*(3), 584–612. https://doi.org/10.1086/725395

Steinmann, I., Strietholt, R., & Rosén, M. (2023). International reading gaps between boys and girls, 1970–2016. *Comparative Education Review, 67*(2), 298–330. https://doi.org/10.1086/724089

Strietholt, R., & Strello, A. (2021). Socioeconomic inequality in achievement. In T. Nilsen, A. Stancel-Piątak, & J. E. Gustafsson (Eds.), *International handbook of comparative large-scale studies in education: Perspectives, methods and findings* (pp. 1–20). Springer. https://doi.org/10.1007/978-3-030-38298-8_11-1

Strietholt, R., Gustafsson, J. E., Hogrebe, N., Rolfe, V., Rosén, M., Steinmann, I., & Hansen, K. Y. (2019). The impact of education policies on socioeconomic inequality in student achievement: A review of comparative studies. In L. Volante, S. Schnepf, J. Jerrim, & D. Klinger (Eds.), *Socioeconomic inequality and student outcomes: Cross-national trends, policies, and practices* (Education policy & social inequality) (Vol. 4, pp. 17–38). Springer. https://doi.org/10.1007/978-981-13-9863-6_2

UNCTAD. (2022). *UNCTAD handbook of statistics 2022*. https://unctad.org/publication/handbook-statistics-2022

UNESCO Institute for Statistics. (2012). *International standard classification of education. ISCED 2011*. https://uis.unesco.org/sites/default/files/documents/international-standard-classification-of-education-isced-2011-en.pdf

Van de Werfhorst, H. G., & Mijs, J. J. B. (2010). Achievement inequality and the institutional structure of educational systems: A comparative perspective. *Annual Review of Sociology, 36*(1), 407–428. https://doi.org/10.1146/annurev.soc.012809.102538

Volante, L., Schnepf, S. V., Jerrim, J., & Klinger, D. A. (Eds.). (2019). *Socioeconomic inequality and student outcomes: Cross-national trends, policies, and practices*. Springer. https://doi.org/10.1007/978-981-13-9863-6

Wang, L., Li, X., & Li, N. (2014). Socio-economic status and mathematics achievement in China: a review. *ZDM, 46*(7), 1051–1060. https://doi.org/10.1007/s11858-014-0617-8

Westbury, I., & Travers, K. (1990). *Second International Mathematics Study*. University of Illinois. https://eric.ed.gov/?id=ED325360

White, K. R. (1982). The relation between socioeconomic status and academic achievement. *Psychological Bulletin, 91*(3), 461–481. https://doi.org/10.1037/0033-2909.91.3.461

Zell, E., Krizan, Z., & Teeter, S. R. (2015). Evaluating gender similarities and differences using metasynthesis. *American Psychologist, 70*(1), 10–20. https://doi.org/10.1037/a0038208

Zhang, Y. (2006). Urban-rural literacy gaps in sub-Saharan Africa: The roles of socioeconomic status and school quality. *Comparative Education Review, 50*(4), 581–602. https://doi.org/10.1086/507056

Chapter 6
School Practices and Environmental Knowledge

Sabine Meinck, Andrés Strello, Yuan-Ling Liaw, Rolf Strietholt, and Purya Baghaei

6.1 Introduction

The previous chapters describe the variation in students' environmental knowledge. In this chapter, we will turn our attention towards the conditions under which students acquire this knowledge. Drawing upon the school effectiveness framework (Creemers & Kyriakides, 2012; Sammons, 1999), which highlights various factors influencing student performance, this study will primarily focus on the aspect of teaching and learning within schools. This component targets the instructional practices, teaching methods, and curriculum delivery within the school, emphasizing the quality of teaching and the alignment between instructional strategies and student learning needs. These factors are also embedded in another conceptual model used widely in education, that is the opportunities to learn framework (Carroll, 1963; McDonnell, 1995; Schmidt & Maier, 2009). The Trends in International Mathematics and Science Study (TIMSS) 2019 has collected information on some of the indicators rooted in these frameworks, but not all of them. Therefore, we will concentrate on indicators available in the TIMSS 2019 dataset. They are fundamental in shaping the learning environment of eighth-grade students and contribute to nurturing their environmental knowledge, attitudes and behavior.

All studies of the International Association for the Evaluation of Educational Achievement (IEA), including TIMSS, use the curriculum model to evaluate and compare educational systems worldwide. They distinguish between the intended,

S. Meinck (✉)
International Association for the Evaluation of Educational Achievement (IEA), Hamburg, Germany

A. Strello · Y.-L. Liaw · R. Strietholt · P. Baghaei
Department of Education, University of Bath, Bath, UK

KU Leuven, Leuven, Belgium

M. M. Isac et al. (eds.), *Knowledge and Willingness to Act Pro-Environmentally*, IEA Research for Education 16, https://doi.org/10.1007/978-3-031-76033-4_6

implemented, and achieved curriculum (see, for example, Mullis et al., 2021b), collecting information from various sources for each of these. While the foregoing chapter presented information on the achieved curriculum, that is, on the environmental knowledge scores, this chapter will unfold the intended curriculum regarding environmental topics as part of the science curricula from a cross-national comparative perspective. In this chapter, we will also present how TIMSS 2019 conceptualized and categorized environmental topics. We will also give an overview on the implemented curriculum, according to teachers' reports, and will benchmark this against the intended curriculum. We will then uncover cross-national differences in classroom practices potentially affecting attitudes and behavior as well as action-competence regarding environmental issues. Specifically, we will present how teachers around the world emphasize science investigation and pluralistic and action-oriented practices in their classrooms. Last, we will investigate how classrooms are equipped with the materials to conduct science investigation and inquiry, as such materials are a basic requirement for effective teaching on the relevant topics.

6.2 National Curricula on Topics Related to Environmental Knowledge

Educational systems around the world attempt to standardize what students should learn at school by developing curricula that are usually manifested in documents available to and often binding for educators in their system (Voogt & Pareja Roblin, 2012). This intended curriculum refers to the formal educational objectives, standards, and content that are intended to be taught in schools. It encompasses the goals, learning standards, and expectations set by educational authorities for what students should learn at different grade levels. The expectations of students relate to the knowledge, skills, and attitudes that they should develop or acquire as part of their formal education. However, the contents, scope, and level of detail of curriculum documents varies widely between systems. They may be created at national, provincial, community or even school level and are constantly evolving (Mullis et al., 2021a; Orpwood & Barnett, 1997; Stacey et al., 2018). TIMSS provides information on the science curricula of the participating educational systems, at primary and secondary grades. To provide standardized information, curriculum experts nominated by countries complete a curriculum questionnaire about policies associated with their mathematics and science curricula, school organizational approaches, and instructional practices (Mullis & Martin, 2017). This information is available in the TIMSS 2019 encyclopedia (Kelly et al., 2020). In TIMSS 2019, there were many science items addressing a variety of environmental issues at the fourth and eighth grade, ranging from local issues like water pollution to global issues like climate change and its impact. As described in Chap. 4, these items stem from two science content domains at both grades: Earth science and life science at grade four, and Earth science and biology at grade eight. They capture four different content

Table 6.1 Content domains and areas of the TIMSS 2019 environmental items

Grade	Content domain	Content area
4	Life science	Organisms, environment, and their interactions
4	Life science	Ecosystems
4	Earth science	Earth's physical characteristics, resources, and history
4	Earth science	Earth's weather and climates
8	Biology	Ecosystems
8	Earth science	Earth's processes, cycles, and history
8	Earth science	Earth's resources, their use and conservation

Source: Yin and Foy (2021)

areas in grade four and three different content areas in grade eight as shown in Table 6.1. In the curriculum questionnaire, country representatives were asked to provide information on at what grades (from preprimary through upper secondary education) specific topics were primarily intended to be taught. It should be noted that these topics are similar but not identical to the content domains and areas listed in Table 6.1. Out of a total of 26 science topics, we identified the following six topics related with environmental science:

- Role of variation and adaptation in survival/extinction of species (including fossil evidence): Biology
- Interdependence of populations of organisms in an ecosystem (e.g., carbon and water cycles, energy flow, food webs, competition, predation, human impacts on ecosystems): Biology
- Human health (e.g., causes, transmission, and prevention of common infectious diseases, immunity) and the importance of diet, exercise, and other lifestyle choices in maintaining health: Biology
- Energy transformation and transfer (e.g., forms of energy, energy conservation, heat, temperature, equilibrium): Physics
- Earth's processes, cycles, and history (e.g., rock cycle, major geological events, formation of fossils and fossil fuels, water cycle, weather versus climate): Earth science
- Earth's resources, their use, and conservation (e.g., renewable/nonrenewable resources, human use of land and water resources): Earth science

In Table 6.2 we present the number of TIMSS science and environmental topics intended to be taught by the end of grade eight, as reported by the TIMSS national experts of each participating country.[1]

Out of the 43 educational systems providing data for this table, 27 indicated that all 6 environmental topics are intended to be taught prior to the end of grade eight, i.e., when the TIMSS test was administered. Eight systems indicated that five of the six topics should have been covered by that time, and only eight countries intend,

[1] As well as "educational systems," the terms "country" or "countries" are sometimes used in this chapter to refer to both countries and benchmarking participants, for ease of reading.

Table 6.2 Number of TIMSS science and environmental topics intended to be taught by the end of eighth grade as reported by national experts

	All environmental topics (6)			All other science topics (20)		
Country	All or almost all the students	Only the more able students	Not included in the curriculum through grade eight	All or almost all the students	Only the more able students	Not included in the curriculum through grade eight
Australia	4	1	1	12	3	5
Bahrain	6	0	0	20	0	0
Chile	6	0	0	20	0	0
Chinese Taipei	4	0	2	13	1	6
Cyprus	4	0	2	13	0	7
Egypt	6	0	0	19	0	1
England	6	0	0	19	0	1
Finland	6	0	0	20	0	0
France	6	0	0	17	0	3
Georgia	3	0	3	16	0	4
Hong Kong SAR	5	0	1	14	1	5
Hungary	3	0	3	20	0	0
Iran, Islamic Rep. of	6	0	0	19	0	1
Israel	6	0	0	20	0	0
Italy	5	0	1	16	1	3
Japan	5	0	1	19	0	1
Jordan	6	0	0	20	0	0
Kazakhstan	6	0	0	20	0	0
Korea, Rep. of	5	0	1	15	1	4
Kuwait	6	0	0	20	0	0
Lebanon	2	3	1	6	4	10
Lithuania	6	0	0	18	0	2
Malaysia	6	0	0	20	0	0
Morocco	6	0	0	18	0	2
New Zealand	6	0	0	13	6	1
Norway	5	0	1	15	0	5
Oman	6	0	0	19	0	1
Portugal	6	0	0	19	0	1
Qatar	4	0	2	17	0	3
Romania	5	1	0	20	0	0
Russian Federation	6	0	0	18	0	2
Saudi Arabia, Kingdom of	6	0	0	20	0	0
Singapore	4	0	2	10	7	3
South Africa	6	0	0	18	0	2
Sweden	6	0	0	20	0	0
Türkiye	5	0	1	13	0	6
United Arab Emirates	6	0	0	20	0	0
United States	6	0	0	16	0	4

(continued)

Table 6.2 (continued)

	All environmental topics (6)			All other science topics (20)		
Country	All or almost all the students	Only the more able students	Not included in the curriculum through grade eight	All or almost all the students	Only the more able students	Not included in the curriculum through grade eight
Benchmarking participants						
Ontario (Canada)	6	0	0	15	0	5
Quebec (Canada)	5	0	1	17	0	3
Moscow City (Russian Federation)	6	0	0	18	0	2
Abu Dhabi (United Arab Emirates)	6	0	0	20	0	0
Dubai (United Arab Emirates)	6	0	0	20	0	0

Source: Mullis et al. (2020, Exhibit 14)
Note: Ireland, Gauteng (South Africa) and Western Cape (South Africa) have provided no data for this table

according to their curricula, to cover four or less topics up to grade eight. Further, just three countries indicated that (some) of these topics are intended to be taught only to the more able students. Hence, environmental topics are universally seen as important learning content for all students as reflected by countries' curricula.

Comparing the presence of environmental topics in the curriculum to other science topics, there seems to be a fair balance—that is, countries who covered all environmental topics in grade eight or before had also covered all or most other science topics, and vice versa. However, there are some notable exceptions. In some countries, the curriculum covers all six environmental topics but includes less than 80% of other science topics, namely New Zealand (13), Ontario (15), and the United States (16). On the other hand, Hungary covered only three environmental topics but all 20 other science topics by grade eight. Hence, we can conclude that there is moderate variation in the emphasis on environmental science education in the curricula of the different countries participating in TIMSS 2019.

Looking into the allocation of environmental science education across school grades allows for a more detailed picture to be painted. Table 6.3 displays the curricular focus on environmental topics across the school years for all TIMSS 2019 participating countries. The shading of the cells corresponds to the number of topics intended to be taught by grade. The more topics are intended to be taught, the darker the cells are shaded; hence, darker shading indicates a focus on teaching environmental topics in the given grade. The table unveils large variation across countries regarding curricular coverage of environmental topics across grades. New Zealand stands out as it covers most or all topics in all grades, without exception. Also, Kuwait and the United States cover all topics, but only starting at later grades (grade 3 and 5, respectively), and Kazakhstan does not cover any topics until grade 5, but all topics in grades 6 to 12. Most countries' curricula do not cover the environmental

Table 6.3 Number of TIMSS science and environmental topics primarily intended to be taught by grade as reported by national experts

Country	PP	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12
Australia	1	1	2	1	3	2	2	3	3	3	3	0	0
Bahrain	0	4	5	5	5	4	5	3	6	4	0	0	0
Chile	0	1	1	1	3	4	4	2	2	3	3	3	4
Chinese Taipei	0	0	0	0	0	0	0	3	1	2	2	0	0
Cyprus	0	0	1	1	1	1	1	4	3	3	0	3	2
Egypt	0	0	0	0	2	3	1	2	1	2	1	1	5
England	0	0	0	0	0	2	6	6	6	5	5	0	0
Finland	0	1	1	2	2	2	3	6	6	6	0	0	0
France	0	0	0	0	0	0	1	6	6	6			
Georgia	0	0	0	0	0	0	0	2	2	2	0	0	0
Hong Kong SAR	0	0	0	1	1	0	0	4	3	3	6	5	5
Hungary	0	1	1	1	1	3	3	3	3	3	4	4	4
Iran, Islamic Rep. of	0	2	2	2	5	2	4	4	3	2	1	1	2
Ireland	0	0	0	0	0	0	0	6	6	6	0	0	0
Israel	0	1	1	0	1	3	3	2	6	3	0	0	0
Italy	0	0	0	0	0	0	0	3	2	0	0	0	0
Japan	0	0	0	0	1	1	3	1	3	5	5	5	5
Jordan	0	0	0	0	1	4	6	6	6	0	0	0	0
Kazakhstan	0	0	0	0	0	6	6	6	6	6	6	6	6
Korea, Rep. of	0	0	0	0	1	3	3	3	4	1	5	3	2
Kuwait	0	2	3	5	5	6	6	6	6	6	4	6	4
Lebanon	0	0	0	0	0	1	2	2	3	1	1	2	2
Lithuania	1	1	1	1	1	3	3	6	6	1	1	0	0
Malaysia	0	0	2	0	2	3	1	3	3	0	0	0	0
Morocco	0	0	0	0	0	0	0	1	1	0	3	4	3
New Zealand	4	4	4	4	5	5	6	6	6	6	6	5	5
Norway	0	0	0	2	2	2	2	2	4	4	4	1	1
Oman	0	1	2	1	2	2	6	4	2	0	6	5	2
Portugal	0	0	0	0	0	1	1	4	2	2	0	0	0
Qatar	1	1	1	1	1	1	0	2	3	1	2	2	1
Romania	0	0	0	0	0	4	5	5	2	0	0	0	0
Russian Federation	0	0	0	0	0	3	3	4	3	2	0	0	0
Kingdom of Saudi Arabia	0	0	0	0	0	0	0	0	6	0	0	0	0
Singapore	0	0	0	1	1	2	2	4	4	5	5	5	5
South Africa	0	0	0	0	0	0	0	2	2	3	0	0	0
Sweden	0	0	0	0	2	2	2	6	6	6	0	0	0
Türkiye	0	0	0	0	1	2	4	1	3	2	1	2	1
United Arab Emirates	0	0	0	0	0	0	3	1	4	0	0	0	0
United States	1	1	1	2	5	5	6	6	6	6	6	6	6
Benchmarking Participants													
Ontario, Canada	0	1	2	3	4	3	2	4	3	2	2	3	2
Quebec, Canada	0	1	1	3	3	4	4	5	5	0	0	0	0
Moscow City, Russian Fed.	0	0	0	0	0	3	3	4	3	2	0	0	0
Abu Dhabi, UAE	0	0	0	0	0	0	3	1	4	0	0	0	0
Dubai, UAE	0	0	0	0	0	0	3	1	4	0	0	0	0

Source: Curriculum data from Fishbein et al. (2021)
Notes: PP = preprimary, G = grade
Gauteng (South Africa) and Western Cape (South Africa) have provided no data for this table

topics specified in TIMSS 2019 in primary grades or cover only a few single topics. Seven countries intend to teach no environmental topic at all in preprimary up to grade six: Chinese Taipei, Georgia, Ireland, Italy, Morocco, the Kingdom of Saudi Arabia, and South Africa. Further, there are some countries who focus only in a few grades on these topics: Georgia, Ireland, Italy, Romania, the Kingdom of Saudi Arabia, South Africa, and the United Arab Emirates (including Dubai and Abu Dhabi). Finally, about half of the educational systems do not intend to cover any of the six environmental topics in any of the upper-secondary grades, grades 10 to 12, which is the period just before adolescents' transition into young adulthood.

6.3 Opportunities to Learn Topics Related to Environmental Knowledge in the Classroom

In the remainder of this chapter, we turn our attention to the implemented curriculum. In this section, we focus on what is actually taught in the classroom.

We use TIMSS 2019 data obtained from the science teachers of eighth graders in the participating countries. Note that TIMSS does not survey a representative sample of teachers but does survey a representative sample of eighth grade students. As suggested in the TIMSS 2019 user guide (Fishbein et al., 2021), we use a dataset where teachers' data are merged with their students' data (i.e., treating them as a feature of the students), applying a so-called *teacher weight*. To be meaningful, any such analysis must be interpreted in terms of the student population, e.g., "X% of students have teachers with the following characteristics… ."

Science teachers were asked to indicate which of the six environmental science topics introduced above had been covered in their class, either in the current school year or before. Table 6.4 displays the percentages of students whose teachers responded that the topics had been mostly taught this year or before this year. Darker shading in the table refers to higher coverage. The first two columns of Table 6.4 give aggregate information across the topics, while the remaining columns present information specific to each of the six topics. The table is sorted by the first column presenting the percentage of students that were exposed to all six topics during their school trajectory.

As can be seen from Table 6.4, there is a large variation in whether students had been taught specific topics across countries. To begin with, the largest variation can be observed in the percentage of students that were taught all six environmental topics (first data column of Table 6.4), according to their teachers, at some point in their school career preceding the TIMSS 2019 test. On average across countries, this was the case for only about one fourth of the students, ranging from as few as less than 10% (14 countries) to more than 50% (six countries), with a maximum of 65% for the Hungarian students, which is certainly counterintuitive given their low intended curriculum coverage of environmental topics. Further, when comparing this result with the intended curriculum as presented in Table 6.3, it appears that the reality in schools often does not match expectations from educational authorities. The percentages stated above are in contrast with the fact that so many educational systems

Table 6.4 Percentages of students taught the TIMSS environmental topics

		Teachers reported all six topics were taught		Average across topics	
Country		**Mean**	(SE)	**Mean**	(SE)
Hungary		65.1	3.7	88.6	1.6
Türkiye		62.6	3.4	91.3	0.9
Bahrain		61.5	2.9	90.2	0.8
United States		60.2	3.1	89.3	1.1
Romania		59.9	12.4	88.2	5.9
Malaysia		55.7	3.5	88.4	1.0
United Arab Emirates	(r)	45.9	1.5	81.9	0.7
Oman		44.9	4.0	84.6	1.4
Egypt		44.3	4.5	84.6	1.7
Jordan		40.6	4.1	79.0	2.0
Kazakhstan		36.6	14.8	65.7	12.8
Chile		31.3	3.7	76.7	1.9
Russian Federation		30.3	4.2	73.5	1.8
Georgia		28.6	10.1	78.9	3.6
Qatar		27.4	3.5	75.9	1.6
South Africa (9)		23.8	2.8	65.2	1.8
Lithuania		22.7	3.7	55.2	3.1
Italy		16.8	3.1	65.9	1.9
Israel		13.3	2.4	58.9	1.7
Lebanon		13.1	4.3	64.0	3.3
Iran, Islamic Republic of		10.8	2.4	60.3	1.6
Finland		10.4	2.6	54.9	2.3
England		10.3	4.0	61.0	3.3
Hong Kong, SAR		9.8	3.1	48.3	2.7
Sweden		9.2	2.5	62.6	2.4
Australia		9.2	2.1	62.3	1.7
Ireland		7.7	1.6	54.8	1.5
Korea, Republic of		7.5	2.0	62.9	1.5
Morocco		4.7	3.5	62.8	3.7
Chinese Taipei		4.6	1.6	62.7	1.3
New Zealand		4.0	1.5	44.0	1.5
Singapore		3.9	1.1	51.4	1.0
Norway (9)	(s)	3.4	1.6	46.3	2.8
Cyprus	(s)	3.1	1.0	40.3	2.2
Portugal		2.3	1.1	52.1	1.9
France	(r)	2.1	2.1	43.3	9.7
Japan		0.5	0.5	32.5	1.3
Benchmarking participants					
Dubai (United Arab Emirates)	(r)	49.1	2.0	83.2	1.4
Abu Dabhi (United Arab Emirates)	(r)	42.2	2.7	81.2	1.1
Ontario (Canada)	(s)	33.8	4.6	82.2	1.7
Moscow City (Russian Federation)		22.2	4.5	62.2	3.1
Gauteng (South Africa) (9)		24.6	4.0	67.5	2.4
Western Cape (South Africa) (9)		20.8	3.5	66.1	2.0
Table average		**25.1**	**0.7**	**67.2**	**0.5**

Role of variation and adaptation in survival/extinction of species		Interdependence of populations of organisms in an ecosystem		Human health		Energy transformation and transfer	
Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
77.5	2.4	91.9	1.6	94.2	1.3	93.8	1.5
98.1	1.1	77.4	3.1	94.0	2.0	96.1	1.5
82.0	2.5	92.9	1.4	93.8	1.6	85.3	2.6
91.8	1.7	94.3	1.9	77.7	2.6	90.2	1.6
81.6	2.9	97.3	1.0	96.0	1.9	99.4	0.4
74.1	3.2	99.6	0.4	98.3	0.7	90.7	2.0
77.4	1.4	88.0	1.5	73.7	1.6	86.0	1.3
89.2	2.1	94.7	1.0	72.8	3.2	72.3	3.4
97.9	1.2	87.1	2.7	56.8	4.2	94.9	2.0
79.8	3.2	96.3	1.5	66.1	3.7	72.6	3.5
51.0	4.0	70.1	3.8	93.3	2.0	94.5	2.5
41.9	4.2	69.6	3.9	93.5	2.1	81.8	3.2
44.8	3.4	39.2	3.0	84.5	2.0	91.4	1.3
12.5	2.4	18.5	3.0	94.7	1.4	98.2	1.1
73.2	3.3	89.8	2.0	58.5	3.5	85.9	2.8
58.5	3.2	79.9	2.7	90.1	1.7	61.1	2.7
42.6	3.4	52.8	3.8	70.1	3.1	66.0	3.0
44.5	4.2	69.6	3.7	96.6	1.2	74.3	3.5
52.9	3.8	85.7	3.1	39.7	3.2	97.1	1.2
44.6	4.2	71.7	3.6	89.3	2.3	67.1	4.1
26.5	3.2	18.5	2.7	65.2	3.5	88.8	2.5
45.2	3.1	86.5	1.6	14.6	1.9	68.7	2.2
58.8	6.0	56.2	5.6	65.8	5.8	83.6	4.8
40.6	4.9	67.6	4.1	23.3	3.9	75.2	4.0
35.0	3.8	88.5	2.9	75.2	3.4	60.2	3.9
27.0	3.3	69.1	2.8	28.9	3.2	86.4	2.5
41.4	3.5	42.4	3.5	70.0	3.2	79.3	3.0
18.0	2.7	39.6	3.3	62.0	3.6	90.0	2.1
64.9	2.8	94.1	1.8	7.9	1.8	37.8	3.4
92.2	2.2	92.5	2.2	88.7	2.6	83.9	2.5
30.9	3.6	65.1	3.5	30.9	3.6	68.7	3.4
32.8	2.6	69.2	1.9	62.0	3.0	89.9	1.7
45.1	4.7	59.2	4.9	37.0	4.8	28.1	4.4
23.2	4.6	50.9	2.7	51.7	4.8	32.8	3.8
71.7	2.4	74.6	2.3	14.7	2.4	49.9	2.9
32.5	4.3	65.5	4.1	59.0	4.2	39.1	4.2
74.9	3.6	6.0	2.0	13.0	2.9	15.3	2.9
74.5	1.8	87.1	2.6	74.7	2.0	86.1	2.4
80.8	1.6	86.8	2.2	71.2	2.5	87.0	2.2
66.9	5.1	92.8	2.8	83.6	4.0	82.4	3.5
28.7	3.2	29.1	2.8	80.5	2.6	87.2	2.0
61.6	4.2	83.9	3.5	91.1	2.5	55.9	4.2
55.9	4.3	80.3	3.3	83.6	2.4	65.3	4.3
56.9	**0.5**	**71.4**	**0.4**	**67.2**	**0.5**	**75.4**	**0.4**

(continued)

Table 6.4 (continued)

Country		Earth's processes, cycles, and history		Earth's resources, their use, and conservation	
		Mean	(SE)	Mean	(SE)
Hungary		88.8	2.1	88.6	2.1
Türkiye		87.1	2.6	94.9	1.8
Bahrain		88.8	2.1	95.6	1.3
United States		91.4	1.7	90.4	1.9
Romania		51.5	10.2	64.5	10.6
Malaysia		82.8	2.8	83.6	2.5
United Arab Emirates	(r)	77.5	1.7	88.0	1.0
Oman		87.7	2.4	89.9	2.3
Egypt		79.2	3.3	92.7	2.2
Jordan		71.9	3.8	87.9	2.6
Kazakhstan		94.8	2.5	90.8	2.9
Chile		84.0	2.9	85.8	3.0
Russian Federation		93.4	1.0	86.9	1.9
Georgia		98.4	0.9	95.4	1.8
Qatar		78.8	3.2	68.3	4.1
South Africa (9)		49.8	3.5	54.2	3.2
Lithuania		72.8	2.1	69.4	2.6
Italy		53.5	3.5	58.6	3.8
Israel		30.0	3.5	49.0	3.8
Lebanon		37.8	3.5	57.0	3.9
Iran, Islamic Republic of		69.3	3.5	93.8	1.6
Finland		66.9	2.5	75.9	2.1
England		56.9	6.3	53.6	6.3
Hong Kong, SAR		31.8	4.3	54.3	4.2
Sweden		64.5	4.4	58.5	4.6
Australia		84.1	2.6	77.9	2.6
Ireland		42.7	3.6	55.5	3.7
Korea, Republic of		96.5	1.2	71.2	3.5
Morocco		89.7	2.1	70.2	3.2
Chinese Taipei		7.1	1.6	9.8	2.2
New Zealand		24.3	3.3	43.8	3.8
Singapore		11.1	1.7	44.9	2.9
Norway (9)	(s)	70.0	4.4	39.2	4.8
Cyprus	(s)	33.5	3.7	62.3	2.0
Portugal		77.6	2.2	49.6	3.1
France	(r)	62.1	3.8	45.6	4.4
Japan		82.7	3.5	5.3	2.0
Benchmarking participants					
Dubai (United Arab Emirates)	(r)	84.0	2.2	91.8	1.7
Abu Dabhi (United Arab Emirates)	(r)	75.8	3.0	84.1	1.9
Ontario (Canada)	(s)	79.4	4.0	89.3	3.3
Moscow City (Russian Federation)		86.9	2.5	82.8	2.6
Gauteng (South Africa) (9)		54.1	4.0	56.4	4.2
Western Cape (South Africa) (9)		48.3	4.2	56.9	3.8
Table average		**67.4**	**0.5**	**68.9**	**0.5**

Notes: The exhibit reports the percentage of students whose teachers responded that the topic had been "mostly taught before this year" or "mostly taught this year." Quebec (Canada) is not displayed as data are available for less than 40% of the students
(r) Data are available for at least 70% but less than 85% of the students
(s) Data are available for at least 50% but less than 70% of the students
(SE) Standard error
(9) Country deviated from international defined population and surveyed adjacent upper grade

intend to have taught all six environmental topics by eighth grade to all students, which is not the case in any country, according to teacher reports.

There is less variation regarding the average across the six topics. According to their teachers, about two thirds of the students were taught the environmental science topics on average across countries, ranging from 32% in Japan to 91% in Türkiye (see the "Average across topics" column in Table 6.4).

Furthermore, there is considerable variation in how these specific topics are covered. On average across countries, most topics were taught to about 70% of the students, except for the *role of variation and adaptation in survival/extinction of species*: less than 60% of the students were exposed to this topic. Further, while many topics were covered for the vast majority of students, there were some notable exceptions. For example, the *role of variation and adaption in survival/extinction of species* was taught to less than 20% of the students in Georgia and the Republic of Korea. Also, less than 20% of students in the Islamic Republic of Iran, Japan and, again, Georgia were introduced to the *interdependence of populations of organisms in an ecosystem*; equally few students in Finland, Morocco and Japan were taught the topic of *human health*. Again, less than 20% of Japanese eighth graders were exposed to the topic of *energy transformation and transfer*. *Earth's processes, cycles, and history* were taught to less than every fifth student in Chinese Taipei and Singapore; and the same low coverage was observed in Chinese Taipei and Japan for the topic *Earth's resources, their use, and conservation*.

It should be noted that there is no correlation between environmental knowledge and the percentage of topics taught to students (neither at country level nor within countries), indicating a further misalignment between the implemented and the achieved curriculum.

6.4 Classroom Practices Potentially Affecting Environmental Awareness

A second aspect of the implemented curriculum relates to teaching practices and methods used by teachers in real classroom settings. Schools and classes have always not only provided the means to build up knowledge, but also shaped attitudes and behaviors of students. Therefore, education is seen as a powerful means for acquiring the knowledge to understand the facets of human impact on the environment, but also to develop environmentally responsible behavior (Reynolds & Komakhidze, 2022). Teaching methods can influence the effectiveness of instruction regarding environmental knowledge, but also environmentally conscious behavior (Boeve-de Pauw et al., 2015; Breiting & Mayer, 2015). In this section, we will investigate classroom practices potentially affecting environmental knowledge, pro-environmental attitudes, behavior, and action-competence regarding environmental issues.

6.4.1 Teachers' Emphasis on Science Investigation

Investigation and experiments play a crucial role in science classes, including for environmental education. Experiments provide a hands-on approach to learning, allowing students to actively engage with environmental concepts and principles (see, for example, Sadi & Çakıroğlu, 2011). This tactile experience can deepen students' understanding and foster a stronger connection to environmental issues. They further offer practical application of theoretical knowledge, enabling students to see how environmental concepts operate in real-world scenarios. This application reinforces learning and helps students grasp complex environmental phenomena more effectively. Experiments and investigative activities also encourage students to develop critical thinking skills and problem-solving abilities (Mullis et al., 2021b). By actively participating in experiments, students learn to analyze data, draw conclusions, and develop solutions, which are essential skills for understanding and addressing environmental challenges. Experiments promote awareness of environmental issues by allowing students to witness the effects of certain actions on the environment firsthand, fostering a sense of responsibility, and encouraging students to actively participate in environmental conservation efforts (Kalamas Hedden et al., 2017). Finally, engaging in experiments can leave a lasting impression on students, inspiring them to pursue further studies and careers in environmental science, sustainability, and related fields. This can lead to a more environmentally conscious and informed future generation capable of addressing complex environmental challenges.

Given the importance of science investigation practices, we have used TIMSS 2019 teacher data to gain insights into the emphasis on science investigation across countries. Science teachers were asked how often students do the following activities in their science lessons, all related to experiments and/or investigations: (a) observe natural phenomena and describe what they see; (b) watch me demonstrate an experiment or investigation; (c) design or plan experiments or investigations; (d) conduct experiments or investigations; (e) present data from experiments or investigations; (f) interpret data from experiments or investigations; (g) use evidence from experiments or investigations to support conclusions; and (h) do field work outside of class. The response categories were "Every or almost every lesson," "About half the lessons," "Some lessons," and "Never." The responses to these items were used to compose a scale and index, "Teachers' emphasis on science investigation" (see Exhibit 13.11 in Mullis et al., 2020, for further information on the scale). Interestingly, experiments and investigations appear to be not very frequently used in science lessons around the globe. As can be seen in Table 6.5, in just four out of 45 countries and benchmarking participants in TIMSS 2019, more than 50% of the eighth-grade students had science teachers who reported to emphasize such practices in at least about half their lessons (Oman, the Islamic Republic of Iran, Kuwait, and Dubai). Other countries from the Persian Gulf region exposed a relatively large number of students to this teaching style, as can be seen in Exhibit 13.11 in Mullis et al. (2020). In 24 of the participating educational systems, just less than one

Table 6.5 Number of educational systems with a given percent of students whose teachers emphasize science investigation in half their lessons or more

Percent of students	Number of educational systems
50 or more	4
25 to 49	17
10 to 24	17
1 to 9	7
Total	**45**

Source: Mullis et al. (2020, Exhibit 13.13)

quarter of students were exposed in every second lesson or more often to such teaching methods. On the other hand, more than 90% of students had teachers emphasizing science investigation in less than half the lessons in seven countries (namely, Norway, Singapore, Sweden, Lithuania, Hungary, Portugal, and Chinese Taipei). More detailed information, for example on the allocation of countries on the scale, can be found in Exhibit 13.13 in Mullis et al. (2020).

6.4.2 Teachers' Emphasis on Pluralistic and Action-Oriented Classroom Practices

Students who are exposed to pluralistic and action-oriented teaching methods demanding an active contribution and debate between students are more likely to show higher awareness about environmental issues, pro-environmental attitudes, and behavior (Uitto et al., 2015). These methods create an environment nurturing critical thinking and engagement, fostering a sense of responsibility, and enhancing collaboration and empathy, all leading to a more holistic and pluralistic view to environmental issues.

TIMSS 2019 provides data on this teaching approach. Teachers were asked to indicate the frequency of using various instructional approaches in their classes, selecting from the options "Every or almost every lesson," "About half the lessons," "Some lessons," or "Never." Six specific items were identified to reflect pluralistic and action-oriented classroom practices: (a) relating the lesson to students' daily lives; (b) asking students to explain their answers; (c) assigning challenging exercises that require students to go beyond the instruction; (d) encouraging classroom discussions among students; (e) allowing students to determine their problem-solving procedures; and (f) encouraging students to express their ideas in class.

We followed the TIMSS 2019 scaling procedure to create a scale from these items for assessing science teachers' instructional approaches regarding students' exposure to different perspectives and action competence.

To facilitate the scaling process, categories with very few respondents were combined. Specifically, the categories "Never" and "Some lessons" were merged for all variables. The scale statistics reported below reflect an analysis of the items following this collapsing. The data for these six items were calibrated across all TIMSS 2019 countries using the Rasch partial credit model in the TAM package

(Robitzsch et al., 2022). The reporting scale was placed on a scale with a mean of 10 and a standard deviation of two. The resulting index was categorized into three groups: "High use," "Medium use," and "Low use." "High use" identifies teachers who encouraged student initiative and action competence in "Every or almost every lesson," as indicated by having a scale score greater than or equal to the cut point of 11.7. This corresponded to selecting "Every or almost every lesson" for four of the six statements and "About half the lessons" for the other two, on average. "Low use" identifies teachers who reported infrequent encouragement of student participation and action competence, with a score no higher than the cut point of 7.0. This corresponded to selecting "Some lessons" or "Never" for four statements and "About half the lessons" for the other two, on average. All other science teachers, with scores above 7.0 but lower than 11.7, were assigned to the category "Medium use."

As presented in Fig. 6.1, there is great variation in the use of pluralistic and action-oriented classroom practices around the globe.

In only three educational systems (the United Arab Emirates, Dubai, and Kazakhstan), more than 50% of the students attend classrooms where teachers report a high use of these practices (Table 6.6). On the other hand, there are six countries where more than a quarter of the students attend lessons where teachers use such methods rarely (falling into category "Low use"). Five of those six countries are high achieving Asian countries, suggesting these practices are not widespread in this region and are not necessarily related to high achievement regarding environmental knowledge.

6.4.3 Association Between Teaching Practices Relevant for Environmental Education

One would think that methods of science investigation usually incorporate pluralistic and action-oriented classroom practices. We therefore investigated in a last step, whether TIMSS 2019 data offer evidence for this hypothesis. We conducted correlation analysis with student level data merged with teacher data, using teacher weights, following instructions in Fishbein et al. (2021).

As expected, the correlation between the two teaching methods was positive, moderate to strong in almost all countries, and significant in all but one country (Norway, Fig. 6.2). On average across countries, the correlation coefficient was 0.41 (significant). This finding suggests that teachers emphasizing one of the methods tend to also use the other methods more frequently.

Also, a strong positive relationship can be observed between those variables at educational system level, indicating that high emphasis on science investigation methods is universally related with high emphasis on pluralistic and action-oriented classroom practices (Fig. 6.3, $r = 0.55$).

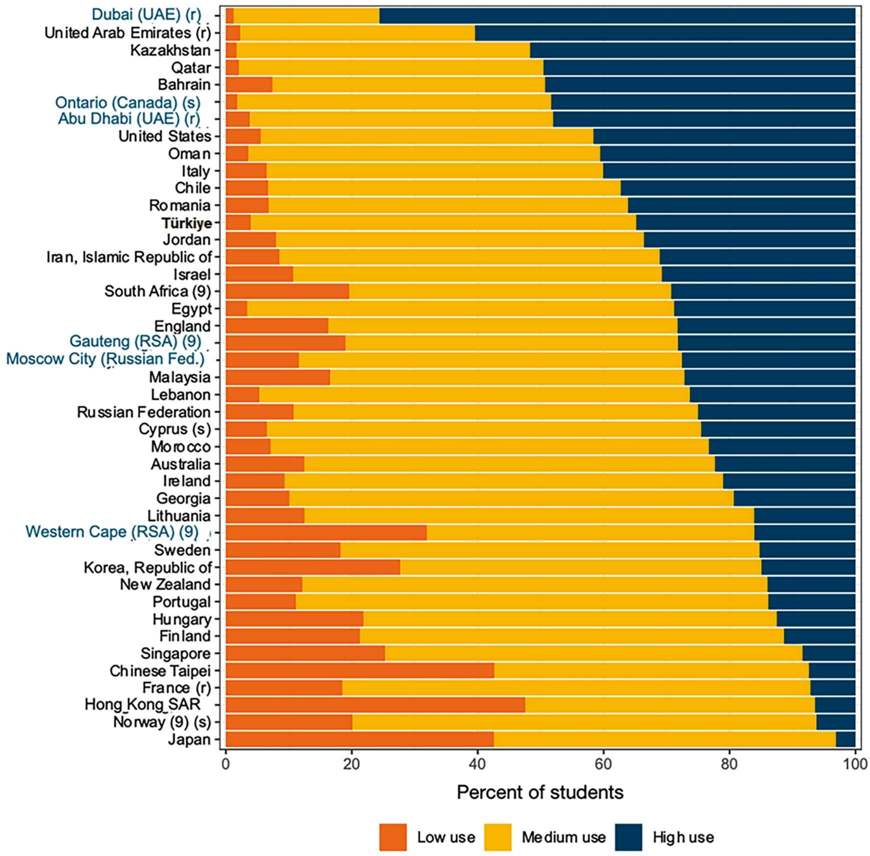


Fig. 6.1 Teachers' emphasis on pluralistic and action-oriented classroom practices (percent of students with teachers in the presented categories
Notes: Benchmarking participants are marked in blue. RSA = South Africa, UAE = United Arab Emirates. Quebec (Canada) is not displayed as data are available for less than 40% of the students. (r) Data are available for at least 70% but less than 85% of the students. (s) Data are available for at least 50% but less than 70% of the students. (9) Country deviated from international defined population and surveyed adjacent upper grade

Table 6.6 Number of educational systems with a given percent of students whose teachers report high use of pluralistic and action-oriented classroom practices

Percent of students	Number of educational systems
50 or more	3
25 to 49	23
10 to 24	13
1 to 9	6
Total	**45**

Source: Mullis et al. (2020, Exhibit 13.13)

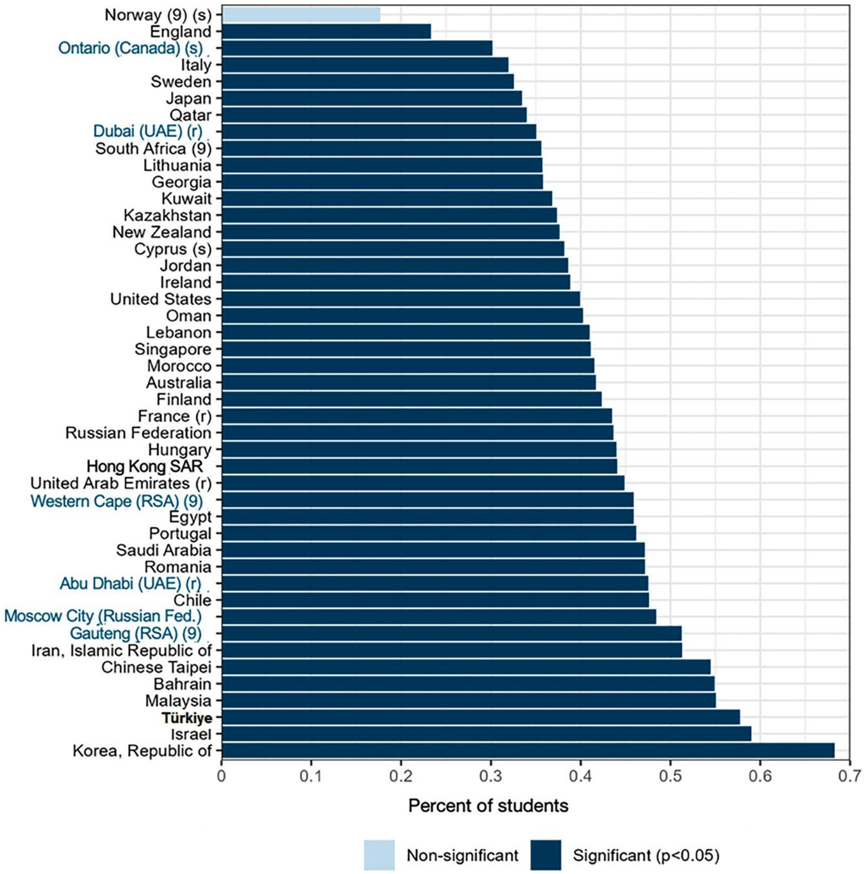


Fig. 6.2 Correlation between teachers' emphasis on science investigation and teachers' emphasis of pluralistic and action-oriented classroom practices (within country, student-level analysis)
Notes: Benchmarking participants are marked in blue. RSA = South Africa, UAE = United Arab Emirates. Quebec (Canada) is not displayed as data are available for less than 40% of the students. (r) Data are available for at least 70% but less than 85% of the students. (s) Data are available for at least 50% but less than 70% of the students. (9) Country deviated from international defined population and surveyed adjacent upper grade

6.5 Shortage in Environmental Science Teaching Equipment and Materials

One last aspect of the implemented curriculum that we will investigate in this chapter relates to the materials being used to teach. As elaborated above, science investigation including the conduct of experiments is an important method to teach environmental science. Obviously, a lack of equipment will impede the implementation of such methods, which is why we examined respective data from TIMSS

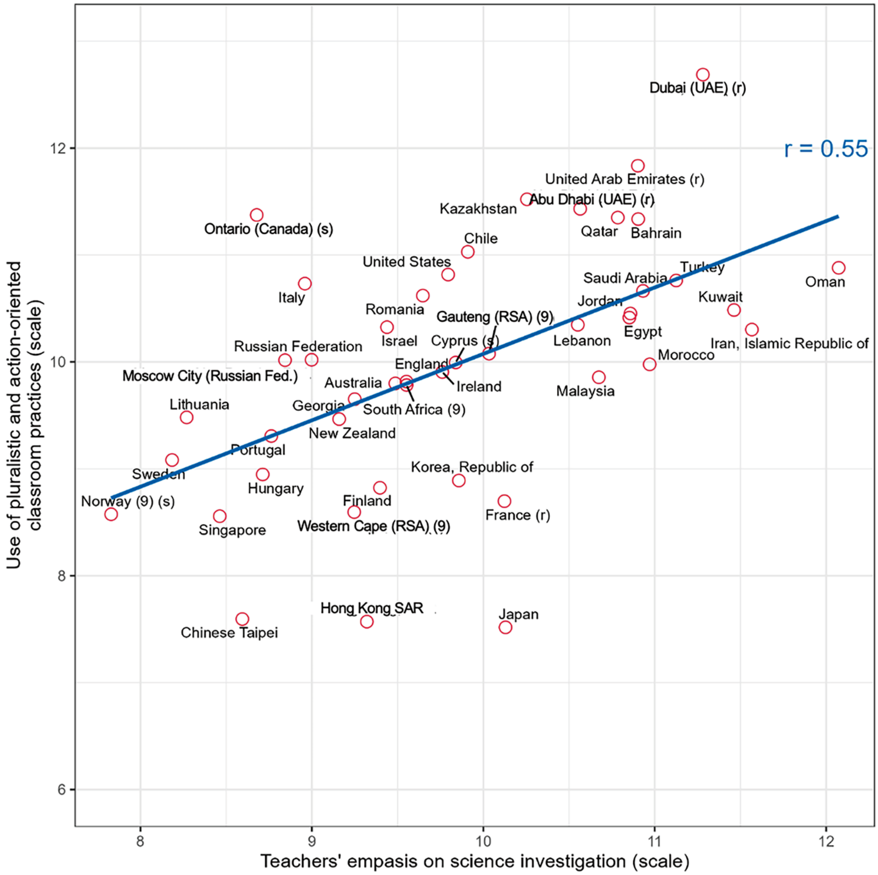


Fig. 6.3 Correlation between teachers' emphasis in science investigation and teachers' emphasis of pluralistic and action-oriented classroom practices (country-level analysis)
Notes: RSA = South Africa, UAE = United Arab Emirates. Quebec (Canada) is not displayed as data are available for less than 40% of the students. (r) Data are available for at least 70% but less than 85% of the students. (s) Data are available for at least 50% but less than 70% of the students. (9) Country deviated from international defined population and surveyed adjacent upper grade

2019 on this aspect. Principals of schools accommodating eighth grade students were asked how much their school's capacity to provide instruction is affected by a shortage or inadequacy of science equipment and materials for experiments. The response options were "Not at all," "A little," "Some," and "A lot." Principals' data were merged to students' data to provide insights into this aspect from the students' perspective. Figure 6.4 shows huge variation across countries regarding this question. On average, only one third of students across countries attend schools that do not experience such shortages at all. However, this figure drops to less than 10% in Malaysia, Romania, Türkiye, and the Islamic Republic of Iran, while schools in

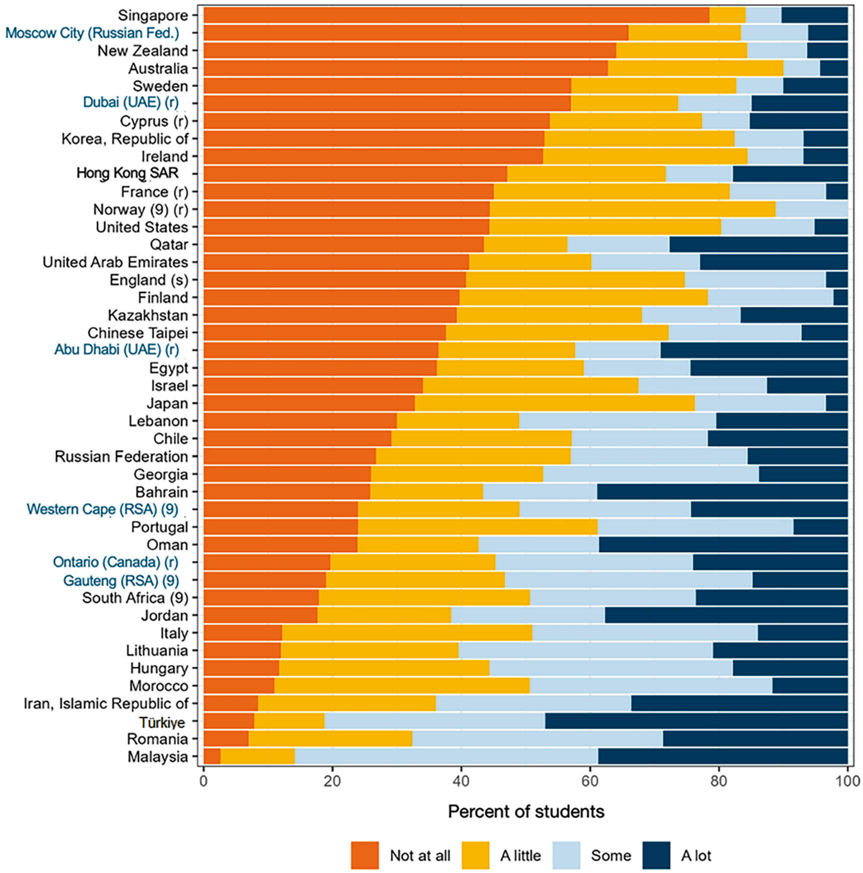


Fig. 6.4 School capacity to provide instruction affected by a shortage or inadequacy of science equipment and materials for experiments (percent of students in schools belonging to the presented categories)

Notes: Benchmarking participants are marked in blue. RSA = South Africa, UAE = United Arab Emirates. Quebec (Canada) is not displayed as data are available for less than 40% of the students. (r) Data are available for at least 70% but less than 85% of the students. (s) Data are available for at least 50% but less than 70% of the students. (9) Country deviated from international defined population and surveyed adjacent upper grade

Australia, the Russian Federation, and Singapore are notably well-equipped, with over 60% of students attending schools without such shortages. On the other hand, in 11 educational systems, more than every fourth student learns in a school where the principal stated that the schools' capacity to provide instruction is affected "A lot" by a shortage of science equipment and materials for experiments, namely in Kuwait, Türkiye, the Kingdom of Saudi Arabia, Bahrain, Malaysia, Oman, Jordan, the Islamic Republic of Iran, the United Arab Emirates, Romania, and Qatar. In conclusion, the shortage of science equipment and materials in a significant share of schools across the world may be one factor hindering teachers to teach environmental science in effective ways.

6.6 Discussion and Conclusion

In this chapter, we investigated factors of the intended and implemented curriculum, including school practices, as a basis for knowledge acquisition and development of attitudes and behaviors regarding environmental issues.

We began with presenting an analysis of the intended curriculum for developing environmental knowledge in students. Even though the informativity of the curriculum analysis is limited, it provides interesting and useful information. Importantly, environmental topics are part of the intended curricula in all countries, with significant variations in how countries envision the representation of such topics in their education across the school career. It is noteworthy that about half of the educational systems do not intend to cover any of the six environmental topics in any of the upper secondary grades 10 to 12, even though this is an important period of shaping the views of young citizens. This is especially unfortunate as upper secondary education is attended foremost by young people who are more likely to attend university and, due to the high education level they will obtain, are more likely to drive and shape innovations and developments of our future. We believe that prominently incorporating environmental topics into the curriculum serves as a powerful signal of a nation's commitment to equipping future citizens with the knowledge and attitudes necessary to steer development toward a sustainable future.

We admit that our analysis of the intended curricula has limited informativeness, as the TIMSS 2019 curriculum questionnaire merely collects data on whether a topic is intended to be covered, and in which grade. No information though is obtained on the depth and scope in which a specific topic was intended to be taught. That is, there is no data about the specific content to be covered, nor about the amount of time it should be taught, or the proposed teaching methods. All these aspects however are important factors impacting the outcome of learning. Further, as stated earlier, a multitude of factors impact students' learning, and the intended curriculum is just one of these factors. One such factor is students' socioeconomic background, including the background of their peers, which is a powerful predictor of performance, as has been demonstrated earlier in this book. Another factor is teaching quality, according to the literature (Nilsen & Gustafsson, 2016). Hence, unsurprisingly, we did not detect a relationship between the intended curriculum and achievement.

Reflecting on the analysis of the implemented curriculum, we would like to highlight that environmental topics are covered in many schools in the participating countries. However, as illustrated, setting out a curriculum plan does not necessarily translate into what is being taught in schools. According to teachers, none of the educational systems participating in TIMSS 2019 cover all six identified environmental topics by grade eight, even though many countries intend to do so. Further, there is no clear association between the implemented and achieved curriculum of environmental topics. This means that even if teachers cover these topics, this is not necessarily reflected in students' environmental knowledge scores. We can only speculate here about the reasons for these misalignments. Do teachers have difficulties knowing, understanding, and implementing the curricula determined by officials? Are the curricula somewhat unrealistic, given limitations in teaching time, equipment and materials, teacher shortages, limited opportunities for teacher professionalization, or other conditions limiting teaching? It is worth looking into these questions at the national level.

We then investigated the emphasis of teaching practices that are, according to theory, related with students' environmental knowledge and attitudes. We were surprised that the use of science investigation practices and pluralistic and action-oriented teaching methods is a lot less widespread than one may think. Further research is needed to reveal mechanisms of associations between those practices, environmental knowledge acquisition, and the development of attitudes and behaviors towards a sustainable future. While TIMSS 2019 data may be suitable to investigate models explaining knowledge acquisition, the data set lacks information on students' attitudes and behavior and sets limits due to its cross-sectional nature. We are looking forward to data from the TIMSS 2023 cycle that will close this gap by asking questions related to students' attitudes and behaviors and may partly overcome limitations when using data from the longitudinal component initiated in this cycle. Last, our analysis on shortage or inadequacy of science equipment and materials for experiments revealed a field of action for education stakeholders, given that a significant percentage of students around the world learn in schools with such limitations.

In summary, our analysis provides significant evidence on the factors influencing the learning environment for students to acquire essential skills, preparing them to contribute to an environmentally sustainable future. Several countries may need to review their intended curriculum to prioritize educating their students for sustainability. Further, all educational systems should seek to implement measures allowing a better alignment of the intended and implemented curriculum regarding environmental topics. Schools should consider whether a promotion of teaching methods fostering science investigation and pluralistic and action-oriented classroom practices is desirable, and how shortages in equipment needed to conduct such methods can be addressed.

References

Boeve-de Pauw, J., Gericke, N., Olsson, D., & Berglund, T. (2015). The effectiveness of education for sustainable development. *Sustainability, 7*(11), 15693–15717. https://doi.org/10.3390/su71115693

Breiting, S., & Mayer, M. (2015). Quality criteria for ESD schools: Engaging whole schools in education for sustainable development. In R. Jucker & R. Mathar (Eds.), *Schooling for sustainable development in Europe: Concepts, policies and educational experiences at the end of the UN Decade of Education for Sustainable Development* (pp. 31–46). Springer. https://doi.org/10.1007/978-3-319-09549-3_3

Carroll, J. B. (1963). A model of school learning. *Teachers College Record, 64*(8), 1–9. https://doi.org/10.1177/016146816306400801

Creemers, B. P., & Kyriakides, L. (2012). Using educational effectiveness research to improve the quality of teaching practice. In C. Day (Ed.), *The Routledge international handbook of teacher and school development* (pp. 389–399). Routledge. https://doi.org/10.4324/9780203815564

Fishbein, B., Foy, P., & Yin, L. (2021). *TIMSS 2019 user guide for the international database* (2nd ed.). TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/international-database/

Kalamas Hedden, M., Worthy, R., Akins, E., Slinger-Friedman, V., & Paul, R. C. (2017). Teaching sustainability using an active learning constructivist approach: Discipline-specific case studies in higher education. *Sustainability, 9*(8), 1320. https://doi.org/10.3390/su9081320

Kelly, D. L., Centurino, V. A. S., Martin, M. O., & Mullis, I. V. S. (2020). *TIMSS 2019 encyclopedia: Education policy and curriculum in mathematics and science*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/encyclopedia/

McDonnell, L. M. (1995). Opportunity to learn as a research concept and a policy instrument. *Educational Evaluation and Policy Analysis, 17*(3), 305–322. https://doi.org/10.2307/1164509

Mullis, I. V. S., & Martin, M. O. (Eds.). (2017). *TIMSS 2019 assessment frameworks*. TIMSS & PIRLS International Study Center, Boston College. http://timssandpirls.bc.edu/timss2019/frameworks/

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 international results in mathematics and science*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/international-results/

Mullis, I. V. S., Martin, M. O., Fishbein, B., Foy, P., & Moncaleano, S. (2021a). *Findings from the TIMSS 2019 problem solving and inquiry tasks*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/psi/

Mullis, I. V. S., Martin, M. O., & von Davier, M. (Eds.). (2021b). *TIMSS 2023 assessment frameworks*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2023/frameworks/index.html

Nilsen, T., & Gustafsson, J.-E. (Eds.). (2016). *Teacher quality, instructional quality and student outcomes: Relationships across countries, cohorts and time* (IEA research for education) (Vol. 2, pp. 135–147). Springer. https://doi.org/10.1007/978-3-319-41252-8

Orpwood, G., & Barnett, J. (1997). Science in the national curriculum: an international perspective. *The Curriculum Journal, 8*(3), 331–349. https://doi.org/10.1080/0958517970080302

Reynolds, K. A., & Komakhidze, M. (2022). *TIMSS 2023 environmental attitudes and behaviors framework*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2023/frameworks/pdf/T23-Environmental-Attitudes-and-Behaviors-Framework.pdf

Robitzsch, A., Kiefer, T., & Wu, M. (2022). *TAM: Test analysis modules*. R package version, 4.1-4. https://CRAN.R-project.org/package=TAM

Sadi, Ö., & Çakıroğlu, J. (2011). Effects of hands-on activity enriched instruction on students' achievement and attitudes towards science. *Journal of Baltic Science Education, 10*(2), 87–97. https://oaji.net/articles/2014/987-1410008481.pdf

Sammons, P. (1999). *School effectiveness*. CRC Press.

Schmidt, W. H., & Maier, A. (2009). Opportunity to learn. In G. Sykes, B. L. Schneider, & D. N. Plank (Eds.), *Handbook on education policy research* (pp. 541–549). Routledge. https://doi.org/10.4324/9780203880968

Stacey, O., De Lazzari, G., Grayson, H., Griffin, H., Jones, E., Taylor, A., & Thomas, D. (2018). *The globalization of science curricula* (Vol. 3). IEA research for education, Springer. https://doi.org/10.1007/978-3-319-71532-2

Uitto, A., Boeve-de Pauw, J., & Saloranta, S. (2015). Participatory school experiences as facilitators for adolescents' ecological behavior. *Journal of Environmental Psychology, 43*, 55–65. https://doi.org/10.1016/j.jenvp.2015.05.007

Voogt, J., & Pareja Roblin, N. (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. *Journal of Curriculum Studies, 44*(3), 299–321. https://doi.org/10.1080/00220272.2012.668938

Yin, L., & Foy, P. (2021). Constructing the TIMSS 2019 environmental awareness scales. In I. V. S. Mullis, M. von Davier, & M. O. Martin (Eds.), *Methods and procedures: TIMSS 2019 technical report* (pp. 18.1–18.30). TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2019/methods/chapter-18.html

Chapter 7
Operationalization and Methodology in ICCS

Diego Carrasco

7.1 Objectives of ICCS 2016

The International Civic and Citizenship Education Study (ICCS) 2016 is a large-scale assessment study (Rutkowski et al., 2010) from the International Association for the Evaluation of Educational Achievement (IEA), that collects responses from 24 educational systems and countries.[1] This study is the primary source for the set of results presented in the following chapters. ICCS 2016 investigates different factors to address how prepared students are to undertake their roles as citizens, after 8 years of schooling (Schulz et al., 2018a). Using different background questionnaires, students, teachers and school principals provide responses to different questions allowing researchers to study student and school attributes, school practices, and the school experiences of these different actors. Using these responses, the study provides scores and indicators for students' civic knowledge, value beliefs, attitudes, behaviors and behavioral intentions, school factors, and activities related to civic and citizenship education curricula (Schulz et al., 2016).

[1] The educational system of North Rhine-Westphalia (Germany) participates in the study as a benchmarking participant. The term "countries" is sometimes used in this chapter to refer to both countries and benchmarking participants, for ease of reading.

D. Carrasco (✉)
Centro de Medición MIDE UC, Pontificia Universidad Católica de Chile, Santiago, Chile
e-mail: dacarras@uc.cl

M. M. Isac et al. (eds.), *Knowledge and Willingness to Act Pro-Environmentally*,
IEA Research for Education 16, https://doi.org/10.1007/978-3-031-76033-4_7

7.2 Participants and Sampling

ICCS 2016 uses a stratified two stage probability sampling design. In this sampling design, in the first stage, schools are randomly selected proportional to their size, following the stratification design. In the second stage, an intact class within the school is selected to participate in the study, so all students from this class participate in the study answering the civic knowledge test and the student background and context questionnaire. Additionally, a fixed number of target grade teachers from the selected school, are randomly selected to participate in the study, answering a teacher questionnaire, reaching about 16,999 teachers on average across all participating countries. Moreover, school principals from each selected school also participate in the study, answering a school principal questionnaire (Meinck, 2018). In general, the sampling design aims for nominal samples of 150 schools and 3000 students (see Table 7.1 for more details).

Table 7.1 Number of participating schools, students and teachers for each survey

	Surveyed students		Surveyed teachers	
Country	Participating schools	Participating students	Participating schools	Participating teachers
Belgium (Flemish)	162	2931	157	2021
Bulgaria	147	2966	140	1549
Chile	178	5081	169	1452
Chinese Taipei	141	3953	144	2239
Colombia	150	5609	136	1580
Croatia	175	3896	176	2723
Denmark	184	6254	59	489
Dominican Republic	141	3937	128	754
Estonia	164	2857	49	403
Finland	179	3173	170	2097
Hong Kong SAR	91	2653	N/A	N/A
Italy	170	3450	170	2331
Korea, Republic of	93	2601	106	1368
Latvia	147	3224	144	1946
Lithuania	182	3631	183	2674
Malta	47	3764	47	737
Mexico	213	5526	210	1918
Netherlands	123	2812	112	1374
Norway	148	6271	143	2010
Peru	206	5166	206	2384
Russian Federation	352	7289	140	1743
Slovenia	145	2844	143	2056
Sweden	155	3264	135	1542
Benchmarking participant				
North Rhine-Westphalia (Germany)	59	1451	N/A	N/A

Source: Meinck (2018)
Note: *N/A* not applicable

7.3 Target Population

The ICCS 2016 target population is students in the eighth grade, aiming at students who have 8 years of schooling in each participating country (Schulz et al., 2018a), counting from ISCED level 1 (UNESCO Institute for Statistics, 2012). Additionally, age is considered an additional criterion in the sampling design, to ensure developmental alignment between test and questionnaires, thus aiming at students in eighth grade or equivalent with a mean age of 13.5 years of age. If students in eighth grade in an educational system are younger than expected, because they may have started formal schooling at 5 years of age, the target grade is changed to grade nine (Meinck, 2018).

Using the information of the sampling design of the ICCS 2016 study, we can produce estimates to make inferences to the target population of students, with expected standard errors of 5% of standard deviation for the study generated scores (Meinck, 2018).

7.4 Exclusions and Participation

Large-scale assessment studies, by design, target a finite set of schools in their sampling design. However, during implementation, some sample loss can occur due to imprecisions of the sampling frame of schools (i.e., the list of schools eligible to the study), due to non-participation of whole schools, non-response of students, and/or exclusions due to characteristic of students such as students with special needs who are less able to endure the test conditions (Meinck, 2018). IEA sampling design standards require participating countries to keep their exclusion rates below 5% of selected students (Meinck, 2020).

In ICCS 2016 most countries reach this set threshold of students' exclusion rates below 5%, with the exception of Croatia (5.2%), Estonia (6.7%), Latvia (6.5%), Lithuania (5.3%), Norway (5.5%), the Russian Federation (5.1%), Sweden (6.4%) and North Rhine-Westphalia (7.0%) (see Meinck, 2018 for more details). Moreover, participation rates in Hong Kong SAR, the Republic of Korea, and North Rhine-Westphalia were below ICCS 2016 standards, and their results should be interpreted with caution (Köhler et al., 2018). More details regarding the achieved sampling design in each participating country can be found in Appendix B of the ICCS 2016 technical report (Schulz et al., 2018b).

7.5 Variables

In the present section, we describe the variables used throughout the next chapters. These are collections of variables consistent with the action competence in sustainable development (ACiSD) framework (Sass et al., 2023), as outlined in Chap. 2.

The selected variables include different inequality factors, and school practices that may act as promoters or risk factors for students' willingness to act pro-environmentally. The following descriptions are brief, as we will expand on their conceptual interpretations in each of the analytical chapters. We first describe the response or dependent variables, and we further divide the independent variables into two sections: variables to address inequalities among students and variables to address schooling factors.

7.5.1 Dependent Variable

The main dependent variable of the following chapters (8, 9 and 10) is a single item asking if students are willing to make personal efforts in their adult life to help the environment. This question is addressing students' intended future behavior to protect the environment in terms of their willingness to make individual efforts. The selected item has been used in previous studies as an indicator of sustainable development dispositions (Sandoval-Hernández & Carrasco, 2020), and as an indicator of environmental citizenship (Huang & Cheah, 2021). In Sect. 4.2, we expand on the position of this selected indicator, in the broader scope of willingness to act pro-environmentally. Within ACiSD in particular, this item is an example of the willingness to act dimension (see Chap. 2), whereas Chaps. 3, 4, 5, and 6 elaborate on the knowledge dimension of the ACiSD framework.

The item presents an ordered category response of four choices, where students indicate if they would certainly do this, would probably do this, would probably not do this, or would certainly not do this. In Fig. 7.1 we include a representation of how this item was presented to the students within Question 31 in the ICCS 2016 international student questionnaire.

7.5.2 Variables to Address Inequalities

In Chap. 9, we look into the different factors that drive population inequalities regarding students' future engagement with pro-environmental behaviors. To this end, we included parents' education, number of books at home, students' self-reported gender, and, based on previous studies on pro-environmental behaviors (Gifford & Nilsson, 2014; Li et al., 2019), immigrant background. Moreover, to study accelerating effects—that is, if the intersection between two of these factors alters the direct relation—we included interacting terms between parents' education and number of books, parents' education and students' gender, and number of books

Q31 Listed below are different ways adults can take an active part in society.
When you are an adult, what do you think you will do?
(Please tick only one box in each row.)

			I would certainly do this	I would probably do this	I would probably not do this	I would certainly not do this
IS3G31A	a)	Vote in <local elections>	☐1	☐2	☐3	☐4
IS3G31B	b)	Vote in <national elections>	☐1	☐2	☐3	☐4
IS3G31C	c)	Get information about candidates before voting in an election	☐1	☐2	☐3	☐4
IS3G31D	d)	Help a candidate or party during an election campaign	☐1	☐2	☐3	☐4
IS3G31E	e)	Join a political party	☐1	☐2	☐3	☐4
IS3G31F	f)	Join a trade union	☐1	☐2	☐3	☐4
IS3G31G	g)	Stand as a candidate in <local elections>	☐1	☐2	☐3	☐4
IS3G31H	h)	Join an organization for a political or social cause	☐1	☐2	☐3	☐4
IS3G31I	i)	Volunteer time to help other people in the <local community>	☐1	☐2	☐3	☐4
IS3G31J	j)	Make personal efforts to help the environment (e.g. through saving water)	☐1	☐2	☐3	☐4

Fig. 7.1 Question 31 from the ICCS 2016 background questionnaire, highlighting the intentions of future behavior for protecting the environment item

and students' gender based on the scholarly culture hypothesis (Evans et al., 2015). In Table 7.2 we describe the variables and scales we selected for the present study.[2]

7.5.3 *Variables to Address Schooling Factors*

To facilitate the description of variables we divided them in two groups: student and school level variables. In this latter group we include variables created with students' responses, teachers' responses, and school principals' responses, referring to the school learning environment.

Before we can address school factors that may promote students' willingness to act pro-environmentally, we need to account for students' differences regarding their current behavior and relevant beliefs that are known to be associated with

[2] Throughout the following tables, we label as "Original variable name" the variable name appearing in the public data release of ICCS 2016 (see Köhler et al., 2018), while we use the label "Generated variables" to refer to the created variables for the purpose of this study. These generated variables will be used in later sections that describe the fitted models.

Table 7.2 Variables included in the inequalities section

Original variable name	Description	Scale	Generated variables
S_HISCED	Parents' education	We used the maximal attained degree between both parents and recoded this index as a dummy variable. The focal category are families where at least one of the parents has attained a bachelor's degree (ISCED level 6 or more = 1), and the reference category are families where none of the parents have attained a university degree (ISCED level 4 or 5 and lower = 0)	edu
S_HOMLIT	Number of books at home	Dummy coded variable where the focal category is more than a 100 books (100 > books at home = 1) and the reference category is less than a 100 books at home (100 or less books = 0)	bok
S_GENDER	Students' gender	Students' self-reported gender. We use girls as the focal category (girls = 1), and left boys as the reference category (boys = 0)	sex
S_IMMIG	Students' immigrant background	Dummy coded variable, leaving students with no immigration background as the reference category (other = 0), and including students with immigrant background as the focal category (immigrant = 1). This latter category includes students whose parents were born abroad, and students who were born abroad, while also their parents were born abroad	imm

Note: Original variable name refers to the variable name appearing in the public data release of ICCS 2016 (see Köhler et al., 2018). Generated variable refers to the created variables for the purpose of this study. These variable names are also used in later sections that describe the fitted models

students' intentions to engage in pro-environmental behaviors (de Leeuw et al., 2015; Yuriev et al., 2020). In the present study we have included an indicator of current behavior, two indicators of injunctive or prescriptive social norms regarding protecting the environment, and three indicators of environmental threat awareness (pollution, water shortage, and climate change). We describe these selected variables in Table 7.3.

Following Carroll's model of school learning (Carroll, 1989) we included a series of indicators that describe different attributes of the school learning environment students are in, that provide different opportunities to learn pertinent to pro-environment behaviors and willingness to act sustainably (Boeve-de Pauw et al., 2015; Olsson et al., 2022). In this selection, we included three different indicators from school principal responses, three different indicators from teacher responses, and two indicators generated using student responses. We describe these different variables in Tables 7.4, 7.5 and 7.6.

Table 7.3 Student level variables

Original variable name	Description	Scale	Generated variable
IS3G15B	Current behavior	Students indicate if they participate in "An environmental action group or organization." We recoded the original responses into a dummy coded variable, leaving the reference category students who have never done this (No = 0), and as the focal category for students who participated in such group more than a year ago, and in the last 12 months (Yes = 1)	inv
IS3G23J	Prescriptive norms regarding taking part in pro-environmental activities	Students indicate the importance of "Taking part in activities to protect the environment" (IS3G23J), and "Making personal efforts to protect natural resources" (IS3G23N). Students use an ordinal set of choices to indicate their importance ("Not important at all," "Not very important," "Quite important," "Very important"). We created two dummy variables for each item respectively (n°1, n°2), leaving as the reference category responses of "Not very important" and "Not important at all" (not important = 0), and as the focal category students' response of very and quite important (important = 1)	no1
IS3G23N	Prescriptive norms regarding pro-environmental individual actions		no2
IS3G28A	Threat awareness regarding pollution	Students indicate the extent to which different issues are a threat to the world's future. Among these issues we selected students' responses to pollution (IS3G28A), water shortages (IS3G28E), and climate change (IS3G28I), using ordinal response categories ("Not at all," "To a small extent," "To a moderate extent," "To a large extent"). We created three different dummy coded variables respectively (th1, th2, th3), specifying responses of "To a large extent" (aware = 1), and the rest of responses as the reference category (not aware = 0)	th1
IS3G28E	Threat awareness regarding water shortages		th2
IS3G28I	Threat awareness regarding climate change		th3

7.6 Analytical Strategy

7.6.1 General Strategy

To address the different research questions included in the next chapters, we fitted a series of ordinal logit models (Rabe-Hesketh & Skrondal, 2012) onto the pooled data of the study including countries' fixed effects, while including the sampling design of the ICCS 2016 study in our estimations, using Mplus software

Table 7.4 School principal school level variables

Original variable name	Description	Scale	Generated variable
IC3G09A-IC3G09E	Schools' likelihood of implementing pro-environment practices	School principals indicate to what extent the schools have implemented different sustainable practices including: differential waste collection, waste reduction, purchase of environmentally friendly items, energy saving practices, and the use of posters to encourage students' environmentally friendly behaviors. We fitted a partial credit model onto school principal responses and retrieved its theta logits scores (IRT WLE[a]). These theta scores presented a person separation reliability index[b] of 0.78; we added these scores to the student data and standardized these scores leaving a mean of zero and standard deviation of one	spt
IC3G04A	Students' exposure to activities related to environmental sustainability	School principals are asked how many target students have had the opportunity to take part in "Activities related to environmental sustainability (e.g. <energy and water saving, recycling>)". We recoded the original responses into a dummy variable, specifying as the focal category when school principals report that most, nearly all and all students have had the opportunity (yes = 1), and left as the reference category, when the school principal reports that only some or less have had this opportunity (no = 0)	eas
IC3G16B	School promotes respect for and safeguard of the environment	School principals select out of a list the three most important aims of civic and citizenship education at the school. We created a dummy variable specifying as the focal category, when the school principal selected "Promoting respect for and safeguard of the environment" among these three aims (yes = 1, no = 0)	sep

[a]Notes: IRT = item response theory, WLE = weighted likelihood estimation
[b]Person separation reliability index is a reliability index indicating the amount of variance accounted for by persons as sources of variance, in comparison to the estimated error of the model (see Adams, 2005)

(Muthén & Muthén, 2017). Survey weights were scaled up to a constant, so all participating countries contributed equally to the estimates (Gonzalez, 2012). We used Taylor series linearization to get corrected standard errors of estimates (Asparouhov & Muthén, 2010).

Table 7.5 Teacher responses used to create school level variables

Original variable name	Description	Scale	Generated variable
IT3G12A-IT3G12G	Schools' likelihood of implementing pro-environmental awareness activities	School teachers indicate if they have carried out with the target grade different activities that promoted pro-environmental awareness during the school year, using "Yes" or "No" choices. The list of activities includes: "Writing letters to newspapers or magazines to support actions about the environment" (IT3G12A); "Signing a petition on environmental issues" (IT3G12B); "Posting on social network, forum or blog to support actions about the environment" (IT3G12C); "Activities to make students aware of the environmental impact of excessive water consumption" (IT3G12D); "Activities to make students aware of the environmental impact of excessive energy consumption" (IT3G12E); "<Cleanup activities> outside the school" (IT3G12F); "Recycling and waste collection in the <local community>" (IT3G12G). We fitted a Rasch model and retrieved theta logit scores (IRT WLE[a]) from the teacher data, reaching a 0.66 of reliability using the person separation reliability index[b]. We then produced school means with this generated score	tea_m
IT3G18D	Teacher readiness to teach on the environment and environmental sustainability	Teachers indicate their readiness to teach on different topics and skills, using four ordinal choices ("Not prepared at all," "Not very well prepared," "Quite well prepared," "Very well prepared"). We created a dummy variable specifying as the focal category teachers' responses of "Quite well prepared" and "Very well prepared," while leaving the rest of categories as the reference, using the teachers' responses to the item "The environment and environmental sustainability" (IT3G18D). With this dummy variable we created a school percentage of teachers who feel ready to teach on the environment and environmental sustainability	tpe_m
IT3G19D	Teacher trained to teach on the environment and environmental sustainability	Teachers indicate if they have attended training courses addressing various topics at school. We use teachers' responses to the item "The environment and environmental sustainability" (IT3G19D) to create a dummy variable, specifying as a focal category if teachers have received training previously (yes = 1), and a reference category if they have not (no = 0). With this created dummy variable, we created a percentage of trained teachers	tpp_m

[a]Notes: IRT = item response theory, WLE = weighted likelihood estimation

[b]Person separation reliability index is a reliability index indicating the amount of variance accounted for by persons as sources of variance, in comparison to the estimated error of the model (see Adams, 2005)

Table 7.6 Student responses used to create school level variables

Original variable name	Description	Scale	Generated variable
IS3G18C	Opportunities to learn how to protect the environment	Students indicate to what extent they have learned "How to protect the environment (e.g. through energy-saving or recycling)" at their school, using four ordered choices. We created a dummy variable with their responses, specifying as the focal category when students indicated they have learned this to a large extent, leaving as a reference category when students indicated they have learned this to a moderate extent, to a small extent and not at all. We then created a school mean percentage with the created dummy variable centered at the grand mean of each country (pte_b) and created school deviations from the school mean of this percentage (pte_w)	pte_w, pte_b
S_OPDISC	Open classroom discussion	Students indicate the frequency of occurrence of different open classroom discussion practices, when discussing political and social issues. A partial credit model was fitted onto students' responses, and the theta logits scores (IRT WLE[a]) were retrieved, and scaled using an international mean of 50 and standard deviation of 10 (see Schulz et al., 2018b). We standardized these scores subtracting the international mean, and then divided these scores by the international standard deviation. We then created school means centered at the grand mean of each country (opd_b), and created students' deviation from their school mean (opd_w)	opd_w, opd_b

Note: [a]IRT = item response theory, WLE = weighted likelihood estimation

7.6.2 Fitted Model

An ordinal logit model is a generalized linear model that can be fitted onto a response variable with ordered categories. Our main dependent variable was the student answers to the item "Make personal efforts to help the environment (e.g., through saving water)," framed by the question "When you are an adult, what do you think you will do?" Students choose options "I would certainly not do this," "I would probably not do this," "I would probably do this," and "I would certainly do this." We interpreted students' responses as ordered, in a sequence of 1, 2, 3 and 4. The basic formulation of the ordinal logit model with a single predictor, with cumulative probabilities, can be expressed with the following equation to our response variable:

$$\Pr\left(y_{ij} \geq s|x_{ij}\right) = \frac{1}{1+\exp\left(\tau_m - \left(\beta_1\right)\right)} s = 1,2,3,4 \tag{7.1}$$

Table 7.7 Subtraction equations among cumulative probabilities to obtained expected probabilities of response per category

Category of response	Specific formula for each expected category of response
1	$\Pr(y_{ij} = 1 \mid x_{ij}) = \Pr(y_{ij} \geq 1 \mid x_{ij}) - \Pr(y_{ij} \geq 2 \mid x_{ij})$
2	$\Pr(y_{ij} = 2 \mid x_{ij}) = \Pr(y_{ij} \geq 2 \mid x_{ij}) - \Pr(y_{ij} \geq 3 \mid x_{ij})$
3	$\Pr(y_{ij} = 3 \mid x_{ij}) = \Pr(y_{ij} \geq 3 \mid x_{ij}) - \Pr(y_{ij} \geq 4 \mid x_{ij})$
4	$\Pr(y_{ij} = 4 \mid x_{ij}) = \Pr(y_{ij} \geq 4 \mid x_{ij})$

In this model, student "i" in school "j" responses to item "y" using category "s" or larger, can be retrieved via the inverse link of the linear predictors' component[3] $\tau_m - \beta_1 x_{ij}$. In the present case, we use three category cumulative logits "m" to model the odds of answering 1 vs 2, 3, 4 (τ_1); 1, 2 vs 3, 4 (τ_2); and 1, 2, 3 vs 4 (τ_3). The fitted model is a proportional odds model. As such, it uses a single coefficient to represent expected differences in the logit scale across the modeled responses conditional to the values of the covariates in the model. Nevertheless, the model implies different conditional probabilities per category in the response variable. Using the results of the fitted model, we can obtain the expected response to each category "s" conditional to values of other covariates, by subtracting the respective cumulative abilities in the following manner (see Table 7.7), where $\Pr(y_{ij} \geq 1) = 1$.

The coefficients from the linear predictor's component of the model, can be interpreted as linear relationships to the logits of the cumulative probability function. Thus, for a binary variable, such as students' gender (coded as girls = 1, and boys = 0) a positive coefficient implies girls endorse higher categories in a higher proportion in contrast to boys. A similar interpretation applies to continuous covariates where β_1 is the expected difference in the outcome for and additional unit in x_{ij} in the logit scale (x_{ij} = a vs x_{ij} = a + 1).

7.6.3 Model Specification

We expanded the described model to include all our covariates of interest, and our interacting terms of interest. The following equation depicts the saturated model.

[3] Mplus parametrized generalized linear models using "negative" thresholds, hence the linear component for a single covariate model is expressed as ($\tau_{\text{m}} - \beta_1 x_{\text{ij}}$), whereas other software parametrized these terms as positive, in which case the linear component is expressed as $-(v_{\text{m}} + \beta_1 x_{\text{ij}})$ (see Masyn, 2003, p. 63).

$$
\begin{aligned}
\text{Logit}\left[\Pr\left(y_{ij} \geq s\right)\right] = \; & \beta_1\left(edu_{ijk} - \overline{edu}_{\ldots}\right) + \beta_2\left(bok_{ijk} - \overline{bok}_{\ldots}\right) + \beta_3\left(sex_{ijk} - \overline{sex}_{\ldots}\right) \\
& + \beta_4\left(imm_{ijk} - \overline{imm}_{\ldots}\right) + \beta_5\left(edu_{ijk} - \overline{edu}_{\ldots}\right)\left(bok_{ijk} - \overline{bok}_{\ldots}\right) \\
& + \beta_6\left(edu_{ijk} - \overline{edu}_{\ldots}\right)\left(sex_{ijk} - \overline{sex}_{\ldots}\right) + \beta_7\left(bok_{ijk} - \overline{bok}_{\ldots}\right)\left(sex_{ijk} - \overline{sex}_{\ldots}\right) \\
& + \beta_8\left(inv_{ijk} - \overline{inv}_{\ldots}\right) + \beta_9\left(no1_{ijk} - \overline{no1}_{\ldots}\right) + \beta_{10}\left(no2_{ijk} - \overline{no2}_{\ldots}\right) + \beta_{11}\left(th1_{ijk} - \overline{th1}_{\ldots}\right) \\
& + \beta_{12}\left(th2_{ijk} - \overline{th2}_{\ldots}\right) + \beta_{13}\left(th3_{ijk} - \overline{th3}_{\ldots}\right) \\
& + \beta_{14}\left(spt_{jk} - \overline{spt}_{..k}\right) + \beta_{15}\left(eas_{jk} - \overline{eas}_{..k}\right) + \beta_{16}\left(tea_{mjk} - \overline{tea}_{m..k}\right) \\
& + \beta_{17}\left(sep_{jk} - \overline{sep}_{..k}\right) + \beta_{18w}\left(pte_{ijk} - \overline{pte}_{.jk}\right) + \beta_{18b}\left(\overline{pte}_{.jk} - \overline{pte}_{..k}\right) \\
& + \beta_{19w}\left(opd_{ijk} - \overline{opd}_{.jk}\right) + \beta_{19b}\left(\overline{opd}_{.jk} - \overline{opd}_{..k}\right) + \beta_{20}\left(tpe_{mjk} - \overline{tpe}_{m..k}\right) \\
& + \beta_{21}\left(tpp_{mjk} - \overline{tpp}_{m..k}\right) + \delta_{1-23}D_k - \tau_m
\end{aligned}
\tag{7.2}
$$

All students' covariates were centered at the grand mean (covariates from Tables 7.2 and 7.3). This centering approach helps to obtain coefficients that represent the overall relationship between each covariate, whereas school covariates created using school principal responses (Table 7.4), and school covariates generated with teacher responses (Table 7.5) were entered into the models as school means centered at each country mean. Students' responses used to create school attributes (see Table 7.6), are a reflective measure of the school attributes and if treated as common students' covariates we could underestimate their expected estimates (Carrasco et al., 2021). Thus, we adapted the disaggregated model specification (Rights et al., 2019) to obtain the population average between school effects (McNeish et al., 2017). These covariates were school mean centered, and school means were centered at the country mean, while country fixed effects $\delta_{1-23}D_k$ represent country differences from the country of reference. We used this latter centering approach, so coefficients β_{18b} and β_{19b} represent the between school change in logits for an additional unit of the school attribute of interest. Teacher responses and covariates are school means centered at the country mean. As such, school covariates are estimated first separated from country differences, and later, when country fixed effects are included, school factors relations are estimated while accounting for country differences.

7.6.4 How Results are Presented

To describe the obtained results in the following chapters, we used the logit estimates and their corresponding odds ratios. For the fitted model, odds ratios are the exponentiated version of the logit estimates. Odds ratios are a comparison between the odds of students endorsing a category of response (or higher), conditional to the values of a covariate, while odds are a division between a proportion $\Pr(y_{ij} \geq s)$, as the numerator, and its complement, $1 - \Pr(y_{ij} \geq s)$, as the denominator. In practical terms, if a covariate logit coefficient is zero, its respective odds ratio will be one. This null result means the endorsement of each category of the response variable is similar across the values of the covariate. For a categorical covariate coded as

0 and 1, if an odds ratio is two, it means the odds of endorsing higher categories are two times higher when the covariate has a value of 1, in comparison to the expected odds when the covariate is 0.

Some caution needs to be taken to interpret the results of an ordinal logit model, as some of the common rules used to make interpretations of regression coefficients from linear regression apply, while others do not, especially for the case of interacting terms (Osborne, 2012). In general, coefficients from linear regression can be interpreted as expected changes in the scale of the response variable. As such, these coefficients carry information of direction and effect size. While coefficients from ordinal logit models are in a different scale, a logit scale, in this case, the ordinal logit estimates are a transformation of odds ratios of conditional odds. These estimates can be easily interpreted in terms of direction of relations but cannot be interpreted directly in terms of effect size (Norton & Dowd, 2018). To address this difficulty, we complemented the reported results with conditional probabilities for some of the variables of interest, comparing the results of the expected proportion of endorsement to the highest category of response ("I would certainly do this"), conditional to the values of the covariate on which we are focusing our result description. For example, this strategy allows readers to see the presented results in terms of what proportion of boys would certainly "Make personal efforts to help the environment" in their adult life, in comparison to the proportion of girls delivering the same response.

To maximize reading comprehension of our results we use a modified version of Cleveland dot plots (Gerbing, 2020, p. 48) to depict these contrasting proportions (see, for example, Yau, 2013, Fig. 3–28). These figures rely on visual cues of (1) *position* within a common scale, for expected proportions between the contrasted values of our covariate of interest, and (2) *length* to convey group differences in the response scale. For example, with these figures we compare groups, such as boys versus girls, or compare expected proportions at mean values of continuous covariate (e.g., open classroom discussion) in contrast to the expected proportion of response at one standard deviation of the covariate of interest. Position and length are the visual cues that lead to fewer errors of interpretation in contrast to other means of data visualization (Cleveland & McGill, 1984). These figures should be less taxing to working memory, due to using a single channel to convey interpretable information (position) and should help readers to have a sense of minimum, average and maximum of the expected proportions of the response variable (Franconeri et al., 2021). Moreover, the present figures were customized, so readers can identify which compared proportions differences are above sampling error (i.e., statistically significant), using an ordinal logit model for each variable for the pooled sample and for each country. In Fig. 7.2 we present an example of the figures presented in the following chapters with guiding notes for interpretation. In this figure we use a reduced ordinal logit model where the covariate of interest (books at home) conditions the responses of the students to the item "Make personal efforts to help the environment." It depicts the expected proportion of students providing the highest category of response ("I would certainly do this"), conditional to the values of the covariate (0 = up to 100 books, 1 = more than 100 books at home).

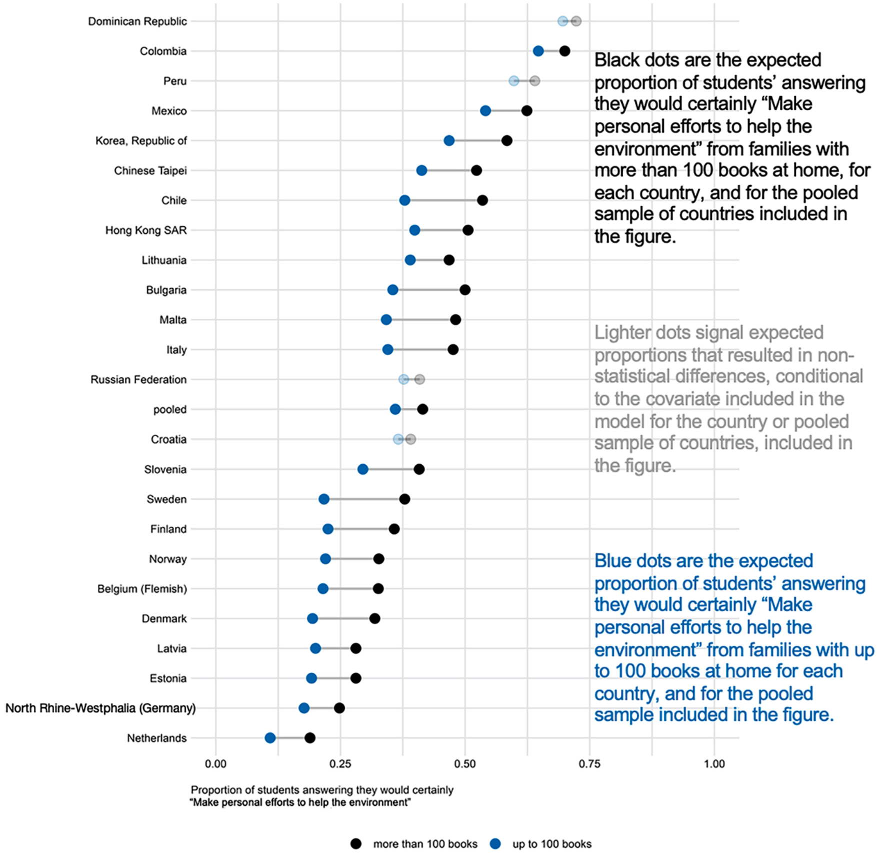


Fig. 7.2 Example of figure used throughout the following chapters to illustrate the obtained results

7.6.5 Limitations

The present approach has some limitations that need to be considered when interpreting the presented results. Ordinal logit models assume proportional odds. That is, the model assumes the estimated coefficients are to be constant for each contrasted cumulative probability. There are other modeling alternatives that can relax this assumption (Rabe-Hesketh & Skrondal, 2012). Nevertheless, the fitted models present low residuals in the expected proportional scale for the response variable (of 0.1–0.2% in the saturated model). As such, we believe the present modeling choice is a reasonable alternative in contrast to other modeling alternatives that would include more parameters and may improve marginally the model fit to the data.

The response variable and the selection of covariates included in the different sections of the following chapters present missing observations. The response variable is missing in 4% of the cases in the pooled sample, and for each country it varies from 0% to 7%, with the exception of the Dominican Republic, where 22% of the nominal sample do not respond to the response variable. Thus, the fitted models estimate can depart with what we could've obtained if these responses were not missing. Moreover, missing observations on covariates can become larger if missing responses are spread across covariates. To minimize the impact of missing observations we fitted separated models for each block of covariates in the following chapters, and present descriptive plots by country and covariate of interest. Thus, minimizing the loss of observations due to joint variable missingness. While in Chap. 9 missing observations on covariates is 4% at the most (for students' immigrant background), in Chap. 10 missing covariates is of 24% at the most for teacher covariates (for "Teacher trained to teach on the environment and environmental sustainability"). This loss of observations is due to lower participation rates in the teacher survey in some participating countries, including Denmark, Estonia, the Republic of Korea, the Netherlands, and the Russian Federation (Schulz et al., 2018b, p. 114).

We ran a sensitivity analysis comparing a version of the saturated model where all covariates are included in the model as single indicator latent variables (MS1) and a version of the saturated model that relies on listwise deletion due to missing covariates (MS2). The first model produces estimates that reaches asymptotically equivalent estimates to those generated with multiple imputations (see Enders, 2013).[4] In this comparison model, the expected percentage of response per category of the dependent variable varies by 1% in two categories. In this comparison four estimated coefficients presented noticeable differences ($Z > 1.96$)[5] out of all compared estimates. "Student sex" (sex), "Prescriptive norms regarding taking part in pro-environmental activities" (no1), and "Prescriptive norms regarding pro-environmental individual actions" (no2) would present larger estimates if all covariates were imputed in the saturated model. Moreover, "Teacher readiness to teach on the environment and environmental sustainability" (tpe_m), present an inversion: it reaches a small negative relation in the MS1 model, and a small positive relation in the listwise model (MS2). Because this last estimate is an overall estimate across countries, in Chap. 10 we interpret this relation with caution and rely on the observed relations of this factor per country. Due to the varying response rates from the teacher survey, we suggest readers interpret the result of this last section with caution. Overall, the results presented in the following chapters do not differ largely to results generated with a form of model-based imputation. Yet, interpretations should be done with caution on the particular coefficients detailed earlier.

---

[4] In particular, we are using a weighted least square mean and variance adjusted (WLSMV) estimator and a probit link to assume multivariate normality among all covariates for this procedure to work. We use the present procedure as a referential diagnostic only, because it requires satisfying the assumption of missing completely at random (MCAR) (Enders & Baraldi, 2018), a condition difficult to assess for the current study.

[5] We use a Z test to compare estimated coefficients from both models (Clogg et al., 1995).

References

Adams, R. J. (2005). Reliability as a measurement design effect. *Studies in Educational Evaluation, 31*(2–3), 162–172. https://doi.org/10.1016/j.stueduc.2005.05.008

Asparouhov, T., & Muthén, B. (2010). *Resampling methods in Mplus for complex survey data*. Mplus technical report. Muthén & Muthén. http://www.statmodel.com/download/Resampling_Methods5.pdf

Boeve-de Pauw, J., Gericke, N., Olsson, D., & Berglund, T. (2015). The effectiveness of education for sustainable development. *Sustainability, 7*(11), 15693–15717. https://doi.org/10.3390/su71115693

Carrasco, D., Treviño, E., López Hornickel, N., & Castillo, C. (2021). Students ratings their open classroom discussion. In M. Wiberg, D. Molenaar, J. González, U. Böckenholt, & J.-S. Kim (Eds.), *Quantitative psychology* (pp. 463–475). Springer. https://doi.org/10.1007/978-3-030-74772-5_41

Carroll, J. B. (1989). The Carroll model: A 25-year retrospective and prospective view. *Educational Researcher, 18*(1), 26–31. https://doi.org/10.3102/0013189X018001026

Cleveland, W. S., & McGill, R. (1984). Graphical perception: Theory, experimentation, and application to the development of graphical methods. *Journal of the American Statistical Association, 79*(387), 531–554. https://doi.org/10.1080/01621459.1984.10478080

Clogg, C. C., Petkova, E., & Haritou, A. (1995). Statistical methods for comparing regression coefficients between models. *American Journal of Sociology, 100*(5), 1261–1293. https://doi.org/10.1086/230638

de Leeuw, A., Valois, P., Ajzen, I., & Schmidt, P. (2015). Using the theory of planned behavior to identify key beliefs underlying pro-environmental behavior in high-school students: Implications for educational interventions. *Journal of Environmental Psychology, 42*, 128–138. https://doi.org/10.1016/j.jenvp.2015.03.005

Enders, C. K. (2013). Analyzing structural equation models with missing data. In G. R. Hancock & R. O. Mueller (Eds.), *Structural equation modeling: A second course* (2nd ed., pp. 493–520). Information Age Publishing.

Enders, C. K., & Baraldi, A. N. (2018). Missing data handling methods. In P. Irwing, T. Booth, & D. Hughes (Eds.), *The Wiley handbook of psychometric testing: A multidisciplinary reference on survey, scale and test development* (pp. 139–185). Wiley-Blackwell. https://doi.org/10.1002/9781118489772.ch6

Evans, M. D. R., Kelley, J., Sikora, J., & Treiman, D. J. (2015). Scholarly culture and occupational success in 31 societies. *Comparative Sociology, 14*(2), 176–218. https://doi.org/10.1163/15691330-12341345

Franconeri, S. L., Padilla, L. M., Shah, P., Zacks, J. M., & Hullman, J. (2021). The science of visual data communication: What works. *Psychological Science in the Public Interest, 22*(3), 110–161. https://doi.org/10.1177/15291006211051956

Gerbing, D. W. (2020). *R visualizations*. Chapman and Hall/CRC. https://doi.org/10.1201/9780429470837

Gifford, R., & Nilsson, A. (2014). Personal and social factors that influence pro-environmental concern and behaviour: A review. *International Journal of Psychology, 49*(3), 141–157. https://doi.org/10.1002/ijop.12034

Gonzalez, E. J. (2012). Rescaling sampling weights and selecting mini-samples from large-scale assessment databases. In *Issues and methodologies in large-scale assessments* (IERI monograph series) (Vol. 5, pp. 115–134). IERI.

Huang, L., & Cheah, S. L. (2021). The young environmental citizens in Nordic countries: Their concerns, values, engagement, and intended future actions. In H. Biseth, B. Hoskins, & L. Huang (Eds.), *Northern lights on civic and citizenship education* (pp. 123–146). Springer. https://doi.org/10.1007/978-3-030-66788-7_6

Köhler, H., Weber, S., Brese, F., Schulz, W., & Carstens, R. (Eds.). (2018). *ICCS 2016 user guide for the international database*. International Association for the Evaluation of Educational Achievement (IEA). https://www.iea.nl/sites/default/files/2019-05/ICCS2016_IDB_User_Guide.pdf

Li, D., Zhao, L., Ma, S., Shao, S., & Zhang, L. (2019, March). What influences an individual's pro-environmental behavior? A literature review. *Resources, Conservation and Recycling, 146*, 28–34. https://doi.org/10.1016/j.resconrec.2019.03.024

Masyn, K. E. (2003). *Discrete-time survival mixture analysis for single and recurrent events using latent variables.* Doctoral dissertation, University of California. Mplus. http://www.statmodel.com/download/masyndissertation.pdf

McNeish, D., Stapleton, L. M., & Silverman, R. D. (2017). On the unnecessary ubiquity of hierarchical linear modeling. *Psychological Methods, 22*(1), 114–140. https://doi.org/10.1037/met0000078

Meinck, S. (2018). Sampling design and implementation. In W. Schulz, R. Carstens, B. Losito, & J. Fraillon (Eds.), *ICCS 2016 technical report* (pp. 43–51). International Association for the Evaluation of Educational Achievement (IEA). https://www.iea.nl/publications/technical-reports/iccs-2016-technical-report

Meinck, S. (2020). Sampling, weighting, and variance estimation. In H. Wagemaker (Ed.), *Reliability and validity of international large-scale assessment* (IEA research for education) (Vol. 10, pp. 113–129). Springer. https://doi.org/10.1007/978-3-030-53081-5_7

Muthén, L. K., & Muthén, B. O. (2017). *Mplus user's guide* (8th ed.). Muthén & Muthén.

Norton, E. C., & Dowd, B. E. (2018). Log odds and the interpretation of logit models. *Health Services Research, 53*(2), 859–878. https://doi.org/10.1111/1475-6773.12712

Olsson, D., Gericke, N., & Boeve-de Pauw, J. (2022). The effectiveness of education for sustainable development revisited – a longitudinal study on secondary students' action competence for sustainability. *Environmental Education Research, 28*(3), 405–429. https://doi.org/10.1080/13504622.2022.2033170

Osborne, J. W. (2012, June). Logits and tigers and bears, oh my! A brief look at the simple math of logistic regression and how it can improve dissemination of results. *Practical Assessment, Research and Evaluation, 17*, 1–10. https://api.semanticscholar.org/CorpusID:117680832

Rabe-Hesketh, S., & Skrondal, A. (2012). *Multilevel and longitudinal modeling using stata, Volumes I and II* (3rd ed.). Stata Press.

Rights, J. D., Preacher, K. J., & Cole, D. A. (2019). The danger of conflating level-specific effects of control variables when primary interest lies in level-2 effects. *British Journal of Mathematical and Statistical Psychology, 73*(S1), 194–211. https://doi.org/10.1111/bmsp.12194

Rutkowski, L., Gonzalez, E., Joncas, M., & von Davier, M. (2010). International large-scale assessment data: Issues in secondary analysis and reporting. *Educational Researcher, 39*(2), 142–151. https://doi.org/10.3102/0013189X10363170

Sandoval-Hernández, A., & Carrasco, D. (2020). *A measurement strategy for SDG thematic indicators 4.7.4 and 4.7.5 using international large scale assessments in education.* UNESCO Institute for Statistics. http://tcg.uis.unesco.org/wp-content/uploads/sites/4/2020/06/Measurement-Strategy-for-474-and-475-using-ILSA_20200625.pdf

Sass, W., De Maeyer, S., Boeve-de Pauw, J., & Van Petegem, P. (2023). Effectiveness of education for sustainability: the importance of an action-oriented approach. *Environmental Education Research, 30*(4), 479–498. https://doi.org/10.1080/13504622.2023.2229543

Schulz, W., Ainley, J., Fraillon, J., Losito, B., & Agrusti, G. (2016). *IEA International Civic and Citizenship Education Study 2016 assessment framework*. Springer. https://doi.org/10.1007/978-3-319-39357-5

Schulz, W., Ainley, J., Fraillon, J., Losito, B., Agrusti, G., & Friedman, T. (2018a). *Becoming citizens in a changing world. IEA International Civic and Citizenship Education Study 2016 international report*. Springer. https://doi.org/10.1007/978-3-319-73963-2

Schulz, W., Carstens, R., Losito, B., & Fraillon, J. (Eds.). (2018b). *ICCS 2016 technical report*. International Association for the Evaluation of Educational Achievement (IEA). https://www.iea.nl/publications/technical-reports/iccs-2016-technical-report

UNESCO Institute for Statistics. (2012). *International Standard Classification of Education. ISCED 2011.* https://uis.unesco.org/sites/default/files/documents/international-standard-classification-of-education-isced-2011-en.pdf

Yau, N. (2013). *Data points: visualization that means something*. Wiley.

Yuriev, A., Dahmen, M., Paillé, P., Boiral, O., & Guillaumie, L. (2020, January). Pro-environmental behaviors through the lens of the theory of planned behavior: A scoping review. *Resources, Conservation and Recycling, 155*, 104660. https://doi.org/10.1016/j.resconrec.2019.104660

Chapter 8
Willingness to Act Pro-environmentally: Conceptualization and Country Comparisons

Cristobal Villalobos and Diego Carrasco

8.1 Sustainable Development, Citizenship and Education

In 1987, the *Our Common Future* report was presented at the United Nations General Assembly by the Brundtland Commission. This report aimed to establish a connection between economic development and environmental stability by introducing the concept of sustainable development, defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987, p. 43). Sustainable development emphasizes the necessity of addressing human needs while being mindful of our planetary limits. Central to this concept is the idea of intergenerational justice within our species, emphasizing that our current actions will have repercussions for future generations and the well-being of humanity (Cooper & Vargas, 2004). Since this foundational milestone, the notion of sustainable development has become a primary concern for most countries, international organizations, educational systems, and, in the past two decades, major transnational corporations. It has evolved into one of the most extensively debated topics in recent years.

While various organizations have sought to establish common goals and objectives related to sustainable development, the most widely disseminated set of objectives to date has been the Sustainable Development Goals (SDGs). In a general sense, the SDGs aim to outline a shared global agenda for sustainable development, encompassing 17 goals in areas such as poverty and hunger eradication, peace,

C. Villalobos (✉)
Faculty of Education, Pontificia Universidad Católica de Chile, Santiago, Chile
e-mail: clvillal@uc.cl

D. Carrasco
Centro de Medición MIDE UC, Pontificia Universidad Católica de Chile, Santiago, Chile
e-mail: dacarras@uc.cl

M. M. Isac et al. (eds.), *Knowledge and Willingness to Act Pro-Environmentally*,
IEA Research for Education 16, https://doi.org/10.1007/978-3-031-76033-4_8

quality education, gender equality, decent work and economic growth, social inequality reduction, affordable and clean energy generation, clean water availability, responsible consumption, and protection of marine and terrestrial life, among others (Sandoval-Hernández et al., 2019; UNESCO [United Nations Educational, Scientific and Cultural Organization] Institute for Statistics, 2017). Despite significant criticisms of the SDGs for their attempt to reconcile the economic model with a growing environmental crisis (Eisenmenger et al., 2020), their failure to adequately acknowledge the speed and magnitude of ecological devastation in the world (Lippert, 2004), or their construction through governance processes distant from the public and with ambiguous indicators (Fondtdevila, 2023; Ward, 2004), it remains a fact that the SDGs have served as a common platform for discussion, allowing for the widespread expansion of discourse on sustainable development.

In the literature of civic and citizenship education, the discussion surrounding the SDGs and sustainable development has permeated traditional notions of citizenship, which were previously linked to legal status and anchored in the concept of the nation. In contrast to these views, the idea of sustainable development facilitates the modeling of a new type of citizenship with at least three distinctive characteristics. Firstly, it broadens the scope of citizenship, extending it beyond national and country boundaries, increasingly conceptualizing it as global citizenship, that is not limited to the borders of countries (Goren & Yemini, 2017). Secondly, sustainable development recognizes the interdependence between human beings and other living and non-living entities, envisioning citizenship as a construct among living and non-living beings (Latour, 2004). Finally, the connection between sustainable development and citizenship allows for a deeper understanding that citizenship is constructed, thereby emphasizing the "actional" aspect of citizenship, differentiating from the traditional idea of citizenship, limited to a legal status that was given to people (Tawil, 2013).

These three features of contemporary citizenship—globality, interdependence, and action—highlight a central fact: sustainable development depends on our current and future willingness to act sustainably (for details, see Chap. 2). Following Sass et al. (2023), the idea of willingness to act sustainably allows us to highlight the willpower component that is necessary for pro-environmental action, which includes aspects such as autonomous motivation, confidence in action, expectations of one's own ability to act and the impact on the result as central elements to consider in education for sustainability and sustainable development (Sass et al., 2020). In this sense, strengthening global citizenship education, which includes learning and skill development related to issues such as climate crises, international cooperation, consumption patterns, or current migration processes, is fundamental to contemporary citizenship (UNESCO, 2015) and emerges as a crucial axis for sustainable development in the coming decades.

As an effort to contribute to this direction, this chapter discusses and presents a pertinent aspect of action competence in sustainable development, willingness to act pro-environmentally (see also Chap. 2), elucidating its prevalence among young people in over 24 educational systems. We use data primarily from the

International Association for the Evaluation of Educational Achievement (IEA) International Civic and Citizenship Education Study (ICCS) 2016 for this analysis. ICCS incorporates the opinions of more than 94,000 eighth-grade students on a range of topics including political participation, attitudes toward others, and environmental attitudes. Notably, it assesses their willingness to act pro-environmentally, as detailed in Chap. 7. Considering that, this chapter delves into describing the intentions for future action among young people in general and specifically their willingness to act pro-environmentally. It seeks to capture the main patterns and differences among countries. Following this introduction, the chapter descriptively compares willingness to act pro-environmentally with other intentions regarding citizenship action, analyzing both common patterns and distinguishing factors between countries.[1] Subsequently, the third section descriptively links willingness to act pro-environmentally with factors such as richness or pollution levels in countries. Finally, the last section synthesizes the findings and presents some conclusions drawn from the study.

8.2 Willingness to Act Pro-environmentally: Main Patterns

As we have pointed out, sustainable development and global citizenship transform the traditional conception of citizenship, incorporating the capacity to enact change as one of its central attributes (Villalobos et al., 2021). Thus, it is not merely a set of knowledge or skills, but also the ability to put this knowledge into action to mobilize changes that contribute to equity, social justice or gender equity (Trully, 2014). In the case of environmental sustainability, considering one's willingness involves recognizing that actions are influenced by the existing motivation for the issue. This motivation is closely tied to the individual's knowledge about the issue, their expectations for possible transformation, and the anticipated results of such actions (Sass et al., 2020). In the case of young people, actions encompass a dual dimension. On one hand, it is interesting to consider the current actions of young people as their contribution to sustainable development and civic engagement is not solely dependent on civil rights or the ability to elect authorities. In this manner, actions such as participation in protests, digital activism, or involvement in rallies for climate change constitute an initial form of civic engagement among young people. On the other hand, youth action can also be measured by their willingness to participate in future civic life, including their readiness to join a political party, participate in elections, or become part of a labor union (Ekman & Amnå, 2012). Both forms are complementary rather than contradictory, accounting for different dimensions of current and future youth participation in citizenship, including a wide range of environmental actions, such as participating in pro-environmental groups,

[1] As well as the term "educational systems," the term "countries" is sometimes used in this chapter to refer to both countries and benchmarking participants, for ease of reading.

promoting volunteer work to improve the environment or making personal efforts that contribute to the environment (Treviño et al., 2018).

In this chapter, our primary focus will be on understanding young people's future intentions to act. Examining these intents is essential for comprehending future political behaviors since youth is a crucial period for the emergence, consolidation, and development of civic viewpoints (Eckstein et al., 2012). In the ICCS 2016 survey, questions about students' willingness to act pro-environmentally were posed alongside questions regarding their intentions to engage in various other civic activities. These activities included involvement with political institutions, political membership, community participation, and environmental engagement. Although this approach in the ICCS 2016 survey allows for a comparison of students' willingness to act pro-environmentally with other civic actions, it presents two main limitations. Firstly, it frames environmental action primarily as an individual endeavor, overlooking the importance of systemic actions in favor of the environment. Secondly, by categorizing environmental action as a "separate" option from other civic activities, it implicitly suggests that it is distinct from activities like voting or protest participation. This creates a perception of environmental involvement as a "different" civic issue, rather than one that is interconnected with the political, social, and cultural dimensions of citizenship.

But, beyond these limitations, the inclusion of specific questions about environmental willingness in the ICCS 2016 survey allows us to gain insight into how young people understand their willingness to act pro-environmentally. The results showing the percentage of secondary school students willing to participate in various citizenship actions in the future across 24 countries are presented in Table 8.1.

As can be observed, there are two distinct patterns regarding the disposition to engage in future civic actions. On the one hand, actions related to political membership (joining a political party, assisting a candidate) or social membership (joining a labor union or a social organization) tend to be declared as actions with lower future intention. As highlighted in previous research (Dalton, 1999), this reduced intention may be related to youth's lesser inclination to perceive civic participation as a statutory form of engagement, giving rise to what Amnå and Ekman (2014) referred to as "standby citizens," individuals willing to actively engage in civic life only under certain conditions, moments, or for specific causes.

In contrast, students show higher intentions towards participating in less structured and more specific civic actions. These include voting in local or national elections, volunteering for a community organization, or making efforts to sustain the environment. Over 70% of students express a willingness, or even a strong willingness, to undertake these actions in the future. Concerning willingness to act pro-environmentally, a significant proportion of young people show a positive inclination. Specifically, 79.28% indicate their willingness to engage in future civic actions related to the environment, understood as an individual effort to act in the environment. This high level of engagement might reflect the centrality of environmental issues in the understanding of what constitutes a "good citizen" among new generations, as suggested by Treviño et al. (2021).

Table 8.1 Willingness to act in the future in different citizenship actions among secondary school students

When you are an adult, what do you think you will do?	Student response (percent of students)			
	I would certainly **not** do this (%)	I would probably **not** do this (%)	I would probably **do** this (%)	I would certainly **do** this (%)
Vote in local elections	4.74	10.57	37.44	47.25
Vote in <national elections>	4.60	10.91	35.53	48.96
Get information about candidates before voting in an election	5.30	14.76	37.13	42.81
Help a candidate or party during an election campaign	13.20	43.22	31.17	12.41
Join a political party	27.29	46.99	17.93	7.80
Join a trade union	23.23	45.15	23.32	8.29
Stand as a candidate in <local elections>	31.78	44.15	16.10	7.97
Join an organization for a political or social cause	21.09	44.98	24.95	8.99
Volunteer time to help other people in the <local community>	8.12	24.97	44.35	22.56
Make personal efforts to help the environment (e.g. through saving water)	5.35	15.36	41.64	37.64

Notes: Proportion of response per category using the pooled sample of all participating countries in ICCS 2016, and survey design for equally weighted countries. All standard errors are of 1% or less, using Taylor series linearization

However, this general pattern is not uniform across different countries and shows significant variation among countries. To explore the variations between countries, Table 8.2 presents the distribution for each of the 24 participating countries in ICCS 2016, including countries from Latin America, Europe, and Asia. This variation indicates that factors such as the social, economic, and environmental context might play a crucial role in shaping their future intentions. These contexts help determine the likelihood of young people engaging in environmental civic action.

In the Asian countries included in the sample, the intention to engage in pro-environmental action is notably positive. For instance, in Chinese Taipei, the Republic of Korea, and Hong Kong SAR, more than 83% of young people express a positive intention to participate in environmental action, and in the case of the Republic of Korea, over 50% declare that they will certainly engage in these actions. Despite having distinct civic traditions and somewhat differentiated perspectives on citizenship (Liu et al., 2023), common environmental issues, particularly high levels of air and sea pollution, might be contributing to this willingness.

In the case of Latin American countries, the intention to participate in environmental actions is also quite positive. In all cases (Chile, Colombia, Peru, and the Dominican Republic), the positive intention exceeds 80%. However, the cases of the Dominican Republic and Colombia are particularly noteworthy, with more than 60% of young people stating with certainty that they will participate in

Table 8.2 Willingness to act pro-environmentally among secondary school students

Country	Student response to "Make personal efforts to help the environment (e.g. through saving water)" (percent of students)			
	I would certainly not do this (%)	I would probably not do this (%)	I would probably do this (%)	I would certainly do this (%)
Belgium (Flemish)	5.41	22.14	47.82	24.62
Bulgaria	7.06	12.31	41.60	39.03
Chile	7.12	11.59	41.23	40.07
Chinese Taipei	2.06	8.05	45.75	44.15
Colombia	1.66	4.56	28.68	65.09
Croatia	4.77	14.26	43.75	37.22
Denmark	4.21	19.04	52.68	24.08
Dominican Republic	3.02	5.20	21.95	69.83
Estonia	4.52	20.91	51.50	23.08
Finland	4.25	18.14	49.49	28.12
Hong Kong SAR	6.39	9.85	40.94	42.83
Italy	4.34	13.82	42.15	39.68
Republic of Korea	2.83	8.14	34.75	54.28
Latvia	6.35	23.58	47.52	22.55
Lithuania	2.89	11.79	44.33	40.98
Malta	7.43	15.35	38.24	38.98
Mexico	3.26	9.06	32.84	54.83
Netherlands	12.21	30.79	43.60	13.40
Norway	8.16	20.83	43.73	27.28
Peru	2.01	6.01	31.69	60.28
Russian Federation	5.68	13.50	42.26	38.56
Slovenia	5.78	15.87	45.23	33.12
Sweden	6.58	21.48	43.35	28.59
Benchmarking participant				
North Rhine-Westphalia (Germany)	10.08	29.96	39.11	20.85

Notes: Proportion of response per category for all participating countries in ICCS 2016. All standard errors are of 1.8% or less, using Taylor series linearization

environmental actions in the future. These two cases have been recognized for their high levels of biodiversity and exemplary curricular programs in the region focused on climate awareness (UNESCO, 2020), which could be related to this trend.

European countries exhibit greater variability in environmental disposition compared to their Asian and Latin American counterparts. While countries like Italy, Belgium, Finland, and Sweden show distributions close to the average (around 80% positive disposition), the cases of Norway, the Netherlands, and North Rhine-Westphalia exhibit lower levels of willingness. In these three cases, at least 30% of the population declares they are not willing to participate in environmental actions, exceeding 40% in the case of the Netherlands. As found in a recent study focused on young people's present actions regarding climate change (Prendergast et al., 2021), while the differences between countries are evident, it is not clear if there is an inherent or natural pattern that can explain them. These differences are likely influenced by contextual, social, educational, and political factors within each of these countries, and the forthcoming section aims to explore these patterns, even if only in a preliminary manner.

8.3 Exploring Country Differences in Willingness to Act Pro-environmentally

As observed in the previous section, although there are significant differences in students' willingness to act pro-environmentally among countries, it is not entirely clear that this trend is solely related to educational, cultural or political factors within young people's living environments. To explore some preliminary patterns that may be affecting this relationship, this chapter focuses on economic and environmental variables that could be associated with willingness to act pro-environmentally.

With regard to economic variables, we particularly focus on gross domestic product (GDP). GDP is a widely used economic measure serving as a proxy for the wealth of a territory, representing the monetary value of all goods and services produced within that territory.[2] As a measure of richness, following Inglehart's post-materialist theories (1981), it is hypothesized that individuals living in societies with higher levels of wealth may have a greater propensity and motivation to engage in individual climate-related actions, given that they already have many of their basic material needs met (such as water, food, shelter). A simple way to study this relationship can be seen in Fig. 8.1, left and right scatter plots, which examine the relationship between GDP and the percentage of young people who indicated a likelihood of participating in environmental actions (left side) or who stated they would certainly participate in environmental actions in the future (right side).

Although with minor differences between the two charts, in both cases, a negative pattern between GDP and environmental disposition can be observed, contrary to the original idea proposed by Inglehart (1981). In other words, young people living in countries with higher levels of wealth tend to be less willing to act pro-environmentally.[3] This pattern tends to be more evident and robust with respect to

[2] As the weight of currencies in different countries varies (allowing access to more or fewer goods in certain regions depending on the currency), in our case, we utilized GDP adjusted for purchasing power parity (PPP).

[3] Two (contrary) hypotheses could explain this result. On the one hand, and contrary to what Inglehart (1981) hypothesized, the result could be explained because people from less developed countries are those who suffer the most direct consequences of the climate crisis and who, therefore, see greater urgency in developing actions to protect the environment. As Ortiz et al. (2022) shows, climate conflicts and protests have grown especially in Asia and Latin America, considering that many of the floods, droughts, heat waves and climate problems take place in these countries. In contrast to this first hypothesis, it could also be that young people with higher levels of wealth have higher levels of knowledge of the environmental problem and its complexity, and that, therefore, they are less willing to act individually (although perhaps not collectively) for the environment.

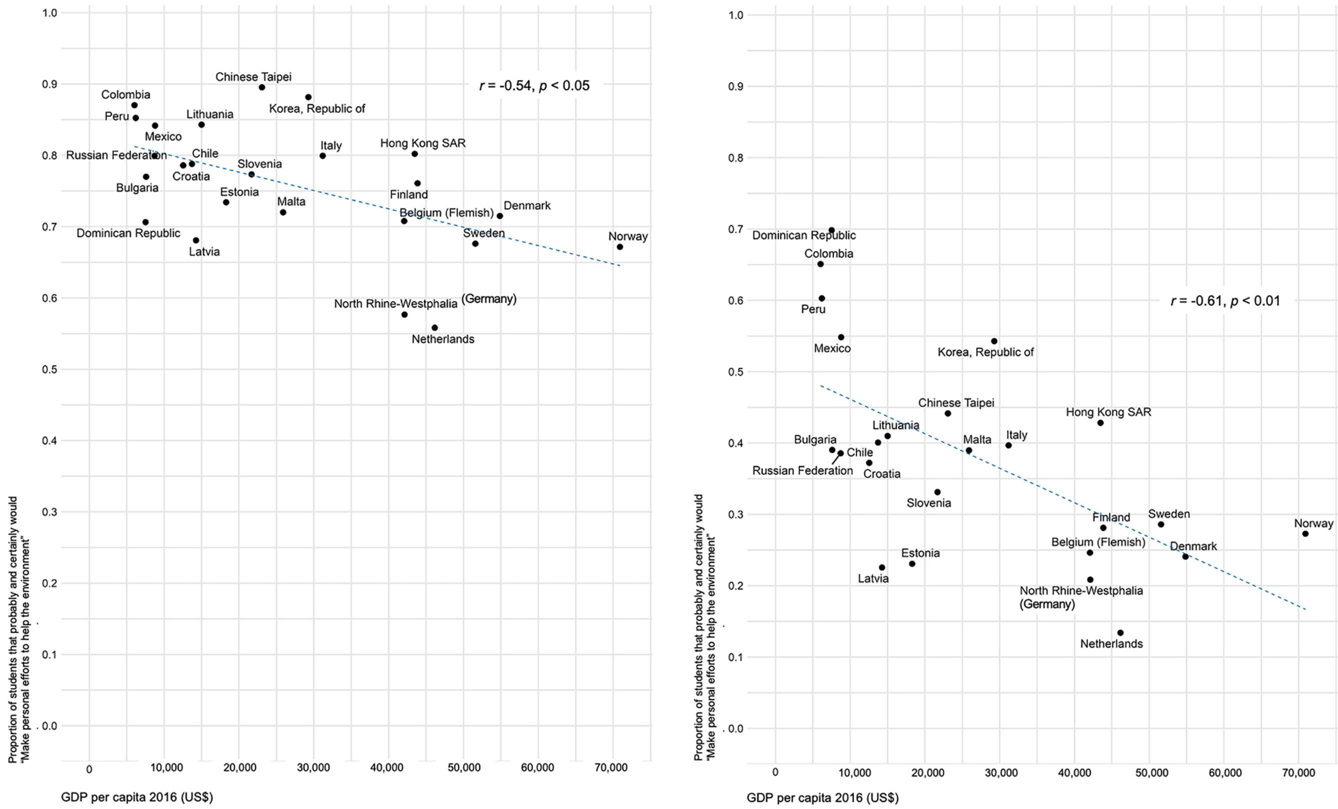


Fig. 8.1 Relation between gross domestic product (GDP) and willingness to act pro-environmentally by country.
Source: GDP data for 2016 from the International Monetary Fund (2023).
Note: Percentages are population expected percentages per category of response using ICCS 2016 survey design

the percentage of students who state that they will certainly make personal efforts to help the environment. For example, Norway and Denmark are the countries with the lowest willingness to act pro-environmentally, they possess the highest GDP per capita (around US$ 60,000 and US$ 70,000, respectively), while Colombia and Peru are among the countries with the highest willingness to act pro-environmentally but are among the countries in the sample with the lowest GDP per capita (around US$ 5000). Naturally, given that ICCS 2016 includes a small number of countries, this trend should be interpreted with caution.

The second comparative variable relates to the perception of pollution in each territory. Following the idea of O'Connor et al. (1999), it is possible to hypothesize that pollution in a territory could modify the perception of climate risk, thereby generating a greater intention to participate in future environmental actions. In our case, we compared willingness to act pro-environmentally with the Annual Greenhouse Gas Index (AGGI), which is a standardized measure of how human activity has affected the atmosphere in each country.[4] Similar to the GDP comparison, we compared the AGGI with both the declaration of future participation in pro-environmental actions with certainty and the intention to participate, including those who indicate certainty and probability. The results of this analysis are represented in Fig. 8.2, left and right-side scatter plots. Overall, there is no clear pattern in the relationship between AGGI and willingness to act pro-environmentally. In contrast to the GDP measure, a significant portion of the countries in ICCS have similar AGGI indices, forming a "cloud" that does not allow for the establishment of a clear relationship, apart from Colombia, Italy, Chile, Bulgaria, and Sweden. At first glance, this group of countries do not appear to share similar environmental policies. However, Chile has been implementing increasingly strict policies in industry, Colombia in environmental conservation, and Sweden in the use of waste, as highlighted by Ejelöv et al. (2022). Nevertheless, beyond these specific cases, this result might suggest that pollution alone is not a factor that effectively transforms willingness or enhances the disposition to take action.

8.4 Discussion and Conclusion

Considering a relevant indicator in the discussion of contemporary citizenship and sustainable development, this chapter aimed to understand the willingness to act pro-environmentally of young people, seeking to grasp the main pattern among countries through an exploration of ICCS 2016 in relation to the action competence framework (see Chap. 2). Willingness to act pro-environmentally was understood as a positive intention to act in young people, along with other "light" intentions to act

[4] Of course, there are other measures that could be used with a similar objective, such as Yale University's Environmental Performance Index (EPI) or the Climate Change Performance Index (CHPI). AGGI was selected because of its sensitivity to the pollution perceived by people, but exploring the relationship with other indices is a pending task for the future.

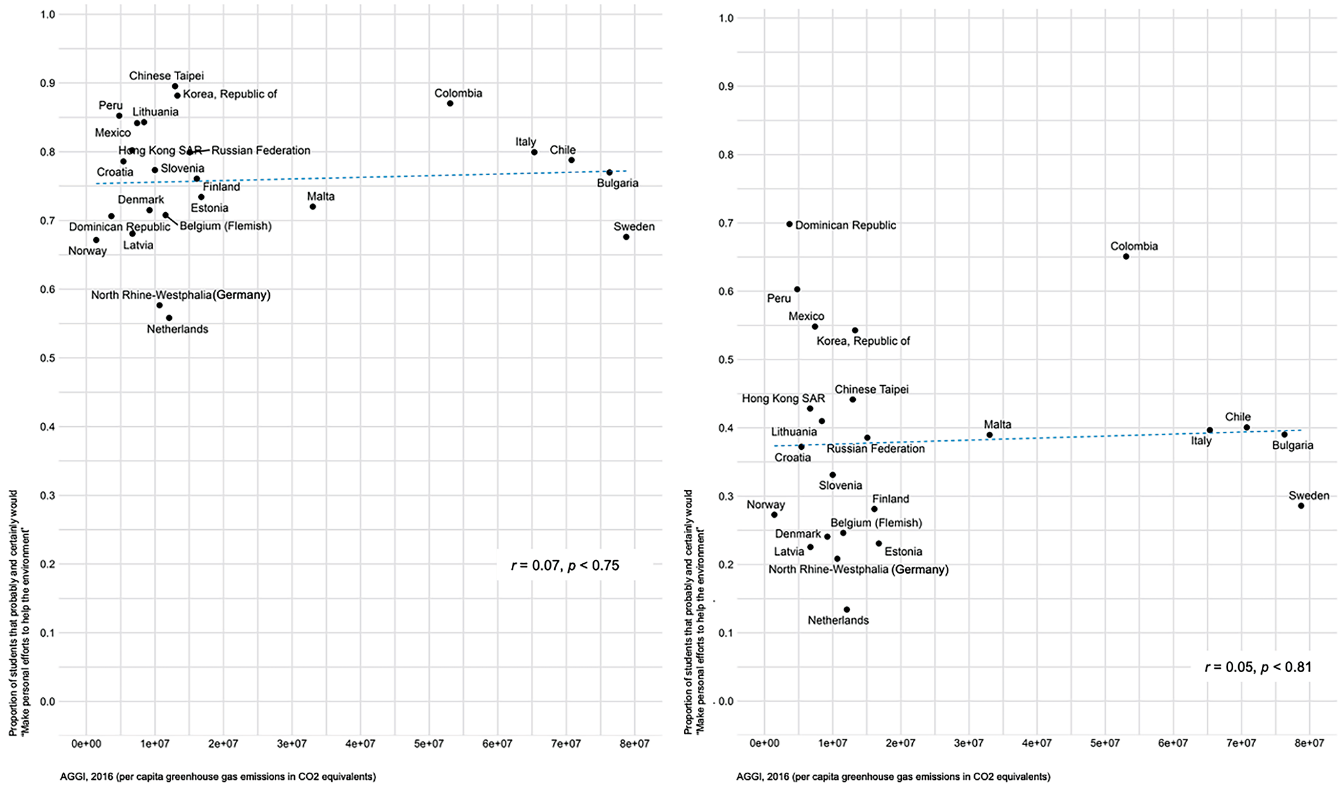


Fig. 8.2 Relation between Annual Greenhouse Gas Index (AGGI) and willingness to act pro-environmentally by country.
Source: AGGI data for 2016 from NOAA Global Monitoring Laboratory (2016).
Notes: Percentages are population expected percentages per category of response using ICCS 2016 survey design

(community action, participation in elections). In this sense, participating in environmental actions is seen as a temporary and concrete way of being a citizen in the world, visualized as a means of exercising sustainable development and global citizenship.

Overall, the results show that more than 70% of the students involved in ICCS 2016 would certainly or probably be involved in individual actions for the environment. Beyond averages, the analysis shows that the distribution of willingness to act pro-environmentally among countries is not uniform. While young people in some countries (such as Colombia) indicate they will participate in environmental actions with great certainty, in other countries (such as the Netherlands) many indicate they will not participate in these actions in the future.

An initial exploration focused on national economic and environmental variables shows that these patterns are not clearly interpretable at the national level, although there is a clear (though negative) relationship between GDP and willingness to act pro-environmentally. This finding may be linked to various explanatory mechanisms. For example, although the cultural patterns and trends (as well as the economic characteristics) of countries are relevant, these do not naturally or linearly explain the intentions of young people regarding future environmental provisions. Moreover, as the results show, although cultural patterns may be important, there are individual and school factors that also affect (significantly) the propensity to participate in environmental actions in the future, as will be seen in other chapters.

The results reported in this chapter, rather than providing clear answers, allow us to formulate questions and advance discussions to be addressed in further research: how is willingness to act pro-environmentally constructed and consolidated in young people? How much does young people's willingness to act pro-environmentally change over time? To what extent is willingness to act pro-environmentally related to or influenced by other forms of action or other perceptions? Although it is not the objective of the chapter to answer these questions, the examination of environmental provisions and their variability between countries compels us to raise these and other questions.

Likewise, the detailed examination of environmental willingness allows us to see the main limitations of this specific way to measure this construct (i.e., focused on the individual perspective and separated from other civic actions). On the one hand, while the relationship between citizenship, sustainable development, and the willingness to act pro-environmentally is evident and allows for the expansion of citizenship beyond traditional frameworks, it does not exhaust the possibilities for understanding the complexity of the environmental problem. This framework assumes that i) current economic development and environmental care are compatible, and ii) gives central importance to the individual subject and their individual actions, often at the expense of social structures. Thus, the willingness to act pro-environmentally at an individual level only encompasses a small part of the outcomes in understanding the issue of climate change and the ecological crisis we are facing. On the other hand, while the willingness to act pro-environmentally is a relevant variable to assess the potential for future youth action, it does not cover all forms of exercising youth environmental citizenship, nor all ways of measuring attitudes toward climate change. Understanding current actions is also crucial to comprehend what young people think and how they understand citizenship today, since currently many of the environmental protests are carried out by young people, such as, for example, Fridays for Future.

References

Amnå, E., & Ekman, J. (2014). Standby citizens: Diverse faces of political passivity. *European Political Science Review, 6*(2), 261–281. https://doi.org/10.1017/S175577391300009X

Cooper, P. J., & Vargas, M. (2004). *Implementing sustainable development: From global policy to local action*. Rowman and Littlefield.

Dalton, R. (1999). Political support in advanced industrial democracies. In P. Norris (Ed.), *Critical citizens: Global support for democratic government*. Oxford University Press.

Eckstein, K., Noack, P., & Gniewosz, B. (2012). Attitudes toward political engagement and willingness to participate in politics: Trajectories throughout adolescence. *Journal of Adolescence, 35*(3), 485–495. https://doi.org/10.1016/j.adolescence.2011.07.002

Eisenmenger, N., Pichler, M., Krenmayr, N., Noll, D., Plank, B., Schalmann, E., et al. (2020). The sustainable development goals prioritize economic growth over sustainable resource use: A critical reflection on the SDGs from a socio-ecological perspective. *Sustainability Science, 15*(4), 1101–1110. https://doi.org/10.1007/s11625-020-00813-x

Ejelöv, E., Harring, N., Hansla, A., Jagers, S., & Nilsson, A. (2022). Push, pull, or inform – An empirical taxonomy of environmental policy support in Sweden. *Journal of Public Policy, 42*(3), 529–552. https://doi.org/10.1017/S0143814X21000271

Ekman, J., & Amnå, E. (2012). Political participation and civic engagement: Towards a new typology. *Human Affairs, 22*, 283–300. https://doi.org/10.2478/s13374-012-0024-1

Fondtdevila, C. (2023). The politics of good enough data. Developments, dilemmas and deadlocks in the production of global learning metrics. *International Journal of Educational Development, 96*(1), 102684. https://doi.org/10.1016/j.ijedudev.2022.102684

Goren, H., & Yemini, M. (2017). Global citizenship education redefined – A systematic review of empirical studies on global citizenship education. *International Journal of Educational Research, 82*, 170–183. https://doi.org/10.1016/j.ijer.2017.02.004

Inglehart, R. (1981). Post-materialism in an environment of insecurity. *The American Political Science Review, 75*(4), 880–900. https://doi.org/10.2307/1962290

International Monetary Fund. (2023). *GDP per capita, current prices. 2016.* https://www.imf.org/external/datamapper/NGDPDPC@WEO/OEMDC/ADVEC/WEOWOD?year=2016

Latour, B. (2004). *Politics of nature. How to bring the sciences into democracy*. Harvard University Press.

Lippert, I. (2004). *An introduction to the criticism on sustainable development*. Brandenburg University of Technology. Environmental Sciences and Process Engineering. https://doi.org/10.13140/RG.2.1.1421.6805

Liu, M., Chang, T. T., & Chen, P. H. (2023). Students' perceptions of good citizenship in an East Asian society: A secondary analysis of the ICCS 2016. *Educational Studies, 49*(3), 507–528. https://doi.org/10.1080/03055698.2023.2173520

NOAA Global Monitoring Laboratory. (2016). *The NOAA annual greenhouse gas index (AGGI)*. https://gml.noaa.gov/aggi/

O'Connor, R. E., Bard, R. J., & Fisher, A. (1999). Risk perceptions, general environmental beliefs, and willingness to address climate change. *Risk Analysis, 19*(3), 461–471. https://doi.org/10.1111/j.1539-6924.1999.tb00421.x

Ortiz, I., Burke, S., Berrada, M., & Saenz Cortés, H. (2022). *World protests. A study of key protest issues in the 21st century*. Palgrave Macmillan. https://doi.org/10.1007/978-3-030-88513-7

Prendergast, K., Hayward, B., Aoyagi, M., Burningham, K., Hasan, M. M., Jackson, T., Jha, V., Kuroki, L., Loukianov, A., Mattar, H., Schudel, I., Venn, S., & Yoshida, A. (2021). Youth attitudes and participation in climate protest: An international cities comparison. *Frontiers in Political Science, 3*(696105). https://doi.org/10.3389/fpos.2021.696105

Sandoval-Hernández, A., Isac, M. M., & Miranda, D. (2019). *Measurement strategy for SDG global indicator 4.7.1 and thematic indicators 4.7.4 and 4.7.5 using international large-scale assessments in education.* UNESCO Institute for Statistics. https://gaml.uis.unesco.org/wp-content/uploads/sites/2/2019/08/GAML6-REF-9-measurement-strategy-for-4.7.1-4.7.4-4.7.5.pdf

Sass, W., Boeve-de Pauw, J., Olsson, D., Gericke, N., De Maeyer, S., & Van Petegem, P. (2020). Redefining action competence: The case of sustainable development. *The Journal of Environmental Education, 51*(4), 292–305. https://doi.org/10.1080/00958964.2020.1765132

Sass, W., De Maeyer, S., Boeve-de Pauw, J., & Van Petegem, P. (2023). Effectiveness of education for sustainability: The importance of an action-oriented approach. *Environmental Education Research, 30*(4), 479–498. https://doi.org/10.1080/13504622.2023.2229543

Tawil, S. (2013). *Education for 'global citizenship': a framework for discussion* (Education research and foresight: working papers 07). UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000223784

Treviño, E., Villalobos, C., Béjares, C., & Naranjo, E. (2018). Forms of youth political participation and educational system. The role of the school for 8th grade in Chile. *Young, 27*(3), 279–303. https://doi.org/10.1177/1103308818787691

Treviño, E., Carrasco, D., Claes, E., & Kennedy, K. J. (Eds.). (2021). *Good citizenship for the next generation. A global perspective using IEA ICCS 2016 data* (IEA research for education) (Vol. 12). Springer. https://doi.org/10.1007/978-3-030-75746-5

Trully, J. (2014). *On global citizenship. A dialogue*. Bloomsbury. https://doi.org/10.26530/oapen_479572

UNESCO. (2015). *Global citizenship education: Topics and learning objectives.* https://unesdoc.unesco.org/ark:/48223/pf0000232993

UNESCO. (2020). *Análisis curricular Estudio Regional Comparativo y Explicativo (ERCE 2019)* [Curriculum analysis Regional Comparative and Explanatory Study (ERCE 2019)]. https://unesdoc.unesco.org/ark:/48223/pf0000373976

UNESCO Institute for Statistics. (2017). *Measurement strategy for SDG Target 4.7: Proposal by GAML Task Force 4.7.* https://uis.unesco.org/sites/default/files/documents/gaml4-measurement-strategy-sdg-target4.7.pdf

Villalobos, C., Morel, M. J., & Treviño, E. (2021). What is a "good citizen"? A systematic literature review. In E. Treviño, D. Carrasco, E. Claes, & K. J. Kennedy (Eds.), *Good citizenship for the next generation. A global perspective using IEA ICCS 2016 data* (IEA research for education) (Vol. 12, pp. 13–32). Springer. https://doi.org/10.1007/978-3-030-75746-5

Ward, M. (2004). *Quantifying the world: UN ideas and statistics*. Indiana University Press.

World Commission on Environment and Development. (1987). *Our common future.* United Nations. https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

Chapter 9
Inequalities on Willingness to Act Pro-environmentally

Daniel Miranda and Diego Carrasco

9.1 Introduction

The growing interest and participation of young people in climate activism in many countries underscores the importance of understanding their willingness to act pro-environmentally (Bessant et al., 2021; Pickard, 2023). An exploration into such willingness, however, must take into account structural inequalities (Kessler, 2023; Kessler & Pizmony-Levy, 2023), considering the significant challenge of potential gaps shaped by gender, immigration background and socioeconomic status. Various studies indicate that women and socioeconomically advantaged people tend to exhibit greater pro-environmental attitudes and behavior (Gifford & Nilsson, 2014; Li et al., 2019). Immigration background could be associated with less sensitivity to the pro-environmental social norms (Gifford & Nilsson, 2014). Adding to these findings, the political socialization literature suggests that the family plays a crucial role in shaping the development of sociopolitical attitudes, particularly in areas related to social position or family academic orientation (Miranda et al., 2018).

This chapter aims to assess differences in young people's willingness to contribute to environmental preservation based on three factors: students' gender, belonging to a family with tertiary education, and family scholarly culture (as indicated by the availability of more than 100 books at home). To this end, we use International Civic and Citizenship Education Study (ICCS) 2016 data from the International

D. Miranda (✉)
Department of Psychology, Universidad de Chile, Santiago, Chile
e-mail: danmiranda@uchile.cl

D. Carrasco
Centro de Medición MIDE UC, Pontificia Universidad Católica de Chile, Santiago, Chile
e-mail: dacarras@uc.cl

M. M. Isac et al. (eds.), *Knowledge and Willingness to Act Pro-Environmentally*,
IEA Research for Education 16, https://doi.org/10.1007/978-3-031-76033-4_9

Association for the Evaluation of Educational Achievement (IEA) to fit a series of ordinal logit models, assessing willingness to act pro-environmentally in relation to the three aforementioned factors.

9.2 Literature Review

To start, research on pro-environmental attitudes and behavior shows, with a high consistency, that gender is a relevant aspect. Women (both in the adult and youth population) tend to develop greater pro-environmental behavior and attitudes (Atik et al., 2022; Duarte et al., 2017; Gifford & Nilsson, 2014; Hunter et al., 2004; Torgler & García-Valiñas, 2007; Zelezny et al., 2000). Zelezny et al. (2000) suggest that a possible explanatory mechanism behind this effect refers to gender socialization processes. The associated care roles link certain behavioral norms to care and feeding tasks, cooperative behavior and empathic development. In that sense, it would be expected that caring for the environment and consistent attitudes would be more common in women/girls than in men/boys. Consistently, Plananska et al. (2023) suggest that gender symbolism can influence behavior or attitudes regarding pro-environmental products or initiatives. In that context, the hypothesis we propose posits that girls will show a greater willingness to act pro-environmentally than boys.

Another relevant aspect is immigrant background. Literature connects the disadvantaged background of minority groups with less involvement in climate action (Kessler & Pizmony-Levy, 2023), consistent with evidence associating immigration background with less sensitivity to pro-environmental social norms (Gifford & Nilsson, 2014). We can therefore hypothesize that immigrant students will show a lower willingness to act pro-environmentally than non-immigrant students.

Further, social position is a characteristic widely used to explain preferences, beliefs, attitudes, and social and political behavior, in both the adult and youth population. Evidence from multiple studies shows that education is a relevant aspect to explain the development of environmental concern; more educated people tend to develop, in general, higher levels of pro-environmental behavior and attitudes (Gifford & Nilsson, 2014). In this context, it is expected that people with greater access to education will be more able to acquire knowledge and awareness of environmental problems and be more willing to generate pro-environmental attitudes (Franzen & Vogl, 2013; Mónus, 2022). The development of material values hypothesis proposed by Ronald Inglehart (Inglehart, 1990; Inglehart & Baker, 2000), states that those generations socialized in developed contexts tend to emphasize more material values, closely linked to attitudes and pro-environmental behaviors. Thus, we propose that students from families with more education will show a greater willingness to act pro-environmentally than those from families with lower education.

Previous studies show that the availability of books at home also plays a role in the attitudinal development of young people. Particularly, Duarte et al. (2017) show that young people who grow up in families with more books tend to develop higher levels of pro-environmental attitudes. This is consistent with the idea that families transmit behaviors and attitudes to the next generation through the resources they make available to their children, in this case books. Thus, families express an orientation to the academic culture that permeates the development of skills (Evans et al., 2014), and in this case, attitudinal development (Miranda et al., 2018). Therefore, it is expected that young people who are more exposed to scholarly culture at home (more books) will present greater willingness to act pro-environmentally than young people who are less exposed to scholarly culture at home.

Why distinguish parental education and books at home to understand their influence on pro-environmental provisions? Educational studies show that the measurement of the social position of students (that is, of their families) is operationalized from variables such as the educational level of the parents, measures of occupational prestige, or family assets (possessions, wealth) (Brese & Mirazchiyski, 2011). Additionally, some studies include the number of books in the home. In other words, parental educational level and number of books in the home tend to be combined in the same indicator. However, there is literature that suggests that books can be valued by both modest and elite families (Sikora et al., 2019). Previous studies show that different aspects considered in social stratification can generate differentiated results. For example, position in the labor market has the potential to influence political attitudes (Chan & Goldthorpe, 2007; Elsässer & Schäfer, 2016), educational level is associated with political attitudes and behavior (Miranda et al., 2018; Schlozman et al., 2012), and the number of books in the home is linked to the development of cognitive abilities, increased intellectual capacities (Evans et al., 2010, 2014, 2015; Park, 2008), and increased post-materialist dispositions such as environmental attitudes (Boeve-de Pauw & Petegem, 2010; Duarte et al., 2017).

Although the different aspects of social position are aligned (correlate with each other), number of books in the home has been considered as an aspect that can be more differentiated from the others. Sikora et al. (2019) consider that books in the home represent an academic family culture that prioritizes book-oriented socialization and, as stated, can be observed in both elite and modest families. Book availability may involve solitary activities, interaction with others, imaginative play, vocabulary development, or recreational reading. This framework is associated with greater success in academic achievement and better employment positions. An important characteristic, which makes it relevant to distinguish the availability of books from other aspects of social position, is that it has the greatest potential to benefit those who are most disadvantaged (Evans et al., 2010, 2014, 2015). In this sense, there is a need to consider the differences in the different aspects of social origin to assess the nuances in the development of attitudes, beliefs and behavior (Barsegyan et al., 2023; Bukodi & Goldthorpe, 2012; Jæger, 2007; Miranda, 2023).

To advance along this line, on the one hand we will evaluate the way in which these resource variables interact; that is, to what extent education conditions the effect of books. This implies three possible results. First, the availability of books generates a more positive effect in families with higher educational levels, which would be an acceleration effect between these two forms of resources. This effect would be aligned with the idea that these two forms of resources generate a double benefit, that is, they enhance each other as is observed in previous studies

(Duarte et al., 2017). Second, education does not condition the role that books play, which would imply that both forms of resources do not interact. And third, the availability of books generates a more positive effect on environmental attitudes in those students who came from families with a lower educational level, which would be aligned with the compensation hypothesis of academic culture and its greater benefit in disadvantaged groups (Evans et al., 2010; Sikora et al., 2019). On the other hand, in a more exploratory sense, it will be evaluated to what extent these resources (education and books) can moderate the observed gender differences.

9.3 Results

Do students differ in their future intention of protecting the environment in terms of gender, immigrant background, parental education, and number of books at home? The first set of models (M1 to M4) that included only the factor of interest, showed that the four evaluated aspects indicate gaps in willingness to act pro-environmentally by parental education, books at home, gender of the student, and immigration background, on average. Model 1 showed that students from families where at least one parent completed a bachelor's degree or higher tend to present slightly higher willingness to act pro-environmentally (M1: E = 0.14 ***, OR = 1.15). Model 2 indicated that students from homes with more books at home are more willing to make efforts to protect the environment in the future (M2: E = 0.23 ***, OR = 1.26). Moreover, female students are more oriented to protect the environment (M3: E = 0.52 ***, OR = 1.68). Finally, students with immigrant background are less willing to engage in future personal efforts to protect the environment (M4: E = −0.35 ***, OR = 0.71). The model that included the four variables of interest (M5), showed that all the considered factors still displayed differences. Finally, we estimated models with interaction terms (M6), where the considered factors still displayed differences, and a model including all countries[1] as a fixed effect (M7). In results of the latter, immigration background was no longer significant. This is most likely due to the differing proportions of students with immigrant background between countries. Similarly, the coefficient of books at home was larger in this latter model (M7: E = 0.40 ***, OR = 1.40), also signaling varying proportions of number of books at home between countries.

The fitted models estimated overall relations between the response variable and the factor of interest across countries but did not inform us on country differences. Thus, we estimated single models per covariate and for the main interactions, for the pooled sample and for each country, and retrieved expected proportion of response to the highest category. This latter approach allowed us to illustrate the main results. Figure 9.1 shows country differences in terms of differing parental educational attainment. In all assessed countries the tendency was the same, but the differences

[1] The term "countries" is sometimes used in this chapter to refer to both countries and benchmarking participants, for ease of reading.

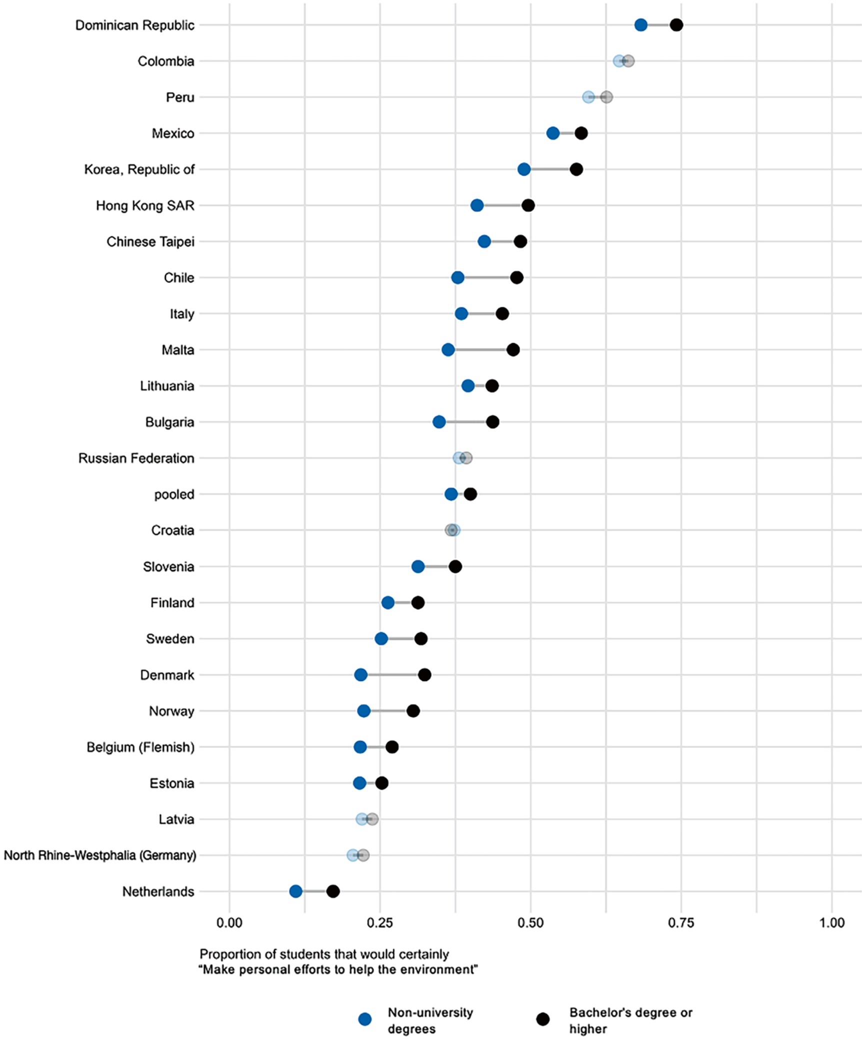


Fig. 9.1 Willingness to act pro-environmentally among students by parental education

between parental educational attainment were non-statistically significant in some countries (Colombia, Peru, the Russian Federation, Croatia, Latvia and North Rhine-Westphalia). In those countries where the differences were statistically significant there was variability in the size of the gap. For instance, in Malta, a country with bigger difference, students from non-tertiary education families showed approximately 36% (blue dot) would certainly make personal efforts to help the environment while students from tertiary education families showed approximately 48% (black dot)—an approximate 12% of difference. On the contrary, observing the plot for Estonia, a country with a smaller difference, students from non-tertiary education families (blue dot) showed approximately 22% would certainly make personal efforts to help the environment, while students from tertiary education families (black dot) rose above 25%—an approximate 3% of difference.

Figure 9.2 allows for observation of differences in terms of scholarly culture. In all assessed countries the tendency was the same, but the differences between the number of books were non-statistically significant in some countries (the Dominican Republic, Peru, the Russian Federation and Croatia). In those countries where the differences were statistically significant there was variability in the size of the gap. For instance, observing the plot for Chile, a country with a bigger difference, students with up to 100 books at home (blue dot) showed approximately 36% that

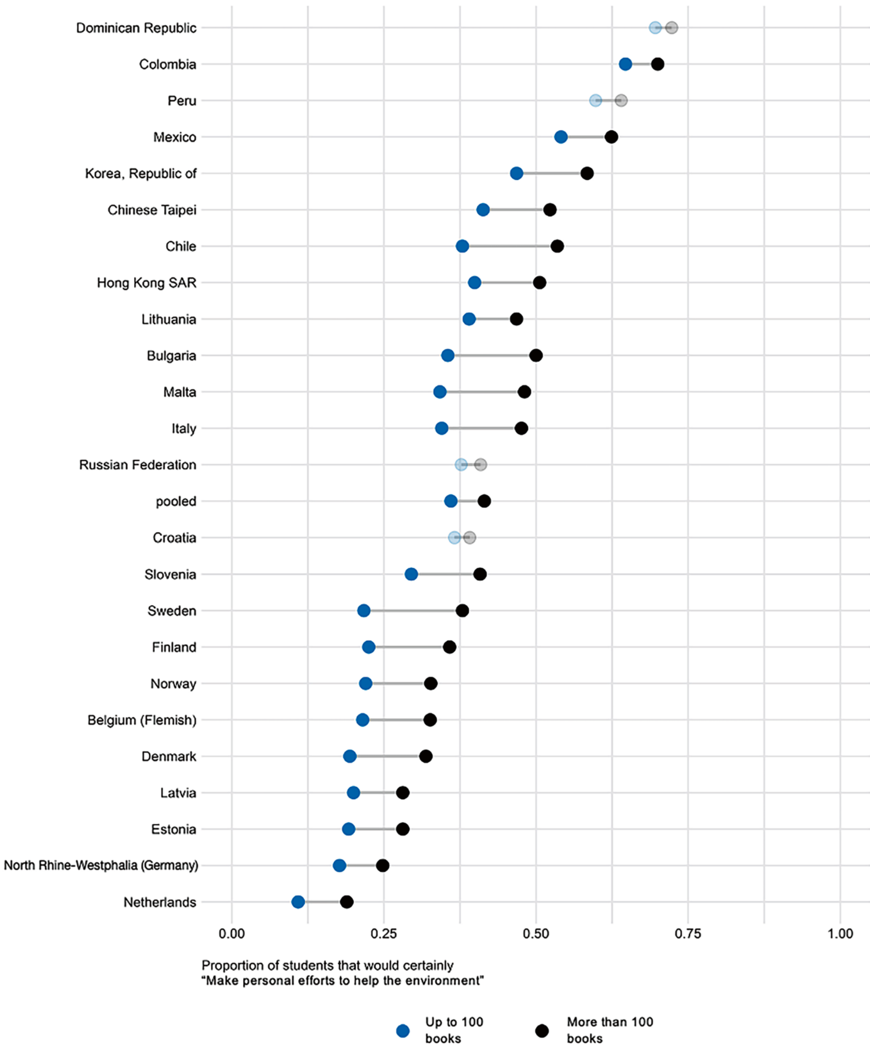


Fig. 9.2 Willingness to act pro-environmentally among students by number of books at home

would certainly make personal efforts to help the environment, while students with more than 100 books at home (black dot) rose above 50%—an approximate 14% of difference. On the contrary, observing the plot for Colombia, a country with a smaller difference, students with up to 100 books at home (blue dot) showed approximately 64% that would certainly make personal efforts to help the environment, while students with more than 100 books at home (black dot) rose above 70%—an approximate 6% of difference.

Figure 9.3 allows for observation of differences in terms of gender. In all assessed countries the tendency was the same, the differences between boys and girls were statistically significant in all countries. Nevertheless, there were differences in the

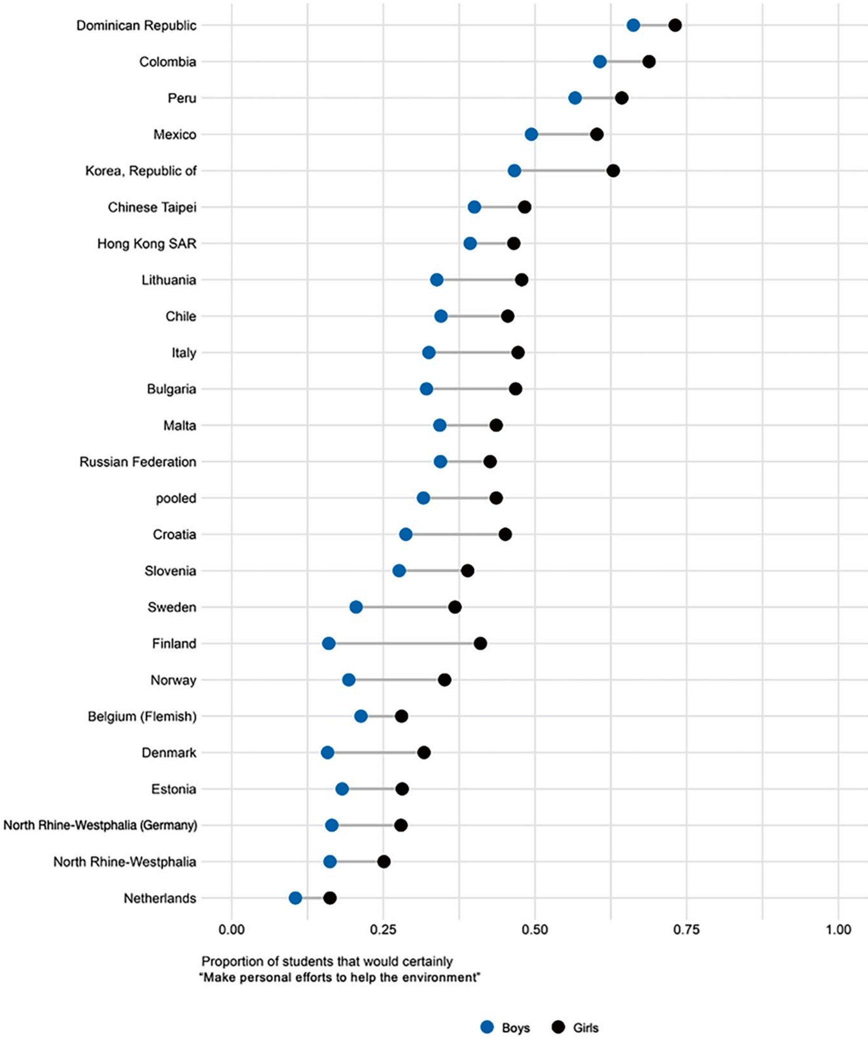


Fig. 9.3 Willingness to act pro-environmentally among students, conditional to their gender

levels and size of the gap in reference to the pooled estimation. For instance, on the one hand, Finnish boys (blue dot) showed approximately 15% would certainly make personal efforts to help the environment while this was approximately 40% for girls (black dot)—an approximate 25% of difference. On the other hand, the difference was lower in countries like Belgium or the Netherlands. Belgian boys (blue dot) showed approximately 20% would certainly make personal efforts to help the environment while this was approximately 25% for girls (black dot)—an approximate 5% of difference.

But are all these gaps homogenous? In particular, does family education or scholarly culture play any additional role in this context? In Table 9.1, Model 6 and Model 7 included the interaction term between parental education and number of books at home (M6: E = 0.22 ***, OR = 1.22; M7: E = 0.12 ***, OR = 1.13). In terms of expected proportion of response to the highest category, $\Pr(y \geq 4)$, in the pooled sample, students from families with lower education and lower number of books at home (100 books or less) reached 36%, whereas students from families with a scholarly culture and lower educational attainment were expected to reach 39% of students, showing a higher willingness to protect the environment. Moreover, this latter gap was larger among students from families with bachelor's degrees or higher. From this latter group, students from families with lower number of books at home (100 or less), 33% were expected to be certainly willing to protect the environment, whereas within students from families with the same educational level, yet with a higher scholarly culture (100 books or more), we expected a higher proportion of 45% of students would be willing to protect the environment to a higher degree ("I will certainly do this"). We illustrate these results in Fig. 9.4. The gap between having less and more than 100 books is higher in the panel for families with a bachelor's degree or higher for most countries. Nevertheless, the pattern could be the opposite in some countries. For instance, in Chile the gap between number of books was higher in the condition of non-university families. In Slovenia and North Rhine-Westphalia the gap was statistically significant only in the condition of non-university families. These results partially support the compensation hypothesis of scholarly culture.

In the same vein, we included the interaction term for parental education and students' gender. Results from Model 6 and Model 7 were of similar size (M6: E = 0.07 *, OR = 1.07; M7: E = 0.07 *, OR = 1.07). In the pooled sample, from families with non-university degrees, we expected that 31% of boys would certainly be willing to protect the environment through personal efforts, while we expected the same response for 42% of girls. In contrast, among families with bachelor's degrees or higher, we expected 33% of boys to give the same response, while we expected a slightly larger proportion of girls, 47%, expressing the same willingness to act pro-environmentally. In Fig. 9.5 we produce estimates for the interplay between these two factors. The gap between boys and girls tends to be larger in the right-side panel, in comparison to the left side panel.

Finally, we estimated the interaction between number of books at home and students' gender. Results also supported a moderation effect of number of books onto students' gender gaps in the pooled sample. While we expected that 31% of boys

Table 9.1 Population average estimates for ordinal logits of students willing to make personal efforts to protect the environment

		M1		M2		M3		M4		M5		M6		M7	
Parameter	Variables	E	P<	E	P<	E	P<	E	P<	E	P<	E	P<	E	P<
β_1	Parent education (university)	0.14	***							0.10	***	0.08	***	0.17	***
		(0.02)								(0.02)		(0.02)		(0.02)	
β_2	Books at home (100 or more)			0.23	***					0.18	***	0.16	***	0.40	***
				(0.02)						(0.02)		(0.02)		(0.02)	
β_3	Sex (girls)					0.52	***			0.52	***	0.51	***	0.55	***
						(0.02)				(0.02)		(0.02)		(0.02)	
β_4	Immigrant (yes)							−0.35	***	−0.32	***	−0.33	***	−0.01	
								(0.03)		(0.04)		(0.04)		(0.03)	
β_5	Parent education * books at home											0.22	***	0.12	**
												(0.04)		(0.04)	
β_6	Parent education * sex											0.07	*	0.07	*
												(0.03)		(0.04)	
β_7	Books at home * sex											0.19	***	0.24	***
												(0.04)		(0.04)	
	Thresholds														
τ_1	1 vs 2, 3, 4	−2.93	***	−2.93	***	−2.96	***	−2.94	***	−2.96	***	−2.95	***	−3.12	***
		(0.02)		(0.02)		(0.02)		(0.02)		(0.02)		(0.02)		(0.07)	
τ_2	1, 2 vs 3, 4	−1.38	***	−1.38	***	−1.39	***	−1.38	***	−1.40	***	−1.38	***	−1.50	***
		(0.01)		(0.01)		(0.01)		(0.01)		(0.01)		(0.01)		(0.06)	
τ_3	1, 2, 3 vs 4	0.49	***	0.50	***	0.50	***	0.49	***	0.51	***	0.52	***	0.58	***
		(0.01)		(0.01)		(0.01)		(0.01)		(0.01)		(0.01)		(0.06)	

Notes: E = Unstandardized estimates are included with their accompanying standard error in parenthesis in the following row. Model 7 displays all estimates while including the country fixed effects (not shown). P < are *** = $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$

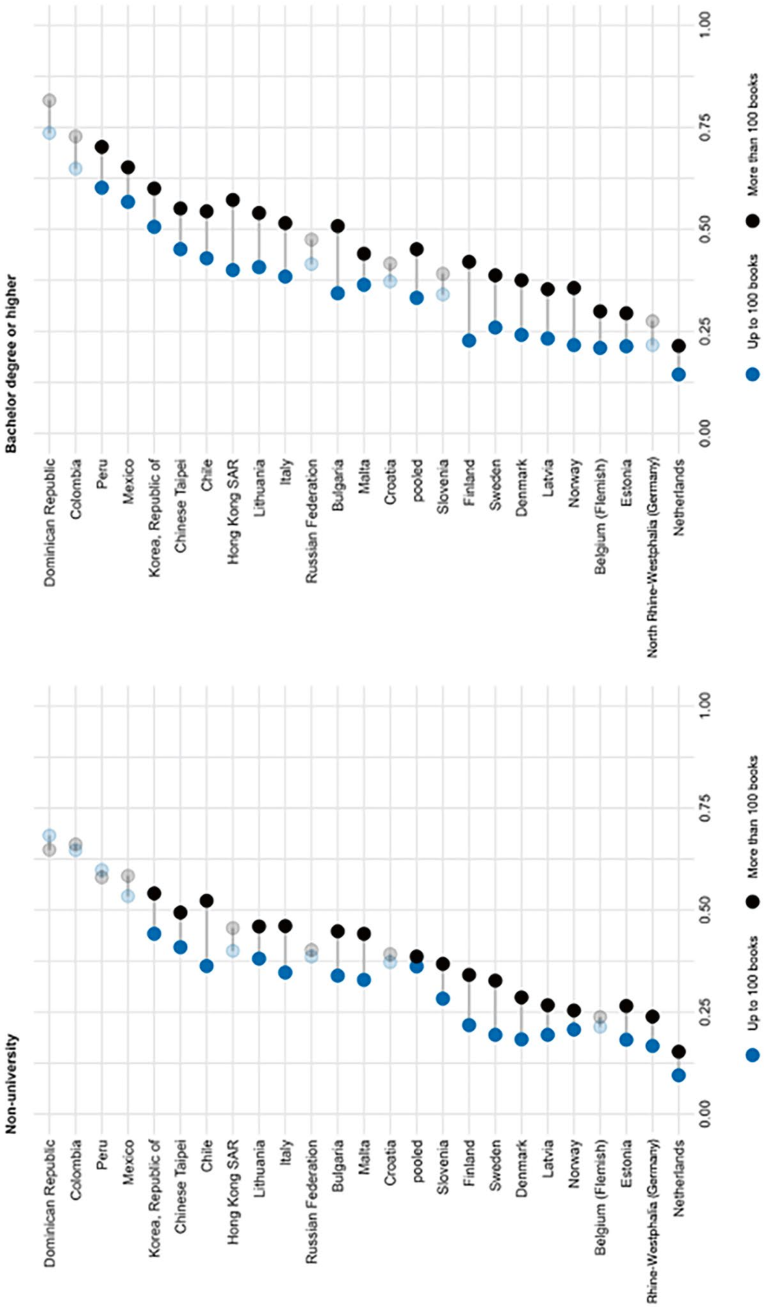


Fig. 9.4 Willingness to act pro-environmentally among students by number of books at home and by parental education

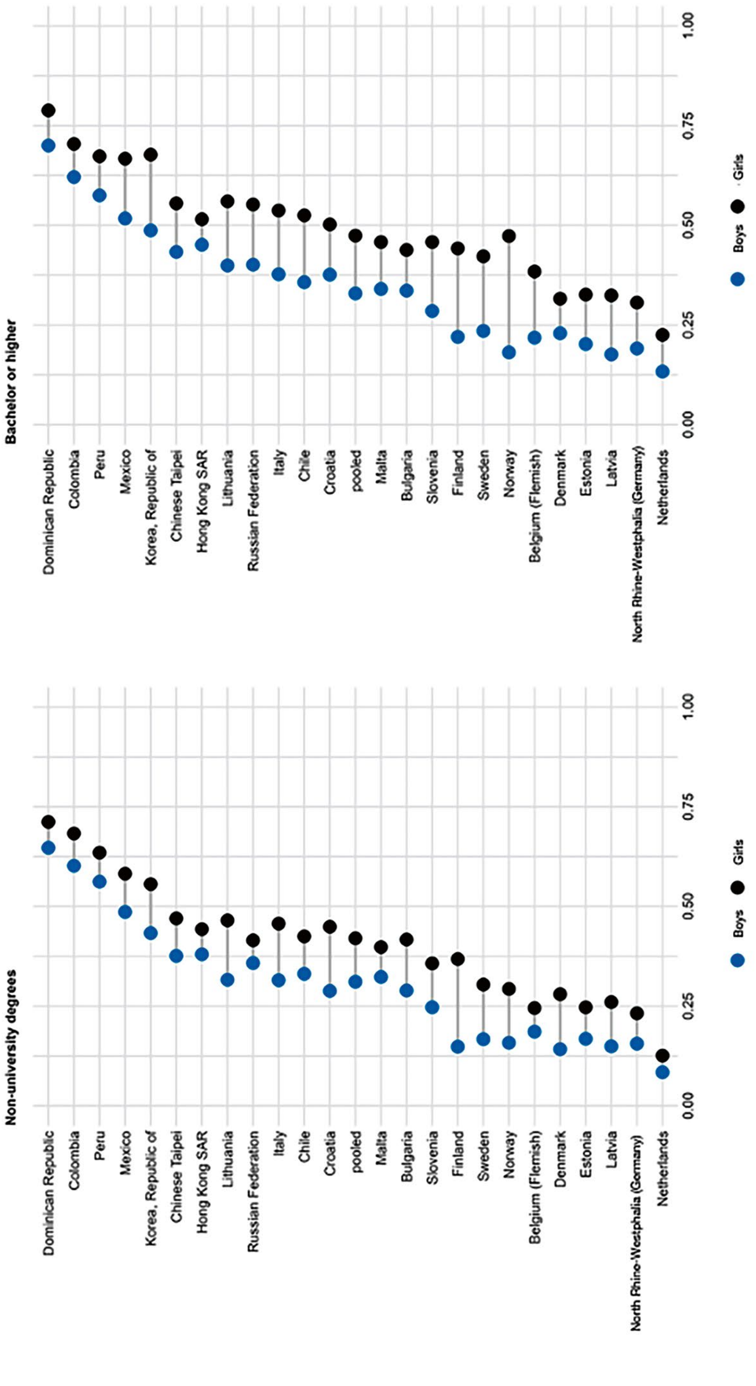


Fig. 9.5 Willingness to act pro-environmentally among students by gender and by parental education

would certainly be willing to protect the environment through personal efforts when coming from families with up to 100 books at home, we expected a higher proportion of girls, 41%, with the same willingness to act pro-environmentally. Whereas, in families with a higher number of books (more than 100 books at home), hence a scholarly culture, we expected a higher proportion of girls with a high willingness to act pro-environmentally (51%), we expected a smaller proportion of boys giving the same response (34%). In Fig. 9.6 we present the expected proportion for girls and boys, by number of books at home. The gender gap is larger among countries in the right-side panel (more than 100 books) than in the left side panel (up to a 100 books).

9.4 Conclusion

This chapter aimed to evaluate a series of gaps regarding willingness to act pro-environmentally. Specifically, we sought to provide information about the extent to which characteristics such as the educational level of parents, the number of books available at home, and student gender and immigration status play a role in student population differences regarding such willingness.

The results show important gaps regarding the aspects evaluated. In a series of bivariate models, it is possible to observe that students who come from families with a university education (at least one of the parents), and students who come from families with a greater availability of books at home (more than 100 books) generally tend to show a greater willingness to "Make personal efforts to help the environment." This result is in line with the literature which suggests that the development of this type of attitude, considered as a post-materialist attitude or relevant attitude for the twenty-first century, tends to show links with the stratification of societies. Thus, people with more privileges have greater chances of developing this type of attitude. The mechanism that would be behind this pattern is here linked to resources, particularly education and in this case also an academic culture, expressed in the availability of books at home. This allows greater exposure to the principles that support the care of the environment and its foundations. For example, a person exposed to more years of parental education will have more time to experience the institutions and discourses that promote this type of attitude. Thus, in more specific terms for the youth population, the fact that young people are exposed to families with greater educational achievement allows them to be exposed to discourses and principles that allow the development of pro-environmental attitudes. A similar logic could operate with the scholarly culture at home. Books translate into greater information and knowledge on these types of topics (as Chap. 5 in this volume shows). It is important to mention that although both factors still have a statistically significant effect, their expected conditional probabilities vary in size. Thus, although parental education shows an effect, it is slightly smaller in comparison to the main effect of books. This is consistent with some studies that have observed that parental education may not have an effect on environmental attitudes (Leppänen et al., 2012).

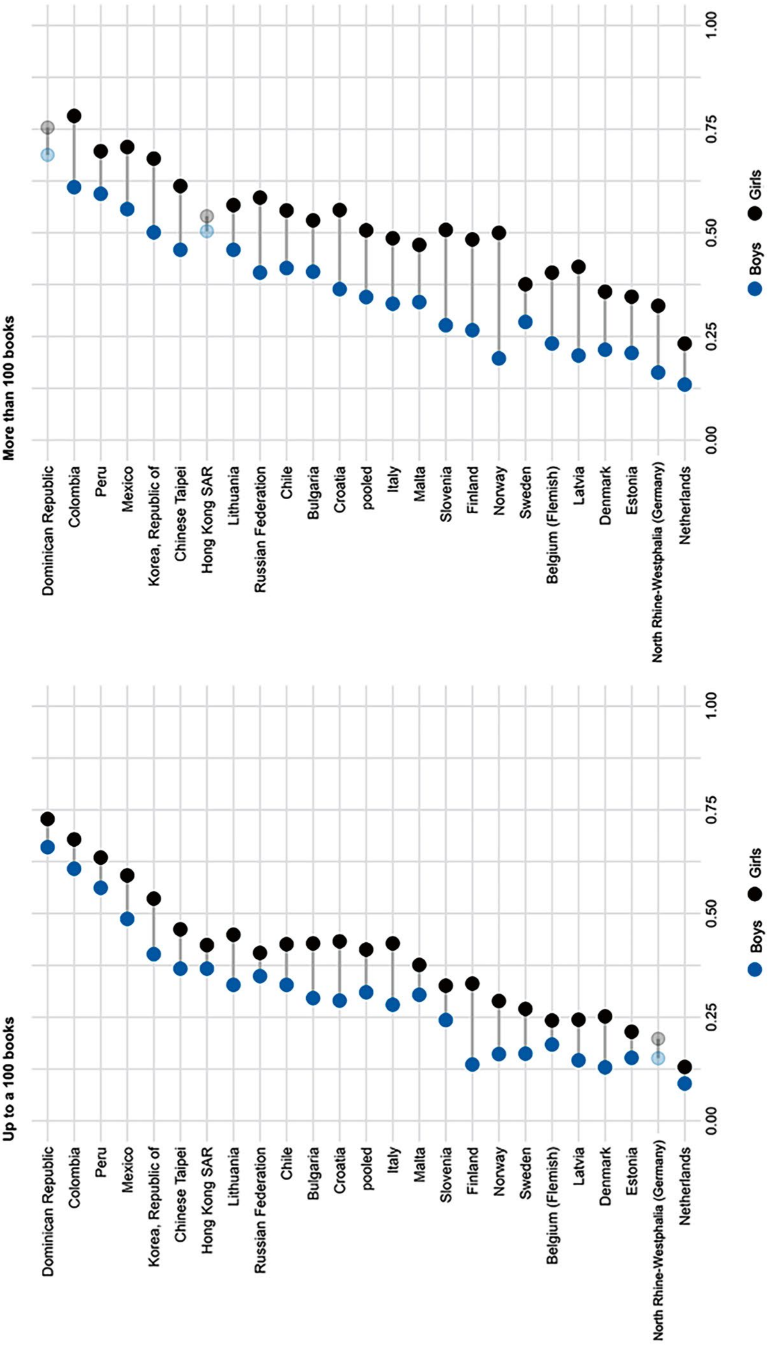


Fig. 9.6 Willingness to act pro-environmentally among students by gender and by number of books at home

The results also show that gender and immigration status are important aspects when considering inequalities around the development of pro-environmental attitudes. Consistent with results from previous literature (Gifford & Nilsson, 2014), it is shown that girls show a greater willingness to make personal efforts to care for the environment. Part of the explanation for this result may be linked to the differences in socialization between girls and boys. Previous literature shows that girls are much more aligned with democratic values or tolerant attitudes as a result of a socialization that promotes them. In this sense, considering gender as an aspect of the development and promotion of the environment seems to be unavoidable. Additionally, based on the interaction models, girls develop even higher willingness to act pro-environmentally when they come from families with higher education or with a higher scholarly culture. This result is similar to previous findings that indicate girls develop higher environmental attitudes when living in families with more books (Duarte et al., 2017).

In the case of immigration status, the explanation is less clear, considering that even controlling for education and books, children who have a migratory background show lower willingness to act pro-environmentally. It would be interesting to unravel in future research what mechanism may operate here. It is possible that the level of development of the country of origin or cultural characteristics may play a role, and that this is reflected in the attitudinal differences with nationals as suggested by Gifford and Nilsson (2014). This information is impossible to obtain from the ICCS study, so it would be interesting to add a question characterizing the country of origin for students with migratory background.

The hypothesis of family scholarly culture stated that the students who would benefit most from the greater availability of books would be those in the lowest socioeconomic positions (in this case in families with less education to the tertiary). The present results are not consistent with this hypothesis. Contrary to what was observed in studies that evaluate academic achievement (Sikora et al., 2019), we found a reverse effect, where there is a double benefit between parental education and the number of books available at home. That is, students who have a greater availability of literary resources (more than 100 books on site) develop a greater willingness to make personal efforts to protect the environment when they grow up in families with higher education attainment (bachelor's degrees or higher). This supports the traditional idea that different forms of stratification enhance each other, and that they could be used interchangeably since they show a similar history. However, when focusing on the results per country, we observed a more complex pattern. For example, in Chile the gap between students with less and more books at home is higher among the less educated families. In Slovenia and North Rhine-Westphalia the gap is statically significant only in the condition of non-university families. These results highlight the need for research into the compensation hypothesis of scholarly culture, not only in measures of achievement but also regarding civic dispositions. As recent research has shown, it is relevant to distinguish the differentiated effects that these stratification measurements can have on sociopolitical results (Miranda, 2023).

The present study evaluates a measure of willingness to make efforts to help the environment that has some limitations. It is important to note that these results are targeted at evaluating a very specific aspect of pro-environmental intentions—willingness to act pro-environmentally. Of course, having only one item available to evaluate these attitudes is not sufficient to comprehensively cover attitudinal development toward the environment. The available measurements cover only a limited willingness to contribute to sustainable development, leaving out aspects from the action competence framework, such as knowledge and skills, capacity expectations and outcome expectancy, as well as interacting social and economic features related to sustainability. In that sense, the results are limited to the measurements available in this type of study. Future international large-scale assessments among young people should incorporate complex measurements of sustainability dimensions that allow this important issue to be addressed in a more complex and comprehensive way.

Acknowledgements The first author received support from the Chilean National Agency of Research and Development through the grants ANID/FONDECYT N° 1240922, the Center of Social Conflict and Cohesion Studies–COES ANID/FONDAP N° 1523A0005 and the Millennium Science Initiative Program under grant NCS2022_046—Millennium Nucleus on Digital Inequalities and Opportunities (NUDOS).

References

Atik, A. D., Işıldar, G. Y., & Erkoç, F. (2022). Prediction of secondary school students' environmental attitudes by a logistic regression model. *Environment, Development and Sustainability, 24*(3), 4355–4370. https://doi.org/10.1007/s10668-021-01618-3

Barsegyan, V., Knigge, A., & Maas, I. (2023). Social origin and political participation: Does education compensate for or reinforce family advantages and disadvantages? *Acta Politica, 59*, 340–363. https://doi.org/10.1057/s41269-023-00296-5

Bessant, J., Mesinas, A. M., & Pickard, S. (2021). *When students protest: Secondary and high schools*. Rowman & Littlefield.

Boeve-de Pauw, J., & Petegem, P. V. (2010). A cross-national perspective on youth environmental attitudes. *The Environmentalist, 30*(2), 133–144. https://doi.org/10.1007/s10669-009-9253-1

Brese, F., & Mirazchiyski, P. V. (2011). *Measures of students' family background in large-scale education studies: Evaluation of current practices and recommendations for the future*. *IERI monograph series.* Issues and Methodologies in Large-Scale Assessments (Vol. 5*,* pp. 1–115). https://files.eric.ed.gov/fulltext/ED561898.pdf.

Bukodi, E., & Goldthorpe, J. H. (2012). Decomposing 'social origins': The effects of parents' class, status, and education on the educational attainment of their children. *European Sociological Review, 29*(5), 1024–1039. https://doi.org/10.1093/esr/jcs079

Chan, T. W., & Goldthorpe, J. H. (2007). Class and status: The conceptual distinction and its empirical relevance. *American Sociological Review, 72*(4), 512–532. https://doi.org/10.1177/000312240707200402

Duarte, R., Escario, J. J., & Sanagustín, M. V. (2017). The influence of the family, the school, and the group on the environmental attitudes of European students. *Environmental Education Research, 23*(1), 23–42. https://doi.org/10.1080/13504622.2015.1074660

Elsässer, L., & Schäfer, A. (2016). *Group representation for the working class? Opinion differences among occupational groups in Germany* (MPIfG Discussion Paper, 16/3). https://hdl.handle.net/11858/00-001M-0000-0029-D51D-C

Evans, M. D. R., Kelley, J., Sikora, J., & Treiman, D. J. (2010). Family scholarly culture and educational success: Books and schooling in 27 nations. *Research in Social Stratification and Mobility, 28*(2), 171–197. https://doi.org/10.1016/j.rssm.2010.01.002

Evans, M. D. R., Kelley, J., & Sikora, J. (2014). Scholarly culture and academic performance in 42 nations. *Social Forces, 92*(4), 1573–1605. https://doi.org/10.1093/sf/sou030

Evans, M. D. R., Kelley, J., Sikora, J., & Treiman, D. J. (2015). Scholarly culture and occupational success in 31 societies. *Comparative Sociology, 14*(2), 176–218.

Franzen, A., & Vogl, D. (2013). Two decades of measuring environmental attitudes: A comparative analysis of 33 countries. *Global Environmental Change, 23*(5), 1001–1008. https://doi.org/10.1016/j.gloenvcha.2013.03.009

Gifford, R., & Nilsson, A. (2014). Personal and social factors that influence pro-environmental concern and behaviour: A review. *International Journal of Psychology, 49*(3), 141–157. https://doi.org/10.1002/ijop.12034

Hunter, L. M., Hatch, A., & Johnson, A. (2004). Cross-national gender variation in environmental behaviors. *Social Science Quarterly, 85*(3), 677–694. https://doi.org/10.1111/j.0038-4941.2004.00239.x

Inglehart, R. (1990). *Culture shift in advanced industrial society*. Princeton University Press.

Inglehart, R., & Baker, W. E. (2000). Modernization, cultural change, and the persistence of traditional values. *American Sociological Review, 65*(1), 19–51. https://doi.org/10.2307/2657288

Jæger, M. M. (2007). Educational mobility across three generations: The changing impact of parental social class, economic, cultural and social capital. *European Societies, 9*(4), 527–550. https://doi.org/10.1080/14616690701449568

Kessler, E. L. (2023). *What future are we studying for? School engagement and youth agency in the youth climate movement.* Doctoral thesis, Columbia University. Academic Commons. https://doi.org/10.7916/dmfc-r743.

Kessler, E. L., & Pizmony Levy, O. (2023). *Schools of activism: Social predictors of students' participation in climate action.* In Proceedings of the 2023 AERA Annual Meeting. American Educational Research Association. https://doi.org/10.3102/2010105.

Leppänen, J. M., Haahla, A. E., Lensu, A. M., & Kuitunen, M. T. (2012). Parent-child similarity in environmental attitudes: A pairwise comparison. *The Journal of Environmental Education, 43*(3), 162–176. https://doi.org/10.1080/00958964.2011.634449

Li, D., Zhao, L., Ma, S., Shao, S., & Zhang, L. (2019). What influences an individual's pro-environmental behavior? A literature review. *Resources, Conservation and Recycling, 146*, 28–34. https://doi.org/10.1016/j.resconrec.2019.03.024

Miranda, D. (2023). Socio-economic inequalities of families and their differential impact on types of political participation in the new generation of 24 countries (Desigualdades socio-económicas familiares y su impacto diferencial sobre tipos de participación política de nuevas generaciones en 24 países). *International Journal of Social Psychology, 38*(3), 602–641. https://doi.org/10.1080/02134748.2023.2239576

Miranda, D., Castillo, J. C., & Cumsille, P. (2018). The political socialization of attitudes toward equal rights from a comparative perspective. In A. Sandoval-Hernández, M. M. Isac, & D. Miranda (Eds.), *Teaching tolerance in a globalized world* (IEA research for education) (Vol. 4, pp. 103–123). Springer. https://doi.org/10.1007/978-3-319-78692-6_7

Mónus, F. (2022). Environmental education policy of schools and socioeconomic background affect environmental attitudes and pro-environmental behavior of secondary school students. *Environmental Education Research, 28*(2), 169–196. https://doi.org/10.1080/13504622.2021.2023106

Park, H. (2008). Home literacy environments and children's reading performance: A comparative study of 25 countries. *Educational Research and Evaluation, 14*(6), 489–505. https://doi.org/10.1080/13803610802576734

Pickard, S. (2023). Disruptive do-it-ourselves politics: Young climate and environmental activists. In J. Bessant, P. Collin, & P. O'Keeffe (Eds.), *Research handbook on the sociology of youth* (pp. 254–268). Edward Elgar. https://hal.science/hal-04126659

Plananska, J., Wüstenhagen, R., & de Bellis, E. (2023). Perceived lack of masculinity as a barrier to adoption of electric cars? An empirical investigation of gender associations with low-carbon vehicles. *Travel Behaviour and Society, 32*, 100593. https://doi.org/10.1016/j.tbs.2023.100593

Schlozman, K. L., Verba, S., & Brady, H. E. (2012). *The unheavenly chorus: Unequal political voice and the broken promise of American democracy*. Princeton University Press. https://doi.org/10.1515/9781400841912

Sikora, J., Evans, M. D. R., & Kelley, J. (2019). Scholarly culture: How books in adolescence enhance adult literacy, numeracy and technology skills in 31 societies. *Social Science Research, 77*, 1–15. https://doi.org/10.1016/j.ssresearch.2018.10.003

Torgler, B., & García-Valiñas, M. A. (2007). The determinants of individuals' attitudes towards preventing environmental damage. *Ecological Economics, 63*(2), 536–552. https://doi.org/10.1016/j.ecolecon.2006.12.013

Zelezny, L. C., Chua, P. P., & Aldrich, C. (2000). New ways of thinking about environmentalism: Elaborating on gender differences in environmentalism. *Journal of Social Issues, 56*(3), 443–457. https://doi.org/10.1111/0022-4537.00177

Chapter 10
School Factors and Students' Willingness to Act Pro-environmentally in the Future

Ernesto Treviño and Diego Carrasco

10.1 Introduction

Environmental degradation requires sustained actions to generate awareness that the human species is an integral part of the environment (Núñez Tobar et al., 2023). As early as 1987, the Brundtland report (World Commission on Environment and Development, 1987) identified the challenges regarding resource depletion and pollution, coupled with poverty and hunger, in the path towards countries' economic development (Keeble, 1988).

The notion of sustainable development is a conceptual tool which may shape strategies to face environmental impacts related to economic development. This may be accomplished through reducing consumption, reusing products, and recycling waste, after creating consciousness among the population (Escario et al., 2020), as a way to safeguard the environment for future generations. Furthermore, sustainable development emphasizes the crucial role of education in empowering individuals and societies to take responsibility for shaping their future (Walid & Luetz, 2018). As such, school systems are viewed as an important vehicle to promote mental models regarding the relationship between humans and their environment, and they may offer opportunities to lead a change in mentality that considers humans not as mere users of the environment, but as part of interconnected ecological systems (Carr, 2016).

E. Treviño (✉)
Faculty of education and Centro de Justicia Educacional, Pontificia Universidad Católica de Chile, Santiago, Chile
e-mail: ernesto.trevino@uc.cl

D. Carrasco
Centro de Medición MIDE UC, Pontificia Universidad Católica de Chile, Santiago, Chile
e-mail: dacarras@uc.cl

M. M. Isac et al. (eds.), *Knowledge and Willingness to Act Pro-Environmentally*, IEA Research for Education 16, https://doi.org/10.1007/978-3-031-76033-4_10

Education for sustainable development (ESD) entails an action-oriented pedagogy, which instills in students the understanding that knowledge and skills need to be accompanied by actions to transform reality (González-Salamanca et al., 2020). However, to date, much of the research agenda has focused on how effective schools promote sustainability consciousness (see, for example, Berglund et al., 2014; Boeve-de Pauw et al., 2015; Olsson et al., 2016), instead of focusing on engagement into either present or future actions. Although bibliometrics analysis of ESD attests to a noticeable growth in publications since the Brundtland report of 1987 to the present (Grosseck et al., 2019), research exploring students' willingness to act pro-environmentally and its relation to school practices remains scarce (Verhelst et al., 2021). Moreover, contemporary educational effectiveness research regarding the implementation of ESD in schools highlights the need to address two aspects: (a) incorporating students' perceptions of relevant ESD teaching practices, and (b) employing an action-oriented focus (Isac et al., 2022; Sass et al., 2023; Sinakou et al., 2019).

The present chapter aims to bridge this latter gap. Making use of International Civic and Citizenship Education Study (ICCS) 2016 data from the International Association for the Evaluation of Educational Achievement (IEA), it looks into different school factors that may influence students' willingness to protect the environment. Essentially, it focuses on learning opportunities relevant to ESD. The study focuses on opportunities to learn (OTL) in schools according to different informants. Firstly, principals report on pro-environmental actions within the school, activities related to environmental sustainability, and the promotion of respect for and safeguarding of the environment. Secondly, the study analyzes students' perspectives on their OTL how to protect the environment at school, as well as the openness of classroom discussions. Finally, the study examines teachers' perceived preparedness to teach about the environment and their opportunities for training in this area.

There are two foreseeable limitations to the present study. On the one hand, the outcome variable is a single item in ICCS 2016, a feature that may limit the variability when measuring students' future intended personal efforts to protect the environment. Therefore, the present study only covers a single focus on students' intention to take action to protect the environment in the future, that contrasts with the full array of components related to action competence as a desired learning outcome of ESD. Additionally, the results constrain our capacity to make causal claims for two reasons. On the one hand, the results originate from an observational design study with a cross-sectional design of data collected in 2016. On the other hand, the methods used, along with the sampling design, do not necessarily warrant the proposition of causal inferences. Consequently, the interpretation of these results should be approached with caution.

10.2 The Role of Schools in Promoting the Protection of the Environment

Schools can offer students relevant ESD learning opportunities. The general idea behind OTL became popular from Carroll's conceptual model (Carroll, 1989), which consists of the idea that a student would learn content, as long as they are exposed to it for enough time (Schmidt et al., 2015). A broader interpretation of what learning opportunities may entail includes curricular coverage in schools, varying instructional quality, and teaching practices, among other relevant attributes of the learning environment of schools (Sandoval-Hernández, 2010). Within the ESD school effectiveness literature we found that students' action competence and their environmental consciousness vary according to the school they are in and are conditional to their school's practices (Berglund et al., 2014; Boeve-de Pauw et al., 2015; Coertjens et al., 2010; List et al., 2020; Olsson et al., 2016; Sass et al., 2022). For a specific example, we reviewed studies on school programs devoted to encouraging recycling behaviors among students. In school programs that aim to promote recycling behaviors, schools have found that teaching and engaging students in recycling activities lead to improvements in their environmental knowledge, particularly in waste management and recycling, as well as in their attitudes and actual engagement in recycling behaviors (Cheang et al., 2019; Goldman et al., 2018). As such, in the present study, we inquire if schools that implement sustainable practices and promote pro-environmental awareness are also more likely to have students with higher willingness to act pro-environmentally. For these purposes, we use indicators generated from the school database using both principal and teacher responses, as well as the student database, using student responses.

For schools to implement ESD teaching practices requires teachers who feel confident to include ESD within their practices and are previously trained for such a purpose (Isac et al., 2022). However, pre-service teacher training on ESD might not be consistent for teachers (Evans et al., 2017), and even though pre-service training may help teachers to gain knowledge of Sustainable Developmental Goals, this might not be enough to alter their teaching practices (García-González et al., 2020). For example, teachers feel less prepared to include ESD content in their teaching when there is a lack of available examples and they feel they lack sufficient expertise on sustainable development (Borg et al., 2012). Nevertheless, the longitudinal study by Boeve-de Pauw et al. (2022) showed that comprehensive training provided through an on-the-job ESD professional development program can enhance teachers' ESD teaching practices in the classroom. Moreover, Olsson et al. (2022) provide longitudinal evidence that, when teachers do include ESD practices in their teaching, students' knowledge regarding sustainability and their willingness to act increase as expected. Although the present study is cross-sectional in design, we include teachers' indicators of their training relative to the environment and environmental sustainability, and teachers' self-reports on readiness to teach ESD topics. We expect that students in schools with a higher proportion of teachers trained to teach ESD topics, are more willing to protect the environment in contrast to their peers, taught in schools with no trained teachers. Moreover, we also compare students' responses, conditional to the proportion of teachers who feel prepared to teach about the environment and environmental sustainability at their schools. We assume that students attending schools where teachers may feel more prepared to teach ESD-related topics, are more willing to act for the protection of the environment, in comparison to their peers.

Within the action competence model, pluralism is described as an ESD teaching practice that involves deliberative exercises with students, encouraging students to take different perspectives before making an informed choice on how to react to an ESD problem (Sass et al., 2023). This teaching practice is aimed at developing critical thinking, complex problem solving and collaborative decision-making among students (Isac et al., 2022). ESD school effectiveness studies have shown that when students were exposed to these practices, they improved their sustainability consciousness and action competence in terms of knowledge, as well as willingness to act (Boeve-de Pauw et al., 2015; Olsson et al., 2022). In the present study we use the measure of open classroom discussion from ICCS 2016 (Knowles et al., 2018), as an indicator of pluralistic ESD teaching practices, where controversial issues are discussed in the classroom, guided by the teachers, promoting facts and controversies to be understood and remembered by the students (Carrasco & Pavón Mediano, 2021). Considering the previous literature on ESD effectiveness, we expect students exposed to open classroom discussion are more willing to protect the environment, in contrast to their peers who are less exposed to such a teaching practice.

Informed by applications of theories of planned behavior on the promotion of pro-environmental behavior among high-school students (see, for example, de Leeuw et al., 2015), in the present study we also include student covariates as control variables, besides students' gender, immigrant background, parents' education and number of books at home (see Chap. 9), to look into the relationships between different learning opportunities students get and their willingness to act. Under an expanded version of models of planned behavior applied to pro-environmental behavior, previous studies have included past behavior, social norms, and environmental awareness, among other factors (Yuriev et al., 2020). In the current study, we selected the following covariates: (a) students' current behavior (participation in an environmental action group or organization); (b) pro-environmental social norms endorsement (prescriptive norms for "Taking part in activities to protect the environment" and "Making personal efforts to protect natural resources"); and (c) knowledge about different threats to the environment (pollution, water shortage, and climate change).

10.3 Analysis and Results

In the present study, we use a series of ordinal logit models (Rabe-Hesketh & Skrondal, 2012) to assess the relationship of all selected factors. We inquire if different OTL at school and teacher preparation contribute to students' willingness to act pro-environmentally. In the following section, we first describe how students' future willingness to protect the environment is related to the learning opportunities that schools provide,[1] controlling for students' current behavior, norms endorsement, and awareness of global threats.

10.3.1 Model Sequence

In the following section we report first on the overall model fit, by comparing the null model with models including covariates. We used a likelihood ratio test to assess the model and a subsequent model including a larger set of covariates and test their contribution to account for students' willingness to protect the environment (Masyn, 2014). We fitted a model including all student factors (current behavior, norms endorsement, threat awareness) (M8) in addition to the selected variables from Chap. 9 (M7). We then fitted a model with all OTL reported by school principals, teachers, and students (M9). We then proceeded to fit a model to assess teachers' readiness and previous teacher training regarding ESD (M10). Finally, we fitted a model with all country fixed effects (M11). This latter model is informative of any large differences between countries[2] in relation to the previously selected factors. We present the estimates of these fitted models in Tables 10.1 and 10.2.

10.3.2 Model Fit

Our selected variables fitted the observed data well, in comparison to the null model (LRT (23) = 13,346.04, $p < 0.001$). The saturated model (M10) with all the covariates of interest accounted for 22% of variance of students' willingness to make personal efforts to protect the environment, while 6% of additional variance was accounted for by country differences ($R^2_{M11} = 28\%$).

[1] In the present section, Hong Kong SAR and North Rhine-Westphalia are not included in the analysis. These two educational systems did not include teacher survey data and were therefore excluded from pooled modeling. However, these were included in the figures per covariate expected proportion of response when data was available.

[2] The term "countries" is sometimes used in this chapter to refer to both countries and benchmarking participants, for ease of reading.

Table 10.1 Population average estimates for ordinal logits of students' willingness to act pro-environmentally by student covariates

		M8		M9		M10		M11	
Parameter	*Variables*	E	P<	E	P<	E	P<	E	P<
β_1	Parent education (university)	0.01		−0.01		−0.01		0.08	**
		(0.02)		(0.02)		(0.02)		(0.02)	
β_2	Books at home (100 or more)	0.18	***	0.15	***	0.16	***	0.28	***
		(0.02)		(0.02)		(0.02)		(0.02)	
β_3	Gender (girls)	0.42	***	0.35	***	0.35	***	0.39	***
		(0.02)		(0.02)		(0.02)		(0.02)	
β_4	Immigrant (yes)	−0.20	***	−0.23	***	−0.20	***	0.07	
		(0.04)		(0.04)		(0.04)		(0.04)	
β_5	Parent education * books at home	0.21	***	0.21	***	0.20	***	0.16	***
		(0.04)		(0.04)		(0.04)		(0.04)	
β_6	Parent education * gender	0.03		0.04		0.03		0.03	
		(0.04)		(0.04)		(0.04)		(0.04)	
β_7	Books at home * gender	0.19	***	0.22	***	0.22	***	0.26	***
		(0.04)		(0.04)		(0.04)		(0.04)	
β_8	Current behavior	0.60	***	0.55	***	0.54	***	0.44	***
		(0.02)		(0.02)		(0.02)		(0.02)	
β_9	Prescriptive norms regarding taking part in pro-environmental activities	0.95	***	0.88	***	0.88	***	0.80	***
		(0.03)		(0.03)		(0.03)		(0.03)	
β_{10}	Prescriptive norms regarding pro-environmental individual actions	1.19	***	1.12	***	1.12	***	0.96	***
		(0.04)		(0.04)		(0.04)		(0.04)	
β_{11}	Threat awareness regarding pollution	0.52	***	0.46	***	0.46	***	0.48	***
		(0.03)		(0.03)		(0.03)		(0.03)	
β_{12}	Threat awareness regarding water shortages	0.36	***	0.33	***	0.33	***	0.23	***
		(0.02)		(0.02)		(0.02)		(0.02)	
β_{13}	Threat awareness regarding climate change	0.24	***	0.22	***	0.22	***	0.26	***
		(0.02)		(0.02)		(0.02)		(0.02)	

Notes: E = Unstandardized estimates are included with their accompanying standard error in parenthesis in the following row. Model 11 displays all estimates while including the country fixed effects (not shown). P < are *** = $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$

10.3.3 Student Covariates

The selected student covariates of current behavior, norms endorsement, and awareness of environmental threats accounted for an additional portion of the variance, as compared to a model that only included inequality factors (students' gender,

Table 10.2 Population average estimates for ordinal logits of students' willingness to act pro-environmentally, by OTL indicators

		M9		M10		M11	
Parameter	Variable	E	P<	E	P<	E	P<
β_{14}	Schools' likelihood of implementing pro-environment practices	0.01		0.02		0.02	
		(0.02)		(0.02)		(0.01)	
β_{15}	Students' exposure to activities related to environmental sustainability	−0.01		−0.01		−0.02	
		(0.03)		(0.03)		(0.02)	
β_{16}	Schools' likelihood of implementing pro-environment awareness activities	0.00		−0.01		0.01	
		(0.03)		(0.03)		(0.02)	
β_{17}	Schools promote respect for and safeguard of the environment	−0.01		−0.01		−0.01	
		(0.03)		(0.03)		(0.02)	
β_{18w}	Opportunities to learn how to protect the environment (w)	0.55	***	0.55	***	0.59	***
		(0.02)		(0.02)		(0.02)	
β_{18b}	Opportunities to learn how to protect the environment (b)	0.85	***	0.86	***	0.93	***
		(0.11)		(0.11)		(0.08)	
β_{19w}	Open classroom discussion (w)	0.14	***	0.14	***	0.16	***
		(0.01)		(0.01)		(0.01)	
β_{19b}	Open classroom discussion (b)	0.27	***	0.28	***	0.28	***
		(0.05)		(0.05)		(0.03)	
β_{20}	Teacher readiness to teach about the environment and environmental sustainability			−0.20	**	−0.10	*
				(0.07)		(0.04)	
β_{21}	Teacher trained to teach about the environment and environmental sustainability			0.37	***	0.03	
				(0.04)		(0.03)	
	Thresholds						
τ_1	1 vs 2, 3, 4	−3.47	***	−3.26	***	−3.54	***
		(0.03)		(0.04)		(0.06)	
τ_2	1, 2 vs 3, 4	−1.66	***	−1.46	***	−1.70	***
		(0.02)		(0.03)		(0.05)	
τ_3	1, 2, 3 vs 4	0.58	***	0.80	***	0.67	***
		(0.01)		(0.03)		(0.05)	

Notes: E = Unstandardized estimates are included with their accompanying standard error in parenthesis in the following row. Model 11 displayed all estimates while including the country fixed effects (not shown). P < are *** = $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$
(w) Within school centered
(b) Means score centered at the country mean

parents' education, number of books at home, and immigration background) (R^2_{M7} = 3%, R^2_{M8} = 19%, LRT (6) = 9749.53, $p < 0.00$). All these covariates presented positive results in relation to students' willingness to help the environment. For example, students that considered "Making personal efforts to protect natural resources" as very and quite important to be considered a good adult citizen, which is a prescriptive social norm endorsement, were also more willing to make personal efforts to help the environment (M11: E = 0.96 ***, OR = 2.60).

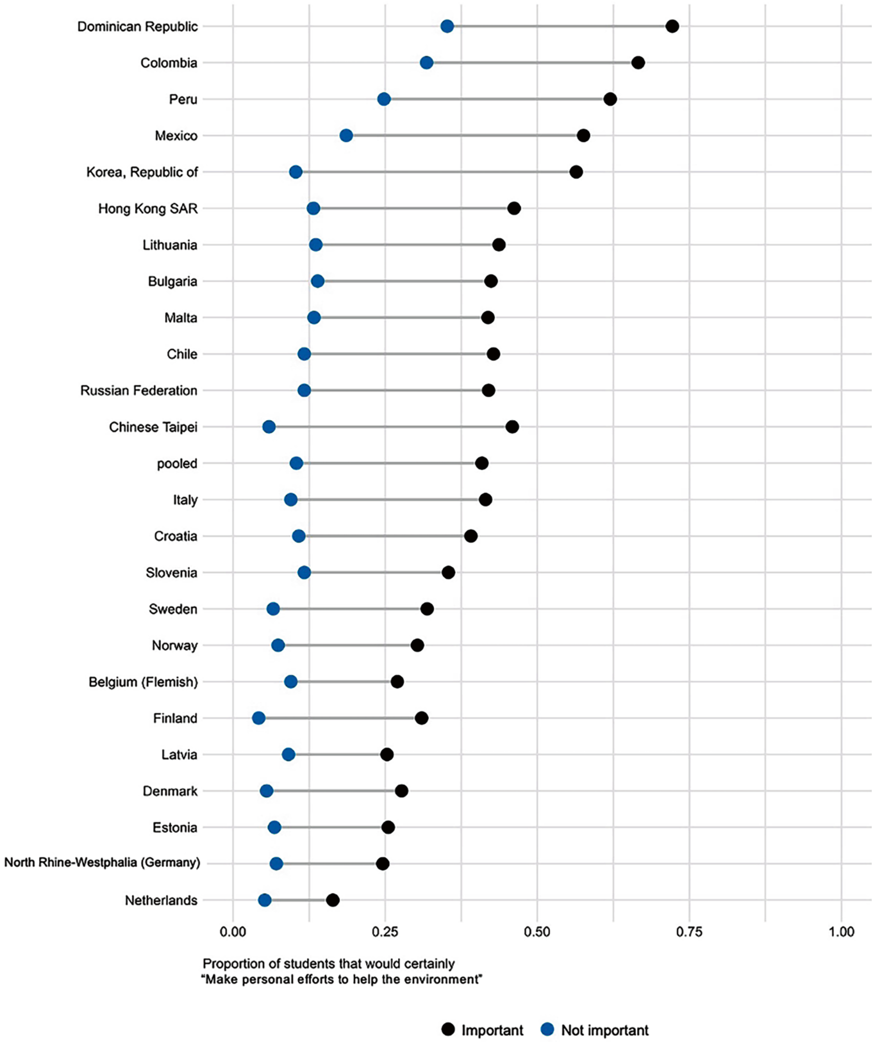


Fig. 10.1 Willingness to act pro-environmentally among students who considered it important to make personal efforts to protect natural resources in order to be considered a good citizen

To illustrate this latter result, we present Fig. 10.1. In the pooled sample, we found that only 10% of students who did not endorse this social norm could be expected to certainly be willing to engage in personal efforts to act pro-environmentally. In contrast, we can expect that 40% of students show a higher willingness to act pro-environmentally when they also considered it important to protect the environment for good citizenry. This positive result was observed across all participating countries in the study. Hence, social norms endorsement related to environmental sustainability is positively related to students' intention to behave pro-environmentally.

10.3.4 Opportunities to Learn at School

To assess the overall relationship between the school context and students' willingness to act pro-environmentally we fitted a multilevel ordinal logit model, without accounting for countries' fixed effects. The intra-class correlation for school membership was 12%, while its median odds ratio was 1.92 (CI95% [1.83, 2.02]) (see Merlo et al., 2006). Thus, when comparing the odds of responses of two students chosen randomly from different schools and comparing their willingness to act pro-environmentally one would exceed the second by almost twice the size, half of the time (Rabe-Hesketh & Skrondal, 2012, p. 596). Retrieving the same estimate while accounting for country differences, this estimate was 1.46 (CI95% [1.39, 1.53]). Conversions of odds ratio to standardized mean differences suggested that odds ratios of 1.6 are similar to a Cohen's d of 0.2 (Chen et al., 2010). Therefore, a non-ignorable portion of the students' willingness to act pro-environmentally varied due to the school students attended.

The previous exercise provided a general sense of the relationship between school context and students' willingness to act pro-environmentally. However, it did not inform us regarding what observed school attributes may account for this variability between students. Comparing the model that included different observed indicators of OTL at school (M9) to the student covariates model (M8), we found that OTL indicators accounted for an additional 3% of variance among students (R^2_{M8} = 19%, R^2_{M9} = 22%, LRT (8) = 1795.39, $p < 0.00$). We present the estimates of these models in Table 10.2. Across all eight OTL indicators we selected, only those generated with students' responses presented positive relations to students' willingness to act pro-environmentally between schools. With the fitted models, we found that students in schools where they have learned how to protect the environment to a large extent, indicated they were more willing to make personal efforts to act pro-environmentally later in life (M11: E = 0.93 ***, OR = 2.50). Likewise, students in schools with a higher open classroom discussion climate also presented higher levels of willingness to act pro-environmentally (M11: E = 0.28 ***, OR = 1.30).

We use Figs. 10.2 and 10.3 to illustrate the obtained results of these two school factors for the pooled sample, and for each participating country. In the pooled sample, we found that a high proportion of students presented a high willingness to act pro-environmentally (75%) in schools where they had learned how to protect the environment to a large extent. According to the results, only 38% of students present a high willingness to act pro-environmentally in schools where they have learned how to protect the environment to a lesser extent. This large difference in proportions of students with high pro-environmental intentions varied between countries by 15–55% across all countries with the exception of Slovenia, where we did not see this pattern of results.

Open classroom discussion is a factor that positively relates to the willingness to act pro-environmentally in the future. The results show that the willingness to act pro-environmentally of students in schools with one standard deviation above the

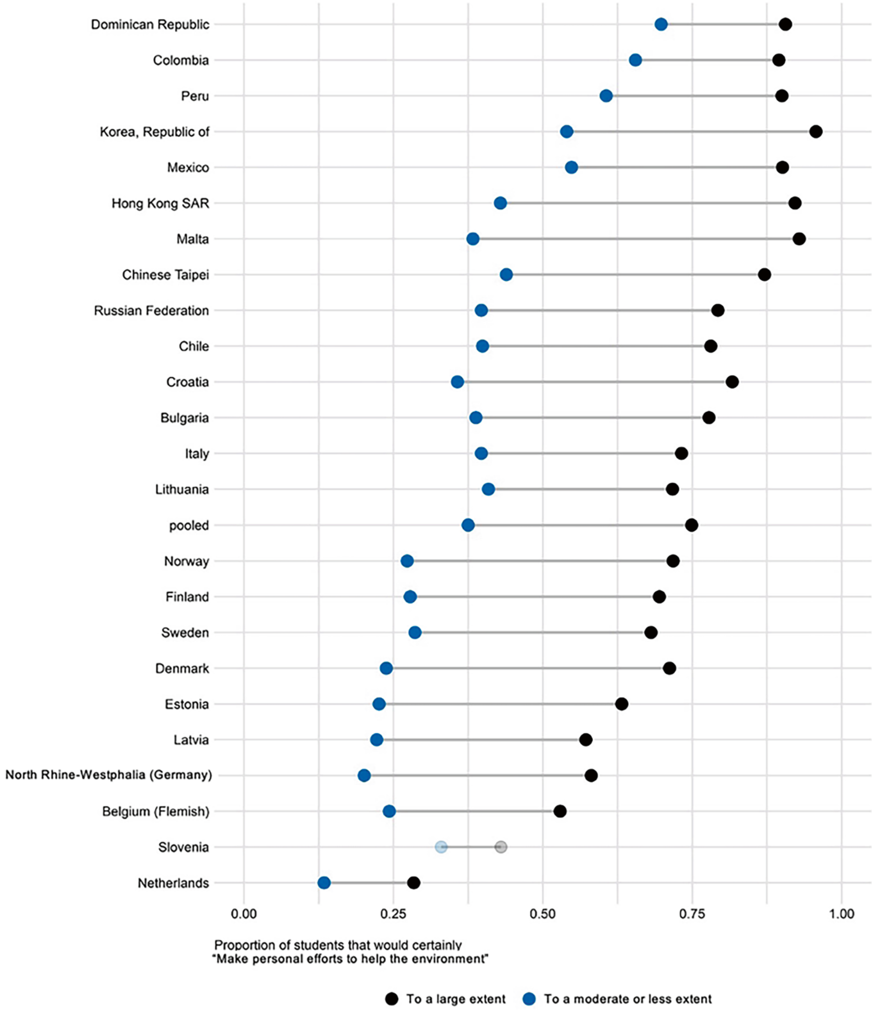


Fig. 10.2 Willingness to act pro-environmentally among students by learning opportunities at school as reported by the students

mean on open classroom discussion increases between 7% and 35%. In the pooled sample, for example, the model expects that 38% of students present a high willingness to act pro-environmentally when exposed to average levels of classroom discussion. In contrast, we expect that more than half of the students (52%) present a high willingness to act pro-environmentally if they are exposed to levels of open classroom discussion one standard deviation higher than the average.

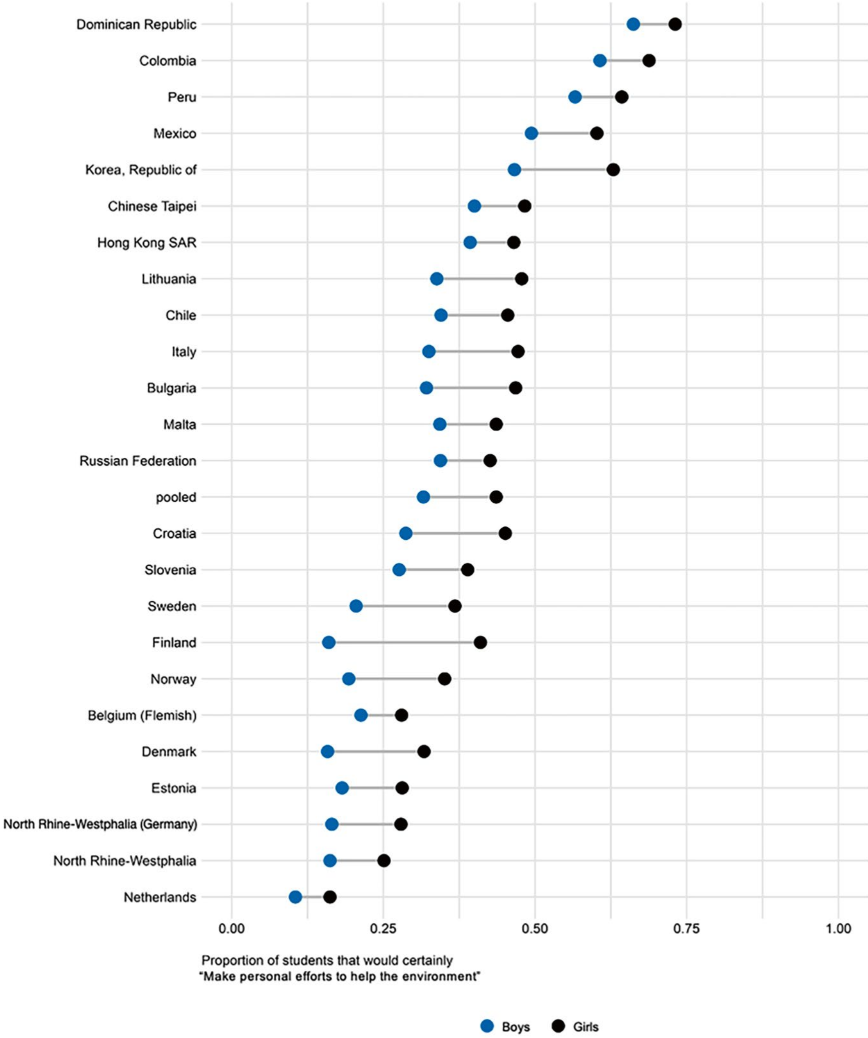


Fig. 10.3 Willingness to act pro-environmentally among students by learning opportunities at school through open classroom discussion as reported by the students

10.3.5 *Teacher Readiness and Preparedness*

In Model 10, we included two indicators of teacher readiness and preparedness to teach about topics regarding the environment and environmental sustainability. These two additional indicators accounted for a small proportion of additional accounted variance, of about 0.4% ($R^2_{M9} = 21.6\%$, $R^2_{M10} = 22.0\%$, LRT (2) = 280.90, $p < 0.00$). We observed a paradoxical effect, i.e., students in schools where all of their teachers felt prepared to teach about topics regarding the environment and environmental sustainability showed lower willingness to act pro-environmentally in the future (M10, E = − 0.20 **, OR = 0.82). In terms of teacher preparation, we observed that, in the pooled sample, students in schools where all their teachers had been trained to teach about environment and environmental sustainability topics, showed a higher willingness to act pro-environmentally in comparison to their peers (M10, E = 0.37 ***, OR = 1.40). This latter estimate became non-significant once we included the country fixed effects (M11, E = 0.03, OR = 1.00). We interpreted this latter result as a sign of substantial variability between countries regarding the proportion of trained teachers per country. To illustrate this result, we include Fig. 10.4. In this figure we found that the obtained result in the pooled sample was not the norm between countries. The general positive result was evident in Malta, the Russian Federation, and Norway; while this relationship appeared to be close to null in the rest of the countries.

The results of the models suggest that teaching practices and action-oriented educational approaches are associated with students' intentions to make efforts to protect the environment in the future. The adjusted models include the entire sample of participating countries, where we find that there is both country and school variability in the results. As a consequence, it is worth including some discussion on country and school differences. Students' willingness to make personal efforts to help the environment varies between schools, and the intra class correlation, close to 10%, is similar to that found by Sass et al. (2022).

The findings on OTL are aligned with those on school effectiveness within the ESD literature. It is important to note that the positive results for OTL factors appear when we use students' responses to build the OTL variables. Hence, it is important to retrieve information of school ESD practices and ESD teaching practices with the students as informants (Isac et al., 2022; Sass et al., 2023; Sinakou et al., 2019).

Among observed school attributes, having been taught how to protect the environment is the OTL activity with the highest magnitude of influence to promote future efforts to care for the environment among students. This OTL, however, also shows variability across countries and between schools. Figure 10.2 shows the proportion of students in the school that have received moderate, small or no OTL how to protect the environment in comparison to students declaring they have been taught these topics to a large extent. The differences by country in both the dependent variable and the most important OTL predictor suggest that there are contextual differences that must be taken into account when carrying out comparative studies on how schools inspire engagement for protecting the environment in the future. Furthermore, this finding may also reflect how much external national factors influence awareness and influence on intentions to act pro-environmentally.

Open classroom discussion appears as an effective teaching practice to promote students' pro-environmental intentions. We interpreted this OTL factor as a pluralistic ESD practice (Boeve-de Pauw et al., 2015; Olsson et al., 2022), in line with ESD effectiveness literature (Isac et al., 2022; Sass et al., 2023). This teaching practice is highly recognized as an effective teaching practice with many positive

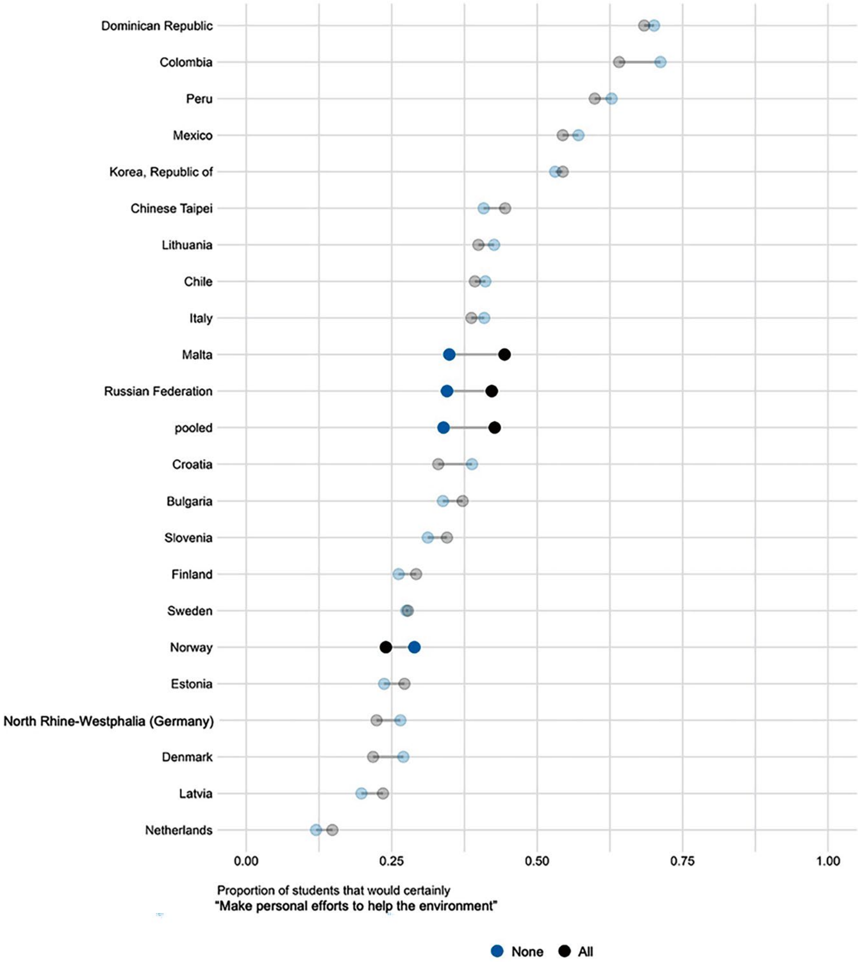


Fig. 10.4 Willingness to act pro-environmentally among students by proportion of teachers trained on the environment and environmental sustainability
Note: In North Rhine-Westphalia (Germany), estimates not accurately estimated

returns in civic education (Knowles et al., 2018), which also presents positive returns on students' pro-environmental intentions.

As for teacher readiness or sense of preparedness, this presents a paradoxically negative effect in the fitted models. Although we naively expected a positive result for this factor, the cautious warning by Boeve-de Pauw et al. (2022) regarding using measures of teachers' self-efficacy as a proxy of teacher practices is well founded. Furthermore, this seems to be consistent across countries, as shown in Fig. 10.4.

10.4 Discussion

Protecting the environment is crucial for ensuring sustainability, as highlighted by the international efforts of the Sustainable Development Goals Agenda for 2030. Educating young people to equip them for protecting the environment in the future entails both multidimensional and international efforts. As seen in the literature review, contextual factors shaping the ways of living in countries with different economic situations may influence the way in which the population approach care for the environment and, therefore, the intergenerational socialization of perspectives on the relationship between human life and the environment.

School and teacher action-oriented practices which engage students in caring for the environment, are promising avenues to motivate students' willingness to act pro-environmentally in the future. These types of practices are well defined within an OTL framework, in which students participate in school activities that teach them how to care for the environment through practice. Therefore, being exposed to teaching regarding how to protect the environment and experiencing open classroom discussion (a pluralistic ESD practice) are robust predictors of students' engagement in future actions to protect the environment.

Research results therefore suggest that school and teacher practices are important ways of leveraging the engagement of students in future actions to protect the environment. However, the potential of such variables may be shaped by the contextual conditions of countries and schools within each country. This finding poses the question of how ESD may blend perspectives on teaching about the environment and teaching for the environment.

Future research may delve into the relationship between country differences in protecting the environment, the prevailing notions on the value that society assigns to environmental protection, as well as the "common sense" local cultural shared meanings on what is the role of humans in the environment and vice versa. This may shed light on the way that cultural and historical differences may be related to differential results when developing comparative studies on education for sustainability.

Acknowledgements Ernesto Treviño acknowledges that this work has been supported by the National Research and Development Agency (ANID) of Chile through PIA CIE160007 and the Project CHIC ANID/BASAL FB210018.

References

Berglund, T., Gericke, N., & Chang Rundgren, S. N. (2014). The implementation of education for sustainable development in Sweden: Investigating the sustainability consciousness among upper secondary students. *Research in Science and Technological Education, 32*(3), 318–339. https://doi.org/10.1080/02635143.2014.944493

Boeve-de Pauw, J., Gericke, N., Olsson, D., & Berglund, T. (2015). The effectiveness of education for sustainable development. *Sustainability, 7*(11), 15693–15717. https://doi.org/10.3390/su71115693

Boeve-de Pauw, J., Olsson, D., Berglund, T., & Gericke, N. (2022). Teachers' ESD self-efficacy and practices: A longitudinal study on the impact of teacher professional development. *Environmental Education Research, 28*(6), 867–885. https://doi.org/10.1080/13504622.2022.2042206

Borg, C., Gericke, N., Höglund, H. O., & Bergman, E. (2012). The barriers encountered by teachers implementing education for sustainable development: Discipline bound differences and teaching traditions. *Research in Science and Technological Education, 30*(2), 185–207. https://doi.org/10.1080/02635143.2012.699891

Carr, K. (2016). Leading sustainability in schools. *Management in Education, 30*(3), 126–130. https://doi.org/10.1177/0892020616653177

Carrasco, D., & Pavón Mediano, A. (2021). Tolerance of corruption among students in Latin America. In E. Treviño, D. Carrasco, E. Claes, & K. J. Kennedy (Eds.), *Good citizenship for the next generation. A global perspective using IEA ICCS 2016 data* (IEA research for education) (Vol. 12, pp. 107–125). Springer. https://doi.org/10.1007/978-3-030-75746-5

Carroll, J. B. (1989). The Carroll model: A 25-year retrospective and prospective view. *Educational Researcher, 18*(1), 26–31. https://doi.org/10.3102/0013189X018001026

Cheang, C. C., Cheung, T. Y., So, W. W. M., Cheng, I. N. Y., Fok, L., Yeung, C. H., & Chow, C. F. (2019). Enhancing pupils' pro-environmental knowledge, attitudes, and behaviours toward plastic recycling: A quasi-experimental study in primary schools. In W. So, C. Chow, & J. Lee (Eds.), *Environmental sustainability and education for waste management* (pp. 159–188). Springer. https://doi.org/10.1007/978-981-13-9173-6_10

Chen, H., Cohen, P., & Chen, S. (2010, January). How big is a big odds ratio? Interpreting the magnitudes of odds ratios in epidemiological studies. *Communications in Statistics – Simulation and Computation, 39*, 860–864. https://doi.org/10.1080/03610911003650383

Coertjens, L., Boeve-de Pauw, J., de Maeyer, S., & Van Petegem, P. (2010). Do schools make a difference in their students' environmental attitudes and awareness? Evidence from PISA 2006. *International Journal of Science and Mathematics Education, 8*(3), 497–522. https://doi.org/10.1007/s10763-010-9200-0

de Leeuw, A., Valois, P., Ajzen, I., & Schmidt, P. (2015). Using the theory of planned behavior to identify key beliefs underlying pro-environmental behavior in high-school students: Implications for educational interventions. *Journal of Environmental Psychology, 42*, 128–138. https://doi.org/10.1016/j.jenvp.2015.03.005

Escario, J. J., Rodriguez-Sanchez, C., & Casaló, L. V. (2020). The influence of environmental attitudes and perceived effectiveness on recycling, reducing, and reusing packaging materials in Spain. *Waste Management, 113*, 251–260. https://doi.org/10.1016/j.wasman.2020.05.043

Evans, N. S., Stevenson, R. B., Lasen, M., Ferreira, J. A., & Davis, J. (2017). Approaches to embedding sustainability in teacher education: A synthesis of the literature. *Teaching and Teacher Education, 63*, 405–417. https://doi.org/10.1016/j.tate.2017.01.013

García-González, E., Jiménez-Fontana, R., & Azcárate, P. (2020). Education for sustainability and the sustainable development goals: Pre-service teachers' perceptions and knowledge. *Sustainability, 12*(18). https://doi.org/10.3390/su12187741

Goldman, D., Ayalon, O., Baum, D., & Weiss, B. (2018). Influence of 'green school certification' on students' environmental literacy and adoption of sustainable practice by schools. *Journal of Cleaner Production, 183*, 1300–1313. https://doi.org/10.1016/j.jclepro.2018.02.176

González-Salamanca, J. C., Agudelo, O. L., & Salinas, J. (2020). Key competences, education for sustainable development and strategies for the development of 21st century skills. A systematic literature review. *Sustainability, 12*(24), 10366. https://doi.org/10.3390/su122410366

Grosseck, G., Tîru, L. G., & Bran, R. A. (2019). Education for sustainable development: Evolution and perspectives: A bibliometric review of research, 1992–2018. *Sustainability, 11*(21), 6136. https://doi.org/10.3390/su11216136

Isac, M. M., Sass, W., Boeve-de Pauw, J., De Maeyer, S., Schelfhout, W., Van Petegem, P., & Claes, E. (2022). Differences in teachers' professional action competence in education for sustainable development: The importance of teacher co-learning. *Sustainability, 14*(2), 767. https://doi.org/10.3390/su14020767

Keeble, B. R. (1988). The Brundtland report: "Our common future". *Medicine and War, 4*(1), 17–25. https://doi.org/10.1080/07488008808408783

Knowles, R. T., Torney-Purta, J., & Barber, C. (2018). Enhancing citizenship learning with international comparative research: Analyses of IEA civic education datasets. *Citizenship Teaching and Learning, 13*(1), 7–30. https://doi.org/10.1386/ctl.13.1.7_1

List, M. K., Schmidt, F. T. C., Mundt, D., & Föste-Eggers, D. (2020). Still green at fifteen? Investigating environmental awareness of the PISA 2015 population: Cross-national differences and correlates. *Sustainability, 12*(7), 2985. https://doi.org/10.3390/su12072985

Masyn, K. E. (2014). Discrete-time survival analysis in prevention science. In Z. Sloboda & H. Petras (Eds.), *Defining prevention science* (pp. 513–535). Springer. https://doi.org/10.1007/978-1-4899-7424-2

Merlo, J., Chaix, B., Ohlsson, H., Beckman, A., Johnell, K., Hjerpe, P., Råstam, L., & Larsen, K. (2006). A brief conceptual tutorial of multilevel analysis in social epidemiology: Using measures of clustering in multilevel logistic regression to investigate contextual phenomena. *Journal of Epidemiology and Community Health, 60*(4), 290–297. https://doi.org/10.1136/jech.2004.029454

Núñez Tobar, J., Navarrete, N. V., Valdebenito Pérez, A., Orellana, A. L., De Dios, J., & Morel, O. (2023). Análisis de la integración de la conciencia ambiental en la educación ambiental del currículo chileno [Analysis of the integration of environmental awareness in environmental education of the Chilean curriculum]. *Pensamiento Educativo, Revista de Investigación Latinoamericana (PEL), 60*(2). https://doi.org/10.7764/PEL.60.2.2023.5

Olsson, D., Gericke, N., & Chang Rundgren, S. N. (2016). The effect of implementation of education for sustainable development in Swedish compulsory schools—Assessing pupils' sustainability consciousness. *Environmental Education Research, 22*(2), 176–202. https://doi.org/10.1080/13504622.2015.1005057

Olsson, D., Gericke, N., & Boeve-de Pauw, J. (2022). The effectiveness of education for sustainable development revisited—A longitudinal study on secondary students' action competence for sustainability. *Environmental Education Research, 28*(3), 405–429. https://doi.org/10.1080/13504622.2022.2033170

Rabe-Hesketh, S., & Skrondal, A. (2012). *Multilevel and longitudinal modeling using stata, Volumes I and II* (3rd ed.). Stata Press.

Sandoval-Hernández, A. (2010). *Towards a realist methodology for school effectiveness research: A case study of educational inequality from Mexico.* Doctoral thesis, University of Bath. University of Bath. http://opus.bath.ac.uk/20328/1/UnivBath_PhD_2010_SandovalHernandez_A.pdf

Sass, W., De Maeyer, S., Boeve-de Pauw, J., & Van Petegem, P. (2022). Honing action competence in sustainable development: What happens in classrooms matters. *Environment, Development and Sustainability, 25*, 3649–3670. https://doi.org/10.1007/s10668-022-02195-9

Sass, W., De Maeyer, S., Boeve-de Pauw, J., & Van Petegem, P. (2023). Effectiveness of education for sustainability: The importance of an action-oriented approach. *Environmental Education Research, 30*(4), 479–498. https://doi.org/10.1080/13504622.2023.2229543

Schmidt, W. H., Burroughs, N. A., Zoido, P., & Houang, R. T. (2015). The role of schooling in perpetuating educational inequality: An international perspective. *Educational Researcher, 44*(7). https://doi.org/10.3102/0013189X15603982

Sinakou, E., Donche, V., Boeve-de Pauw, J., & Van Petegem, P. (2019). Designing powerful learning environments in education for sustainable development: A conceptual framework. *Sustainability, 11*(21), 5994. https://doi.org/10.3390/su11215994

Verhelst, D., Vanhoof, J., & Van Petegem, P. (2021). School effectiveness for education for sustainable development (ESD): What characterizes an ESD-effective school organization? *Educational Management Administration and Leadership, 51*(2), 502–525. https://doi.org/10.1177/1741143220985196

Walid, M., & Luetz, J. M. (2018). From education for sustainable development to education for environmental sustainability: Reconnecting the disconnected SDGs. In W. Leal Filho (Ed.), *Handbook of sustainability science and research* (World sustainability series) (pp. 803–826). Springer. https://doi.org/10.1007/978-3-319-63007-6_49

World Commission on Environment and Development. (1987). *Our common future*. United Nations. https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

Yuriev, A., Dahmen, M., Paillé, P., Boiral, O., & Guillaumie, L. (2020, January). Pro-environmental behaviors through the lens of the theory of planned behavior: A scoping review. *Resources, Conservation and Recycling, 155*, 104660. https://doi.org/10.1016/j.resconrec.2019.104660

Chapter 11
Environmental Knowledge and Willingness to Act Pro-environmentally: Final Remarks

Maria Magdalena Isac, Wanda Sass, and Andrés Sandoval-Hernández

11.1 Introduction

In an era marked by environmental, social, and economic challenges of unprecedented scale, the role of education in fostering sustainable development has never been more crucial. Recognizing this urgency, international bodies such as the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the European Union have strongly promoted education for sustainable development (ESD), embedding it within educational policies globally (Bianchi et al., 2022; European Commission, Directorate-General for Education, Youth, Sport and Culture, 2022; UNESCO, 2020). However, despite the significant increase in ESD educational policies and practices worldwide, the integration of ESD within educational systems remains a complex and unevenly implemented endeavor (Stepanek Lockhart, 2018; Taylor et al., 2019).

Challenges persist in formulating learning goals and appropriate ESD learning opportunities, as well as in collecting data and developing adequate tools for assessing and monitoring ESD learning outcomes and processes. Consequently, there has

M. M. Isac (✉)
Centre for Political Science Research, KU Leuven, Leuven, Belgium

Department of Education, University of Bath, Bath, UK
e-mail: mariamagdalena.isac@gmail.com

W. Sass
Freudenthal Institute, Utrecht University, Utrecht, The Netherlands

Department of Training and Education Sciences, University of Antwerp, Antwerp, Belgium

Department of Environmental and Life Sciences, Karlstad University, Karlstad, Sweden

A. Sandoval-Hernández
Department of Education, University of Bath, Bath, UK

M. M. Isac et al. (eds.), *Knowledge and Willingness to Act Pro-Environmentally*,
IEA Research for Education 16, https://doi.org/10.1007/978-3-031-76033-4_11

been a recognized lack of comparative data enabling empirical monitoring and evaluation of these outcomes and processes on a cross-national scale (Buckler & Creech, 2014). Therefore, we first (see Chap. 2) discussed the concept of action competence in sustainable development (ACiSD) and introduced an ACiSD-ESD framework to formulate desired learning outcomes in terms of relevant knowledge and skills, willingness to contribute, the confidence in one's own capacities for change, and the confidence in the impact of action for sustainability (Sass et al., 2020). ESD is typically transformative in nature. It embraces an educational approach that is holistic (Gericke et al., 2020; Mogensen & Schnack, 2010; Sass et al., 2020), pluralistic (Öhman & Östman, 2019; Olsson et al., 2022; Sass et al., 2020), and action-oriented (Sass et al., 2023; Sinakou et al., 2019; Varela-Losada et al., 2016).

This book, utilizing the rich data from the International Association for the Evaluation of Educational Achievement (IEA) Trends in International Mathematics and Science Study (TIMSS) 2019 and International Civic and Citizenship Education Study (ICCS) 2016, illustrates how data from international large-scale assessments (ILSAs) can be pivotal to understanding ESD and, in particular, the environmental aspects of ESD. Our aim was to contribute to the understanding of how educational systems globally are achieving and conveying ESD learning outcomes. The use of TIMSS 2019 and ICCS 2016 provided a unique perspective for examining these outcomes, especially in terms of students' environmental knowledge and their willingness to act pro-environmentally. While these assessments are not primarily focused on ESD, they offer invaluable insights into its global state, bridging a critical gap in comparative data and empirical monitoring (Buckler & Creech, 2014).

Our main aim in this project has been to scrutinize the extent to which educational systems[1] achieve and foster ESD learning outcomes, such as environmental knowledge and a willingness to act pro-environmentally. This goal was anchored in three specific research questions:

1. To what extent are there variations in environmental knowledge and willingness to act pro-environmentally across different countries?
2. To what extent do disparities among students within countries, associated with various background characteristics, relate to learning outcomes?
3. To what extent are specific educational opportunities for learning about environmental sustainability and development issues implemented in lower-secondary schools, and how do these opportunities relate to young people's learning outcomes?

In the following sections, we discuss how findings from the empirical chapters of this book contribute to achieving these goals and address the underlying research questions. Additionally, this chapter includes reflections on ways to further enhance the relevance of ILSAs such as TIMSS and ICCS for understanding key ESD learning outcomes and processes.

[1] As well as the term "educational systems," the term "countries" is sometimes used in this chapter to refer to both countries and benchmarking participants, for ease of reading.

11.2 Key Findings and Conclusions

In this section, we summarize the most relevant findings reported throughout this book, focusing on insights that align with the three research questions established for this project. It is important to note, however, that the individual chapters offer a wealth of information on a variety of additional topics. These include the theoretical foundations of our work (see Chap. 2), detailed descriptions of the TIMSS 2019 and ICCS 2016 studies, their coverage of environmental ESD topics (see Chaps. 3 and 7 for a detailed overview), and potential links between system-level variables (such as levels of economic development) and ESD learning outcomes, among others. For a more comprehensive and nuanced understanding of the diverse results and perspectives presented, we strongly encourage readers to consult each chapter in detail.

11.2.1 Country Variations in Environmental Knowledge and Willingness to Act Pro-environmentally

An important initial goal of this book was to document and analyze variations in environmental knowledge and willingness to act pro-environmentally across countries participating in the TIMSS 2019 and ICCS 2016 studies. Our review of the literature highlighted the need for comparative data on ESD learning outcomes and also pointed to a lack of conceptual clarity in formulating ESD learning goals. To bridge this knowledge gap, we adopted the action competence framework to conceptualize and operationalize ESD learning outcomes (see Chaps. 1 and 2 for details). This framework suggests that an action-competent individual possesses relevant knowledge about and skills related to sustainable development issues, demonstrates strong motivation and willingness to contribute to solving these issues, and has confidence in their capacity to induce change. We argue that while TIMSS 2019 and ICCS 2016 do not cover all aspects of this framework, they significantly contribute to measuring environmental aspects of knowledge and willingness to act, providing highly relevant information about variations in these areas across countries.

As detailed in Chaps. 3, 4, 5, and 6, TIMSS 2019 measures students' environmental knowledge via its environmental awareness scale. This data is crucial for understanding variations in average environmental knowledge achievements across countries and offers valuable insights for educational systems worldwide. Chapters 4 and 5 present significant findings in this area. The results show substantial variability in environmental knowledge among the countries and educational systems participating in the study. Notably, the highest-achieving countries average well above 550 points, more than half a standard deviation above the scale's midpoint, while the lower-achieving countries do not reach an average of 400 points, approximately one standard deviation below the midpoint. Moreover, the results reveal considerable within-country differences in environmental knowledge between lower and higher achieving students, as indicated by score distribution variations. In every country, the interquartile range is at least 100 points. In 11 countries this range exceeds 150 points, while in eight countries the range is less than 120 points.

Chapters 7, 8, 9, and 10 illustrate how the ICCS 2016 study is successful in measuring one important aspect of students' action competence: their willingness to act pro-environmentally.[2] This ESD learning outcome is strongly emphasized in educational policy documents, which stress the importance of modeling these intentions in addition to imparting knowledge and skills. The data provided by ICCS 2016 is therefore highly informative in understanding variations in willingness to act pro-environmentally among the participating educational systems. Chapter 8 is particularly relevant in contributing to this understanding. The results indicate variability in willingness to act pro-environmentally among the countries and educational systems participating in the study. More specifically, although a large majority of students across countries (70%, on average) would certainly or probably be willing to act pro-environmentally, this general trend varies among countries. In Asian and Latin American countries, students' intention to engage in pro-environmental action is notably positive, with 80% or more of the students willing to act pro-environmentally. However, European countries show more pronounced variability in willingness to act. Specifically, while students in countries like Italy, Belgium, Finland, and Sweden show distributions close to the average (around 80% positive disposition), students in countries such as Norway, the Netherlands, and North Rhine-Westphalia exhibit much lower levels of willingness. In these latter three cases, at least 30% of the population declares they are not willing to participate in environmental actions.

Taken together, the results of TIMSS 2019 and ICCS 2016 demonstrate variability in environmental knowledge and willingness to act pro-environmentally among the countries and educational systems participating in the study. These differences seem slightly more pronounced regarding cognitive ESD learning outcomes such as environmental knowledge but do apply as well to country differences in willingness to act. This comparative information on ESD learning outcomes, concurrently obtained from two ILSAs (TIMSS 2019 and ICCS 2016) that were conducted close in time, can inform educational systems about their achieved ESD curricula outcomes and can further assist in the monitoring of these learning goals over time.

The results described in this book illustrate the potential of ILSAs to further ESD implementation in lower-secondary schools through the provision of data on environmental knowledge (TIMSS) and willingness to act pro-environmentally (ICCS). Still, there is always room for improvement. First, the data did not allow acknowledgment of the interconnectedness of environmental, social, and economic

[2] The outcome variable is a single item from ICCS 2016 that captures students' intended future efforts to protect the environment (see details in Chaps. 7 and 8).

dimensions of sustainability. A deeper examination of this interconnectedness would provide a more holistic understanding of ESD. Integrating measures of environmental, social and economic sustainability and their interconnectedness into future assessments would not only enrich the analysis but also provide a more comprehensive perspective on ESD outcomes. Second, the willingness dimension of ACiSD was represented by a single item in the ICCS 2016 data. A broader development of the four ACiSD components (relevant knowledge and skills, willingness to contribute, confidence in one's own capacities for change, and in the impact of action for sustainability), consisting of a number of items would allow development of ACiSD scales. Validated instruments such as the Self-Perceived Action Competence for Sustainability Questionnaire (SPACS-Q) (Olsson et al., 2020) and the Sustainability Consciousness Questionnaire (Gericke et al., 2019) may provide inspiration. Finally, broadening the possibilities to find associations between ESD implementation and manifestations of ACiSD, as observed by means of the context questionnaires, would offer potent information for national entities to inform educational policy. Based on the results from secondary analyses offered in this book, it is our firm belief that ILSAs such as TIMSS and ICCS hold such potential.

11.2.2 Inequalities in Environmental Knowledge and Willingness to Act Pro-environmentally

Our second goal in this book was to explore potential disparities among students within countries, focusing on how various background characteristics contribute to inequalities in ESD learning outcomes, such as environmental knowledge and willingness to act pro-environmentally. While a substantial body of literature addresses inequalities in more traditional learning domains like mathematics, language, and science, particularly their cognitive aspects, inequalities in ESD learning outcomes are less documented. Highlighting these gaps is essential, as it can lead to educational initiatives aimed at combating diverse sources of potential disadvantage, including tailoring educational opportunities to different student populations.

As detailed in Chaps. 3 and 5, TIMSS 2019 provides ample opportunities to examine differences in environmental knowledge arising from various student background characteristics. These include potential inequalities shaped by socioeconomic status, gender, and rural versus urban areas of residence. Chapter 5 reveals a strong association between students' environmental knowledge and their socioeconomic status, gauged by parental education and the number of books at home. The findings indicate substantial knowledge gaps between socioeconomic groups, with students from more advantaged backgrounds (marked by higher parental education and greater access to reading materials at home) showing significantly higher levels of environmental knowledge. Regarding gender differences, about half of the countries exhibit no significant gender gap in environmental knowledge. In the other half, the gender gaps are statistically significant but relatively small. In countries where the achievement gap is significant, approximately half show gaps favoring boys and the other half favoring girls. Additionally, sizeable gaps in environmental knowledge based on urbanicity were observed, with urban students often outperforming their rural counterparts.

Chapters 7 and 9, using ICCS 2016 data, explore disparities in willingness to act pro-environmentally, examining variations due to socioeconomic status, gender, and immigration background. Chapter 9 indicates significant gaps in willingness to act pro-environmentally. Female students, those from more educated families, and students with greater access to reading materials at home tend to display a higher willingness to act pro-environmentally. Furthermore, different sources of socioeconomic inequality seem to reinforce each other, as the study found greater endorsement of pro-environmental behavior among students from more educated families who also have greater access to books in the home environment. Moreover, results regarding differences due to students' immigration background indicate that students with an immigration background may show a lower willingness to act pro-environmentally.

Taken together, these findings reveal substantial disparities in both environmental knowledge and willingness to act pro-environmentally among students, especially those with higher socioeconomic status (as indicated by parental education and home access to books). In the case of willingness to act, ICCS 2016 data also shows that different sources of socioeconomic inequality can reinforce each other, creating compounded disadvantages. Gender differences are notable in students' willingness to act pro-environmentally, favoring female students. This aligns with results regarding a variety of attitudinal and behavioral learning outcomes covered by ICCS 2016. In contrast, patterns regarding gender differences in environmental knowledge are mixed and, when present, tend to be small.

All these findings, coupled with other disparities shaped by rural versus urban divisions or immigration background, underscore the urgent need for action in the ESD field. The information presented in this book can be valuable for educators and policymakers in their efforts to equip all students equally with the knowledge and skills necessary to understand, evaluate, and act upon environmental issues, thereby contributing to a more sustainable future.

11.2.3 The Implementation and Relevance of ESD Opportunities for Learning

A key goal of this book was to assess the implementation of educational opportunities for learning about environmental sustainability in lower-secondary schools and to explore how these opportunities are associated with students' learning outcomes. Such information is crucial for designing, monitoring, and assessing the impact of appropriate ESD learning opportunities. In this respect, our review of the literature also underscored the need for comparative data on ESD learning opportunities and highlighted a lack of conceptual clarity regarding the main features of ESD learning processes. To bridge this gap, in Chaps. 1 and 2, we clarified the conceptualization of ESD and environmental education, detailing the teaching approaches and learning opportunities that define ESD capable of fostering action competence. We particularly focused on ESD principles like holism, pluralism and participation, and an action-oriented approach, illustrating their potential operationalization throughout the book.

Chapters 3 and 6 demonstrate how TIMSS 2019, drawing on responses from its national curriculum, school leader, and teacher questionnaires, can pinpoint ESD learning opportunities and teaching practices as formulated in the intended and implemented curricula of several educational systems. Chapter 6, in particular, provides insightful findings regarding the intended and implemented ESD curriculum. Echoing the literature reviews, the results reveal that while environmental ESD topics are part of the intended curricula in all countries, significant country variation exists. This variation is notably pronounced in the representation of different environmental ESD topics at various education levels. As for the implemented curriculum, the chapter reports that although environmental ESD topics are covered in many schools, the actual coverage is much lower than expected based on the intended curriculum. Furthermore, no clear association is established between the intended and implemented curriculum and students' environmental knowledge. The chapter also indicates that the emphasis on theoretically beneficial teaching practices, such as science investigation methods and pluralistic, action-oriented teaching approaches, is less widespread than anticipated.

Chapters 7 and 10 explore how ICCS 2016 data can inform us about ESD learning opportunities and their relation to students' willingness to act pro-environmentally. Chapter 10 uncovers several key findings in this area. Most notably, the analyses suggest that students' willingness to act is generally more associated with ESD learning opportunities reported by the students themselves, rather than other indicators based on school principal or teacher data. On average, the highest proportion of students willing to act pro-environmentally (75%) were in schools where they had substantial opportunities to learn about environmental protection. Additionally, students in schools with a higher open classroom discussion climate and a pluralistic ESD teaching approach also exhibited higher levels of willingness to act pro-environmentally.

These findings collectively offer valuable insights into the implementation and effectiveness of ESD learning opportunities. The TIMSS 2019 data suggests a need for several educational systems to strengthen their intended ESD curricula, ensure consistent implementation, and promote teaching methods that foster scientific inquiry and pluralistic, action-oriented classroom practices. The ICCS 2016 findings emphasize the importance of providing students with opportunities to learn about environmental protection and engaging in open classroom discussions, as these factors significantly shape their pro-environmental intentions.

11.3 Using TIMSS and ICCS Data to Describe ESD Learning Outcomes and Processes

In this book, we highlighted challenges in various countries in formulating learning goals and appropriate ESD learning opportunities, as well as in collecting data and developing adequate measurement tools for assessing and monitoring ESD learning outcomes and processes. Recognizing a lack of comparative data that would enable empirical monitoring and evaluation of ESD learning outcomes and processes on a cross-national scale, we argued the value of ILSAs such as TIMSS 2019 and ICCS 2016 in informing ESD initiatives in several educational systems. Although TIMSS 2019 and ICCS 2016 were not primarily designed to capture ESD aspects, these studies provide ample space for exploring ESD topics. However, it is worth mentioning some limitations inherent in these studies, as there are possibilities to further expand their coverage and potential in grasping ESD topics. In this section, we briefly reflect on the limitations of the research reported here, point out avenues to further utilize TIMSS and ICCS data in the short term, and engage in a reflection regarding potential future developments that would make these studies even more relevant to current theoretical developments around ESD.

We start by restating that both TIMSS 2019 and ICCS 2016 can provide valuable information regarding ESD learning outcomes and processes. In this research, we successfully built on these studies to describe important learning outcomes, such as students' environmental knowledge and willingness to act pro-environmentally. We also identified several teaching and learning opportunities anchored in ESD principles that are promising in promoting action-competent students. However, these studies can only partially shed light on ESD issues. Both are mainly concerned with environmental aspects of sustainable development and provide limited coverage of different sustainable development dimensions (i.e., environmental, social, economic) and their interconnectivity. As we have shown, the coverage of action competence dimensions is only approximate. TIMSS 2019 covers the knowledge and skills dimension with its environmental awareness scale. However, this measure is closely linked to its science framework and has limitations in terms of topic coverage and measurement properties (see Chap. 4 for an extensive account of its measurement properties). Similarly, ICCS 2016 measures willingness to act pro-environmentally with an individual item. This measure, too, is limited as it captures only personal efforts to protect the environment, as opposed to other sustainable development actions (see Chap. 8 for an extensive discussion of its limitations). Likewise, in both studies, the coverage of ESD learning opportunities is limited to environmental aspects and, particularly for TIMSS 2019, could be more consistent in gathering and triangulating connected information from different informants (i.e., students, teachers, school principals).

Despite these limitations, both TIMSS and ICCS are evolving toward better ESD coverage. Specifically, the TIMSS 2023 cycle keeps the focus on environmental sustainability, ensuring possibilities for monitoring over time. Notably, with the development of the Environmental Attitudes and Behaviors Framework, the 2023 cycle takes this a step further, adding noncognitive constructs such as students' attitudes, students' and parents' behaviors, and school and teaching practices related to environmental sustainability (Reynolds & Komakhidze, 2022, pp. 1, 4). In doing so, TIMSS 2023 acknowledges the social and political dimensions of the environmental crisis. Also, insights into the importance of environmentally-friendly attitudes and values for students' development into well-informed and environmentally responsible decision-makers are honored. Thus, possibilities to complement the cognitive environmental knowledge dimension with attitudinal and behavioral components in the TIMSS 2023 edition are present. Although such attitudinal and behavioral measures are limited to practices such as reusing or commenting on environmentally harmful behavior of friends, TIMSS 2023 data will certainly be even more relevant in grasping the degree to which future generations are receiving opportunities to be equipped to face current and future environmental challenges (Reynolds & Komakhidze, 2022, p. 2).

Likewise, building on work started in its 2016 cycle, ICCS maintained environmental sustainability as a focus area for its 2022 assessment. Moreover, the 2022 cycle broadened the notion, adding social and economic sustainability to this civic knowledge assessment framework. Thus, ICCS not only continued but even expanded its focus on sustainability, presenting it as a more comprehensive notion that consists of environmental, social, and economic dimensions (Schulz et al., 2023, pp. 7–8). An increased coverage of attitudinal and behavioral aspects, as well as ESD learning opportunities, is also visible across all its student, teacher, and school questionnaires. Although the information regarding education for sustainability in ICCS 2022 remains closely aligned with the previous perspective that views sustainability predominantly as an environmental issue, this initiative strengthens ICCS's function as a valuable ESD data source. This role was initiated in the previous cycle when ICCS data proved highly informative in constructing indicators tapping into UNESCO's sustainable development goals linked with global citizenship education and ESD (Sandoval-Hernández et al., 2019).

In conclusion, while TIMSS and ICCS are evolving to provide more comprehensive insights into ESD, there remain opportunities for further development and expansion in their coverage of sustainability topics. The evolving nature of these studies is promising, particularly in their increasing focus on the multifaceted nature of sustainability, encompassing not only environmental but also social and economic dimensions. As highlighted in policy documents and scholarly papers, there is a growing recognition of the interrelated character of environmental, social, economic, and peace dimensions of sustainability (Berglund & Gericke, 2022; Boström et al., 2018; United Nations, 2015). This has led to calls for more interdisciplinary teaching in education to enhance holistic knowledge acquisition and systems thinking competencies through a pluralistic approach (Berglund & Gericke, 2022; Boström et al., 2018). Recent findings suggest that students can be aware of how different aspects of sustainability interact, even at a young age (Sass et al., 2021).

Building on this understanding, future iterations of TIMSS and ICCS could incorporate these dimensions more explicitly. TIMSS 2023 has already broadened its scope by including attitudinal and behavioral components alongside cognitive science assessments (Reynolds & Komakhidze, 2022). A potential direction for further evolution could involve broadening the cognitive science achievement assessment to focus on integrated science items that engage students in applying knowledge coherently across different scientific domains. Similarly, ICCS 2022 already included environmental, social, and economic dimensions in its civic knowledge framework. The study could grow towards better and more coherently capturing and representing these dimensions also in its attitudinal and contextual frameworks.

Additionally, aligning context questionnaires with the conceptual framework used in this book, future ILSAs could provide data on students' self-perceived action competence, inquiring about their readiness to take action for sustainability. Instruments like the SPACS-Q (Olsson et al., 2020) and the Sustainability Consciousness Questionnaire (Gericke et al., 2019) could serve as inspirations. Gathering data on how teachers and students experience action-oriented ESD practices at school may open up new avenues for research into the effectiveness of schools' ESD implementation and its impact on fostering students' action competence based on ILSA data.

As they continue to evolve, TIMSS and ICCS will likely become even more integral to understanding and advancing ESD globally, providing critical data to inform educational policy and practice and contribute to the development of future generations equipped to address the myriad challenges of sustainable development.

References

Berglund, T., & Gericke, N. (2022). Diversity in views as a resource for learning? Student perspectives on the interconnectedness of sustainable development dimensions. *Environmental Education Research, 28*(3), 354–381. https://doi.org/10.1080/13504622.2021.1980501

Bianchi, G., Pisiotis, U., & Cabrera Giraldez, M. (2022). *GreenComp—The European sustainability competence framework*. Publications Office of the European Union. https://doi.org/10.2760/13286

Boström, M., Andersson, E., Berg, M., Gustafsson, K., Gustavsson, E., Hysing, E., Lidskog, R., Löfmarck, E., Ojala, M., Olsson, J., Singleton, B. E., Svenberg, S., Uggla, Y., & Öhman, J. (2018). Conditions for transformative learning for sustainable development: A theoretical review and approach. *Sustainability, 10*(12), 4479. https://doi.org/10.3390/su10124479

Buckler, C., & Creech, H. (2014). *Shaping the future we want. UN decade of education for sustainable development (2005–2014). Final report*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000230171

European Commission, Directorate-General for Education, Youth, Sport and Culture. (2022). *Proposal for a Council Recommendation on learning for environmental sustainability*, COM/2022/11 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022DC0011

Gericke, N., Boeve-de Pauw, J., Berglund, T., & Olsson, D. (2019). The sustainability consciousness questionnaire: The theoretical development and empirical validation of an evaluation instrument for stakeholders working with sustainable development. *Sustainable Development, 27*(1), 35–49. https://doi.org/10.1002/sd.1859

Gericke, N., Huang, L., Knippels, M.-C., Christodoulou, A., Van Dam, F., & Gasparovic, S. (2020). Environmental citizenship in secondary formal education: The importance of curriculum and subject teachers. In A. C. Hadjichambis, P. Reis, D. Paraskeva-Hadjichambi, J. Činčera, J. Boeve-de Pauw, N. Gericke, & M.-C. Knippels (Eds.), *Conceptualizing environmental citizenship for 21st century education* (Environmental discourses in science education) (Vol. 4, pp. 193–212). Springer. https://doi.org/10.1007/978-3-030-20249-1_13

Mogensen, F., & Schnack, K. (2010). The action competence approach and the 'new' discourses of education for sustainable development, competence and quality criteria. *Environmental Education Research, 16*(1), 59–74. https://doi.org/10.1080/13504620903504032

Öhman, J., & Östman, L. (2019). Different teaching traditions in environmental and sustainability education. In K. Van Poeck, L. Östman, & J. Öhman (Eds.), *Sustainable development teaching: Ethical and political challenges* (pp. 70–82). Routledge. https://doi.org/10.4324/9781351124348

Olsson, D., Gericke, N., Sass, W., & Boeve-de Pauw, J. (2020). Self-perceived action competence for sustainability: The theoretical grounding and empirical validation of a novel research instrument. *Environmental Education Research, 26*(5), 742–760. https://doi.org/10.1080/13504622.2020.1736991

Olsson, D., Gericke, N., & Boeve-de Pauw, J. (2022). The effectiveness of education for sustainable development revisited—A longitudinal study on secondary students' action competence for sustainability. *Environmental Education Research, 28*(3), 405–429. https://doi.org/10.1080/13504622.2022.2033170

Reynolds, K. A., & Komakhidze, M. (2022). *TIMSS 2023 environmental attitudes and behaviors framework*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2023/frameworks/pdf/T23-Environmental-Attitudes-and-Behaviors-Framework.pdf

Sandoval-Hernández, A., Isac, M. M., & Miranda, D. (2019). *Measurement strategy for SDG global indicator 4.7.1 and thematic indicators 4.7.4 and 4.7.5 using international large-scale assessments in education*. UNESCO Institute for Statistics. https://gaml.uis.unesco.org/wp-content/uploads/sites/2/2019/08/GAML6-REF-9-measurement-strategy-for-4.7.1-4.7.4-4.7.5.pdf

Sass, W., Boeve-de Pauw, J., Olsson, D., Gericke, N., De Maeyer, S., & Van Petegem, P. (2020). Redefining action competence: The case of sustainable development. *The Journal of Environmental Education, 51*(4), 292–305. https://doi.org/10.1080/00958964.2020.1765132

Sass, W., Quintelier, A., Boeve-de Pauw, J., De Maeyer, S., Gericke, N., & Van Petegem, P. (2021). Actions for sustainable development through young students' eyes. *Environmental Education Research, 27*(2), 234–253. https://doi.org/10.1080/13504622.2020.1842331

Sass, W., De Maeyer, S., Boeve-de Pauw, J., & Van Petegem, P. (2023). Effectiveness of education for sustainability: The importance of an action-oriented approach. *Environmental Education Research, 30*(4), 479–498. https://doi.org/10.1080/13504622.2023.2229543

Schulz, W., Fraillon, J., Losito, B., Agrusti, G., Ainley, J., Damiani, V., & Friedman, T. (2023). *IEA International Civic and Citizenship Education Study 2022 assessment framework*. Springer. https://doi.org/10.1007/978-3-031-20113-4

Sinakou, E., Donche, V., Boeve-de Pauw, J., & Van Petegem, P. (2019). Designing powerful learning environments in education for sustainable development: A conceptual framework. *Sustainability, 11*(21), 5994. https://doi.org/10.3390/su11215994

Stepanek Lockhart, A. (2018). Monitoring ESD: Lessons learned and ways forward. In W. J. Leicht, A. Heiss, & W. J. Byun (Eds.), *Issues and trends in education for sustainable development* (pp. 215–231). UNESCO. https://doi.org/10.54675/YELO2332

Taylor, N., Quinn, F., Jenkins, K., Miller-Brown, H., Rizk, N., Prodromou, T., Serow, P., & Taylor, S. (2019). Education for sustainability in the secondary sector—A review. *Journal of Education for Sustainable Development, 13*(1), 102–122. https://doi.org/10.1177/0973408219846675

UNESCO. (2020). *Education for sustainable development: a roadmap*. https://unesdoc.unesco.org/ark:/48223/pf0000374802

United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development.* https://sdgs.un.org/sites/default/files/publications/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

Varela-Losada, M., Vega-Marcote, P., Pérez-Rodríguez, U., & Álvarez-Lires, M. (2016). Going to action? A literature review on educational proposals in formal environmental education. *Environmental Education Research, 22*(3), 390–421. https://doi.org/10.1080/13504622.2015.1101751