FROM IDEAS *to* ACTION

Transforming Learning to Inspire Action on Critical Global Issues

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A Smithsonian Contribution to Knowledge

Smithsonian
Scholarly Press

WASHINGTON, D.C.
2021

Published by
SMITHSONIAN INSTITUTION SCHOLARLY PRESS
P.O. Box 37012, MRC 957
Washington, D.C. 20013-7012
https://scholarlypress.si.edu

Cover design by Claire Purnell. Background globe image courtesy of Nikita Kulchitskiy/Dreamstime.

Library of Congress Cataloging-in-Publication Data
Names: Gibson, Heidi (Educator), author. | Smithsonian Institution Scholarly Press, issuing body.
Title: From ideas to action : transforming learning to inspire action on critical global issues / Heidi Gibson.
Other titles: Transforming learning to inspire action on critical global issues | Smithsonian contribution to knowledge.
Description: Washington, D.C. : Smithsonian Scholarly Press, 2021. | Series: A Smithsonian contribution to knowledge | Includes bibliographical references.
Identifiers: LCCN 2021016220 | ISBN 9781944466503 (paperback) | ISBN 9781944466497
Subjects: LCSH: Smithsonian Institution—Curricula. | Global method of teaching. | Education—Curricula—United States. | Science—Study and teaching—United States. | Social sciences—Study and teaching—United States. | Sustainable development—International cooperation.
Classification: LCC LB1029.G55 G53 2021 | DDC 371.9046—dc23 | SUDOC SI 1.60:L 47
LC record available at https://lccn.loc.gov/2021016220

ISBN-13: 978-1-944466-49-7 (online)
ISBN-13: 978-1-944466-50-3 (print)

Publication date (online): 18 August 2021

Printed in the United States of America

♾ The paper used in this publication meets the minimum requirements of the American National Standard for Permanence of Paper for Printed Library Materials Z39.48–1992.

Contents

Foreword

Carol O'Donnell

Director, Smithsonian Science Education Center

HISTORY OF SMITHSONIAN SCIENCE FOR GLOBAL GOALS

Sometimes, world emergencies make us reconsider the way we need to educate. In 2016, organizations and governments around the globe were faced with the public health emergency presented by the mosquito-borne disease of Zika. Late in 2016, the Smithsonian Science Education Center, in collaboration with the InterAcademy Partnership Science Education Programme and funded by the Gordon and Betty Moore Foundation, committed to developing a set of lessons (a community research guide) that would build student skills necessary to understand the scientific concepts related to Zika and engage students with this global issue on a local level so that they could help their communities address the issue head-on.

Since concerns over the threat of transmission and rapid movement of the disease were very real, the Zika module was intended for as broad an audience as possible. However, the need for broad engagement presented another challenge—without a local government, national curriculum, or state standards to align this material to, there was no clear framework for what it should teach students. There was no clear sense of the content knowledge or skills to prepare students to face new

global challenges. Enter the United Nations (UN) Sustainable Development Goals (SDGs). As a compendium of the world's most pernicious and damaging problems, the SDGs provide a unique opportunity to ground student learning in real-world, pressing global issues. The SDGs open the door to the development of more modules that not only respond to the need for students to learn about the UN SDGs and what they are but also to understand the science content, practical skills, and spirit of action taking that is necessary for meeting the goals by their 2030 target. Thus, Smithsonian Science for Global Goals was born, and the Global Goals Action Progression—or Global GAP, which is the foundation of Gibson's work outlined in this book—became the guiding learning framework for this project.

THE IMPORTANCE OF SMITHSONIAN SCIENCE FOR GLOBAL GOALS

Both disease transmission and mosquito prevalence can change rapidly and are highly influenced by local action or inaction, so education is a critical component in creating change. However, educators need support in helping students engage with these types of emerging threats that link local actions to global issues. To date, the Smithsonian Science Education Center has developed community research guides responsive to the most pressing global issues—including topics focused on mosquito-borne diseases, food and nutrition security, COVID-19, vaccines, biodiversity loss, and the need to ensure sustainable communities. We believe that every young person around the world should have access to the educational tools necessary to not only enter the workforce but to develop knowledge, skills, and values that lead to continued prosperity and peace for themselves, those in their own community, and the planet at large. Sustainable development is the "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: 16). This kind of human progress necessitates embracing the underlying science, technology, engineering, and mathematics (STEM) information, new research, concepts, and problem-solving skills that are the foundation for a sustainable and thriving society.

The Smithsonian Science Education Center seeks to support every young person to develop the knowledge and understanding of STEM subjects to enable them to tackle the world's most pressing issues in their own communities and around the world. Through the work that the center has carried out since 1985, and the 2018 addition of the Smithsonian Science for Global Goals project and its associated learning framework, the Global GAP, a more sustainable future can become a reality.

THE GLOBAL GAP AND SUSTAINABILITY MINDSETS

The Global GAP—the focus of this book—empowers youth to take an active role and contribute their own local actions to have a global impact. This is accomplished by developing science and engineering skills, scientific content knowledge, interdisciplinary thinking abilities, and sustainability mindsets. The sustainability mindsets are the attitudes and habits of thinking needed to continue to engage with SDGs and other global issues. By repeatedly revisiting the action progression to address the many issues outlined in the SDGs, students build their action competence—the knowledge and skills needed to determine action and the confidence to perform it (Hedefalk et al. 2014) and also develop a lifelong foundation for science literacy. This burgeoning literacy supports youth to not only understand scientific content knowledge but to be able to apply it toward novel situations in their everyday lives—providing a local lens through which to view global issues.

WHY IS THIS BOOK IMPORTANT?

Young people face a world with problems that require broad collaboration and innovation to ensure a positive future for everyone. Giving young people the tools to help build this future is essential. This book will help educators give young people the experiences that will enable the development of these tools. The work detailed in this book is foundational to the Smithsonian Science for Global Goals community research guides. Gibson articulates a framework that young people can follow to build their sustainability mindsets, the skills they need to successfully engage in the work of transforming their communities.

The Global GAP starts by acknowledging the significant resources young people bring to learning in the forms of their ideas and their local knowledge. This is particularly important because young people drive what they are learning. The Global GAP gives young people the opportunities to refine their initial ideas through investigations, synthesize and evaluate what they find out, and finally put their refined ideas into action to transform their local and global spaces. Young people are empowered as valuable agents of change.

With the goal of supporting young people to transform the world around them into the place they want it to be, equity must be at the heart of every choice and conversation. This means that learning resources must be available to all young people, not only those in well-resourced spaces. It also means that tools for educators must feel relevant to the lived worlds of every young person and speak directly to the issues they face. Taking culturally and place specific ideas out of learning resources and encouraging local customization not only provides a more equitable opportunity for students in a variety of cultures but helps young people build the skills they need to make global issues local. Rather than following a prescriptive model, young people become cocreators, navigating and designing their own learning journey. This allows for participation by a wider variety of young people, coming from a broad swath of places and cultures.

Although this learning progression was developed to help guide Smithsonian Science for Global Goals community research guides, it also represents a valuable starting point for a broader conversation about the best way to help students investigate, make sense of, and change their local, national, and global communities. By pulling together strands from so many curricular areas, Gibson has created a learning progression that can be used both in individual disciplines and in a transdisciplinary way.

Organizations and educators around the world are considering how to give young people the skills they need to create a thriving future. They can look to the Global GAP as a road map of how to develop the most essential skills that can be transferred between disciplines and locations. Skills such as equity and justice, open-mindedness and reflection, empowerment and agency, and an ability to recognize the global-local interconnection will help young people develop sustainability mindsets for the future they want.

Preface

Transforming learning from a passive to an active endeavor is critically important in today's world. In 2015, the United Nations identified a series of 17 important worldwide goals, the Sustainable Development Goals (SDGs). These goals represent a global consensus on the world's most pressing issues. Realizing the ambitious goals specified by the SDGs will require concerted action at all levels, including local ones. Young people are valuable components of this local action, and their learning experiences should both inspire and inform them as current and future changemakers. This publication articulates the theoretical basis of Smithsonian Science for Global Goals, a socio-scientific community research guide focused on achieving a systemic understanding of global problems with the goal of inspiring students to take informed and sustained action to help address global issues, such as the ones highlighted by the SDGs. Undergirding this guide are the best practices and frameworks found in inquiry-based science education, socio-scientific issues education, global citizenship education, civic education, social studies education, education for sustainable development, participatory action research, and place-based education. Perspectives from a variety of disciplines, such as scientific understandings, social behaviors, economic considerations, and ethical components, must be considered before determining sustainable actions in communities. Concepts from the different disciplines were blended together to form a learning progression. This progression, the Global Goals Action Progression (Global GAP), guides students

from an initial stage of developing questions around a specific SDG-aligned issue, through investigations on the nature of that issue and how it relates to their local context, to a balance between critical reasoning on specific aspects of the issue and a systemic understanding of the issue as a whole, to a consensus-building process to determine future steps, and, finally, to implementing a local action and reflecting on it. Through this process, students build a habit of action that is transferrable to different problems. They also learn how to cultivate mindsets related to global interconnections, scientific literacy, equity and justice, open-mindedness and reflection, and empowerment and agency. These mindsets support long-term informed engagement with global issues, such as the ones defined by the SDGs. Given the worldwide nature of global problems, also discussed are guide design elements necessary to make a broadly available guide both non-exclusionary and locally relevant. The Global GAP learning progression and the mindsets it promotes are designed to encourage sustained, informed, student-led action.

Introduction to Sustainable Development Goals

The Big Picture

The United Nations (UN) Sustainable Development Goals (SDGs) are a series of 17 ambitious goals agreed to by the UN member countries as the development priorities between 2015 and 2030. Unlike their nominal predecessor, the UN Millennium Development Goals (MDGs), the SDGs are goals for all countries, rather than limited to those from less affluent or industrialized contexts. In addition, the SDGs are much broader in scope than the MDGs, which were restricted to eight areas. The SDGs represent the consensus of issues seen as most critical to address during the 15-year period (United Nations General Assembly 2015). The pressing issues addressed under the SDGs include a number of explicit environmental goals (e.g., Goal 13, Climate Action; Goal 14, Life below Water; and Goal 15, Life on Land), social goals (e.g., Goal 5, Gender Equality; Goal 10, Reduced Inequalities; and Goal 16, Peace, Justice and Strong Institutions), public health goals (e.g., Goal 2, Zero Hunger; Goal 3, Good Health and Well-being; and Goal 6, Clean Water and Sanitation), and economic goals (e.g., Goal 1, No Poverty; Goal 9, Industry, Innovation and Infrastructure; and Goal 12, Responsible Consumption and Production). Each goal contains multiple targets that break down the overarching goal into smaller components.

Naturally, although each goal may perhaps fit broadly into a specific category, the complexity of real-world systems interconnects them. One cannot consider environmental goals without also, for instance, encompassing economic and public health concerns. An analysis by

Pradhan et al. (2017) focused on these interactions between goals and showed that correlations/synergies between SDG goals outweighed trade-offs. The International Council for Science also found overwhelmingly positive implementation relationships between SDGs (McCollum et al. 2017). Essentially, this means that making progress on one goal can help make progress on others. Pradhan et al. (2017) detailed the positive correlation between No Poverty (Goal 1), Good Health and Well-Being (Goal 3), Quality Education (Goal 4), Reduced Inequalities (Goal 10), Responsible Consumption and Production (Goal 12), and Climate Action (Goal 13). Put broadly, individuals who have better health and are better educated are less likely to live in poverty, which reduces inequality. In addition, these healthy, educated individuals might engage in more responsible production and consumption, which would have positive impacts on achieving action on climate change. However, these relationships also work in other ways. For example, climate change can lead to poverty because of impacts on farmers, forced migration, and so on. Therefore, taking action on climate change can help reduce poverty and, thus, inequality. Clearly, given both the interconnected nature of the goals and the synergies between them, examining the goals in a systemic way within both local and global contexts seems wise.

Understanding issues of sustainable development by individuals is of critical importance if there is a need for action at the local level to achieve the SDGs. Recognition of this need is written into the SDGs themselves. Goal 4.7 specifically addresses the need for education in sustainable development; it states, "By 2030 ensure all students acquire knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship, and appreciation of cultural diversity and of culture's contribution to sustainable development" (United Nations General Assembly 2015). Education is a crucial part of the SDGs, not only due to its role as a specific goal but also because it is essential to the possibility of progress on all goals (Aichi-Nagoya 2016). However, the consensus of the nature and format of the education needed for progress on the SDGs is still coalescing. Many of the ambitious goals specified by the SDGs will require concerted

action at all levels, including local ones. To be successful, SDG-related education needs to both inspire and inform this action (Sterling 2016). In addition, since the SDGs are, by their very nature, pernicious problems that are not easily solved, SDG-related education needs to promote long-term engagement on these global goals.

Recognizing that students' scientific understandings should inform this need for action and engagement, the Smithsonian Science Education Center (SSEC), in partnership with the InterAcademy Partnership of the National Academies of Sciences, identified a need for SDG-aligned learning materials that incorporate scientific perspectives, and created the Smithsonian Science for Global Goals community research guides. Scientific understandings are crucially important for students to comprehend both the nature of the SDG problems and the possible solutions. However, limiting student understanding solely to science is insufficient to build a complete picture of the constraints and possibilities of SDG action in local communities. Additional perspectives, such as social behaviors, economic considerations, and ethical components, must be considered before determining sustainable actions in communities. Data and perspectives that are often siloed in different disciplines come together in Smithsonian Science for Global Goals to create socio-scientific guides focused on achieving a systemic understanding of problems with the goal of inspiring students to take informed and sustained action to contribute to the SDGs.

The SDGs are important for all students to understand, not just ones in a specific place or those who are well resourced. Given the important nature of the SDGs and the necessity of action in all places around the world, it is essential that Smithsonian Science for Global Goals is freely available for all teachers and students to access. Although Smithsonian Science for Global Goals can be translated, only a limited amount of local customization is feasible given the breadth of locales where the learning materials are intended to be used. This presented a design challenge centered on how to make Smithsonian Science for Global Goals relevant to varied places and cultures around the world. The proposed solution is to lead students themselves through structures and activities to supply their local information through a series of investigations rather than incorporating content specific to one place or context within the

Smithsonian Science for Global Goals guides themselves. This design feature not only solves the issue but also enriches Smithsonian Science for Global Goals by empowering students through its emphasis on accessing and building their local knowledge. The global SDGs are made local by questioning and investigating them in the local context then making local decisions on the most sustainable actions and implementing them at the local level. By empowering students to make decisions relevant to and sustainable in their own contexts, there is a greater chance of long-term civic engagement (Noddings 2005) and engagement with the goals themselves. Ultimately, in Smithsonian Science for Global Goals, students have the opportunity to share data, personal connections, contexts, and their efforts with others from around the world, embedding their local concerns and contexts into global ones.

After examining literature in a number of thought areas, the SSEC believes that the goal of education for the SDGs can best be achieved by focusing on developing habits of empowered, informed action; providing structures for scaffolding difficult concepts to make them accessible, while not diminishing real-world complexity; promoting long-term engagement in solving global problems; and connecting the abstract global SDGs to local contexts in a concrete way. In addition, in the interests of equity and efficiency, the Smithsonian Science for Global Goals learning materials must be available to all students and must incorporate design features so they are relevant and accessible to different contexts, as will be discussed further in the section "Developing Learning Materials Relevant to All."

The Global GAP

FIVE STAGES OF GLOBAL GAP LEARNING PROGRESSION

Stage 1: Questioning

The Global GAP learning progression begins with questioning—the identification of a problem, the formulation of a question, and then the determination of data requirements. As discussed, the Global GAP stages incorporate ideas from a variety of frameworks from across disciplines (see Table 1). For example, starting with a question and establishing the need for evidence are standard elements of the scientific process and are explicitly part of the United States' Next Generation Science Standards (NGSS) practice of "Asking Questions and Defining Problems." However, they are also common in the social sciences, as evidenced by the "Developing Questions and Planning Inquiries" dimension of the C3 Framework (National Council for the Social Studies [NCSS] 2013). This idea is also inspired by global competency education with its goal: "Identify an Issue, generate questions, and explain its significance" (Boix-Mansilla and Jackson 2011). Finally, it draws from civics literature with the concept of teaching through "big" (in this case global) ideas. Teaching through these big ideas helps ground students in a larger picture and enables them to look beyond their purely individual concerns (Cavieres-Fernandez 2014).

TABLE 1. Global GAP Stage Overview: Questioning.

Exploring the Problem	Inspiration from Other Disciplinary Frameworks[a]
• Identify the problem locally and globally • Formulate and prioritize questions • Explore the importance of the problem in local and global contexts • Determine data requirements	• Ask questions and define problems (NGSS) • Develop questions and plan inquiries (C3) • Identify an issue, generate questions, and explain its significance (GCE) • Teach through big ideas (civics) • Engage students as research partners (PAR) • Identify problems as part of responsible decision making (SEL) • Set goal as part of self-management (SEL)

[a] Abbreviations and sources:
civics = Cavieres-Fernandez (2014);
C3 = College, Career & Civic Life Framework for Social Studies State Standards (National Council for the Social Studies, NCSS 2013);
GCE = Global competence education, using a framework developed by the Asia Society (Boix-Mansilla and Jackson 2011);
NGSS = Next Generation Science Standards, an example of inquiry-based science (NGSS 2013);
PAR = Participatory action research (YPAR Hub n.d.);
SEL = Social–emotional learning framework (CASEL n.d.).

Drawing on the work of participatory action research, the questioning stage is an opportunity to engage students as fellow researchers and begin building empowerment and equity (Ozer 2016). In most settings, school has extreme power hierarchies. Smithsonian Science for Global Goals attempts to flatten these hierarchies by giving students a voice in determining the design and outcome of all stages. Students determine the formulation of questions and research agendas, which gives a voice to a group that typically has only limited power over decision making (Langhout and Thomas 2010). This inquiry is very important for students to access and formulate knowledge. As Paolo Freire states, "knowledge emerges only through invention and re-invention, through the restless, impatient, continuing, hopeful inquiry human beings pur-

sue in the world, with the world and with each other" (Freire 1996: 53). Empowering students in this way helps not only with their own identity formation and sense of purpose (Malin et al. 2015) but also their connection with the research group and the community at large (Berg et al. 2009). Through inquiry and questioning, students are empowered, are connected to the group, and have an opportunity for self-reflection.

The Global GAP questions, although initially inspired from the SDGs, will need to allow for additional questions of local relevance to be added and explored by students. For example, on a topic of agriculture and food pathways, general questions related to the structure of growing and transporting food will be universal. However, students in some places may have to contend with additional questions related to the lack of reliable refrigerated storage and transport for food products. Students in other areas may want to ask questions related to environmental impacts of using refrigerated transport and explore how this impact may not be visible to consumers. Thus, although there are consistent questions around the global issue that span different contexts, there are also very specific questions that reflect the lived reality for students. This combination of global significance and local relevance and applicability makes an issue particularly engaging for students (Noddings 2005).

Stage 2: Investigating

The second stage of the Global GAP is investigating. Time spent investigating encompasses planning and carrying out different methods of investigation, which can include scientific experimentation, gathering information from written sources, and social science–based explorations into community practices, needs, and values. This stage also brings together the scientific conceptions of "obtaining information" and "planning and carrying out investigations" (Next Generation Science Standards 2013) and from social sciences the ideas of "applying disciplinary tools and concepts" including using tools from civics, economics, geography, and history (NCSS 2013; see Table 2). Socio-scientific frameworks and thought leaders often highlight the importance of data-driven decision making (Zeidler et al. 2005). During the investigation stage, students gather this data to use in future stages as part of

TABLE 2. Global GAP Stage Overview: Investigating.

Finding Evidence to Inform Decisions	Inspiration from Other Disciplinary Frameworks[a]
• Plan methods of investigation • Gather data from a variety of sources • Find information through research • Enhance understanding through experimentation	• Plan and carry out investigations (NGSS) • Apply disciplinary tools and concepts (C3) • Collect and/or analyze scientific data (SSI) • Use tools and techniques to collect data (PAR) • Evaluate local knowledge (ESD) • Search for data-driven knowledge (SSI) • Obtain information (NGSS) • Gather data (SSI) • Investigate the world (GCE) • Acquire knowledge and understanding of global and local issues (GCED)

[a] Abbreviations and sources:
C3 = College, Career & Civic Life Framework for Social Studies State Standards (National Council for the Social Studies, NCSS 2013);
ESD = Education for Sustainable Development (Aichi-Nagoya 2016);
GCE = Global Competence Education, using a framework developed by the Asia Society (Boix-Mansilla and Jackson 2011);
GCED = Global Citizenship Education (UNESCO 2015);
NGSS = Next Generation Science Standards, an example of inquiry-based science (NGSS 2013);
PAR = Participatory action research (YPAR Hub n.d.);
SSI = Socio-scientific issues (Zeidler et al. 2005).

the decision-making process. Students can also use various techniques of social science–based participatory action research such as focus groups, interviews, observations, and mapping (Ozer 2016; YPAR Hub n.d.). Using these multidisciplinary tools students have a chance to explore how investigations can elucidate the nature of a problem in a variety of ways.

During this time, students can also dig deeper to understand local knowledge. For example, a study of aspects of sustainable cities might include how locals confront these challenges in place-specific ways or a study of agriculture might include an exploration of traditional farming practices.

This emphasis on local understanding is supported by the education for sustainable development experts working on the SDGs who suggest that students should "evaluate local knowledge and re-evaluate using participation and empowering processes with a focus on creating new validity for young people" (Aichi-Nagoya 2016: 223). Using local knowledge helps to build empowerment; instead of the deficit mindset often applied to children, they can be viewed as experts in their own lives and communities (Langhout and Thomas 2010). Flexibility among educators in allowing investigations into multiple areas and ideas allows students to develop a more comprehensive picture of the problem and possible solutions.

Throughout this stage, students build mindsets related to empowerment and agency, global interconnection, and open-mindedness and reflection. The focus on inquiry-led research, with students finding answers for themselves through experimentation and community understanding, is related to building the empowerment and agency mindset. Students take charge of their own learning, allowing them to build confidence and belief in their own efficacy as they conduct their own investigations to build understanding. Sharing power and decision making with students helps build ownership over the process (Ozer 2016), which helps empower students to view themselves as knowledgeable agents of change.

The multidisciplinary approach of investigation builds student mindsets in two major ways related to the goals of global interconnection and open-mindedness and reflection. One, it builds the complex thinking necessary to understand global interconnection. Students explore complexity by understanding the nuances that arrive by using different disciplines to provide a variety of types of evidence. Two, students develop open-mindedness by learning perspective taking and respect for diversity. The multidisciplinary approach encourages understanding different perspectives by providing different types of evidence that may lead to different conclusions. Student grow in their appreciation of the impact of perspective by examining the way science might approach an issue and how that method may differ from local community understanding of an issue. Students examine the broader empirical scientific evidence, together with insights gained about the local community's practices and values. Weaving together these different worldviews leads to greater student understanding of different perspectives.

Stage 3: Critical Reasoning and Systemic Understanding

The third stage of the Global GAP has two sections—critical reasoning and systemic understanding. This central stage focuses on discussion and understanding. During this stage, students seek to deeply comprehend problems in two ways.

One, the critical reasoning section can be broadly understood as being in vitro, a Latin term meaning "in glass." This scientific term means something examined in a test tube, laboratory, or similar isolated method. Applied to the Global GAP, it encompasses students examining their generated data and other characteristics of a problem in an isolated way to more fully comprehend them. For example, if students were studying equitable energy access, during this section they may think critically about different types of energy creation or the infrastructure needed for energy access.

The second section, Systemic Understanding, can be broadly understood as being in vivo from the Latin term for "in life." This term means examining something within the system where it is normally found. Within the context of the Global GAP, it means the systemic consideration of the global problem with all the complexity and interactions that accompany that problem in the local and global system. Continuing with the example of a topic on energy access, during the systemic understanding section students may use their understandings of types of energy access and infrastructure requirements developed in the critical reasoning section to go further by examining how understandings and potential solutions change when placed into a system. Students may understand energy access choices of a community more fully when they look at systemic relationships between factors such as poverty, infrastructure, and cultural norms. In addition, examining potential solutions in a system should lead students to think about potential barriers to implementation and possible unintended consequences. These two aspects of considering a problem help develop a rigorous understanding. Just as in scientific thought, these two areas inform each other.

Determining Root Causes: Critical Reasoning

The critical reasoning section of stage 3 focuses on the skills associated with critical thinking, evidence-based reasoning, and argumentation (see Table 3). Drawing on work from SSI, "reasoning is what we do when we involve a spectrum of thought—combining rationalistic, emotive and intuitive justifications and actions" (Mueller and Zeidler 2010: 112). Data and evidence are examined in isolation to understand them more fully without preemptively introducing the complications involved in a systemic view.

For example, if students conducted a scientific experiment in the investigating stage, then during the critical reasoning section, they would take the results of that experiment, analyze them, and use the analysis of that data to support claims about the phenomena. Likewise, if students gathered community data through interviews with community members in the investigating stage, then during this stage, they might focus on the analysis of those interviews and determine how that analysis might affect their thinking about a root cause of the global problem. The topics explored through Smithsonian Science for Global Goals are so large and complex that understandings first need to be developed for individual aspects of the problem before grounding it in the complex whole. This individual deep understanding of different aspects of the topic, an in vitro approach, is the aim of this section. This focus on individual aspects of and data related to the global problem sets up students to add these individual causes and phenomena into a system in an accessible way later in the Global GAP.

Activities during the critical reasoning stage also help develop important skills such as critical thinking, which are widely acclaimed as crucial for students in the twenty-first century (National Education Association 2012; NCSS 2013; NGSS 2013). The characteristics of critical-thinking skills developed within the critical reasoning stage are drawn from a number of disciplinary areas.

For example, critical-thinking skills can include developing models and using mathematics and computational thinking, a part of the Next Generation Science Standards (2013). If students were studying the topic of sustainable agriculture, one smaller portion of this topic might

TABLE 3. Global GAP Stage Overview: Critical Reasoning.

Using Evidence to Shape Explanations and Actions	Inspiration from Other Disciplinary Frameworks[a]
• Analyze data and propose explanations • Explore possible causes of problem • Creatively propose actions • Critically evaluate potential impacts of actions • Construct a reasoned argument based on evidence	**Critical thinking** • Develop models (NGSS) • Use mathematics and computational thinking (NGSS) • Critically reflect (ESD) • Critically evaluate competing claims (SSI) • Evoke critical thinking (GCED) • Use values thinking and futures thinking (ESD) • Use habits of mind (NEA, 4 Cs) **Evidence-based reasoning** • Develop argument based on compelling evidence and draw defensible conclusions (GCE) • Analyze, integrate, and synthesize evidence to construct coherent responses (GCE) • Use a variety of languages, sources, and media to identify and weigh relevant evidence (GCE) • Consider nature of science themes (SSI) • Transform reasoning (to take evidence and change your mind) (SSI) • Explain the impact of cultural interactions (GCE) • Evaluate information (NGSS) • Construct explanations (NGSS) • Analyze and interpret data (NGSS) **Argumentation** • Take a position (SSI) • Acquire skepticism (SSI) • Construct an argument (SSI) • Have a dialogue (socio-ecological issues) • Argue (SSI) • Engage in an argument from evidence (NGSS)

[a] Abbreviations and sources:

4 Cs = Twenty-first century skills (National Education Association 2012);

ESD = Education for sustainable development (Aichi-Nagoya 2016);

GCE = Global competence education, using a framework developed by the Asia Society (Boix-Mansilla and Jackson 2011);

GCED = Global Citizenship Education (UNESCO 2015);

NEA = Twenty-first century skills (National Education Association 2012);

NGSS = Next Generation Science Standards, an example of inquiry-based science (NGSS 2013);

SSI = Socio-scientific issues (Zeidler et al. 2005).

be an examination of the impact of erosion on agricultural outcomes. During this stage, students might build real or virtual models based on their previous investigations, to understand the impacts and causes of erosion more fully. Drawing ideas from SSI education, students then might engage in a critical evaluation of competing claims, which might take claimed causes of erosion and try to understand their relative effects (Zeidler et al. 2005).

As a final part of critical-thinking skills, drawing on ideas from ESD, students move from understanding a problem to proposing different solutions. The relevant concepts from this area from ESD include proposing an innovation, values, and futures thinking (Presley et al. 2013; Besong and Holland 2015). What this means in the erosion example is that students could propose different potential mitigating actions and try to understand how these actions would impact agricultural erosion in the future. The critical-thinking skills needed to unpack and analyze the evidence previously collected, to evaluate root causes, and to propose solutions are developed through the activities and discussions of the critical-reasoning section.

Activities during this section also develop evidence-based reasoning skills, identified by many disciplinary areas as important. Evidence-based reasoning skills include constructing an argument based on evidence (College, Career & Civic Life [C3] framework, GCE), using a variety of evidence (GCE), considering the nature of science (SSI), and evaluating information and constructing explanations (NGSS) (Boix-Mansilla and Jackson 2011; NCSS 2013; NGSS 2013; Presley et al. 2013). Continuing to use the example of the examination of agricultural erosion, to develop evidence-based reasoning skills, students must evaluate and use evidence to support their arguments and explanations, while making claims about competing root causes.

Students also must be prepared to rethink their initial ideas in response to evidence that supports alternate claims, which is part of considering the nature of science, a concept discussed in SSI (Zeidler et al. 2005). In this stage, students are empowered to explore the dilemma of whether scientific results should be seen as the best way to understand a phenomena or a focus on science as something continually contested and revised (Tytler 2012). This nature of science question

cuts to the heart of this stage's critical examination of evidence—essentially, attempting to establish claims about veracity and the methods of both reaching and evaluating claims of truth. Evidence, especially when gathered using different disciplinary tools, may lead toward different explanations and different solutions. For example, our agricultural erosion students may, through scientific investigation, gather evidence related to how certain plants bind the soil and help prevent erosion. However, through community investigations, they may find that certain farming practices are dictated by constraints such as lack of access to water or cultural norms that lead to certain crop preferences. Understanding how the evidence can lead to varied root causes and trying to understand how this affects solutions is an important part of the evidence-based reasoning skills that are part of the critical-reasoning section.

Students also need to critically examine their own identity and its relationship to their conclusions (Simonneaux and Simonneaux 2009). As Nel Noddings (2005: 59) pointed out, "as educators, we want young people to make a commitment to preservation of the natural world. However, a real commitment demands engagement, study, and critical thinking of the most difficult kind—thinking that examines and questions our own intial positions." This self-examination necessitates reflection about one's own values and perspectives and how they relate to others, leading to self-reflection about ethical dilemmas. For example, the ethical dimensions of environmental action range from who or what has value and therefore needs to be taken into account for environmental decision making to the basis of the relationships between humans and nature (Kronlid and Öhman 2012). Students need to wrestle with the underlying beliefs behind their ideas. As students think through the relationship between humans and ecosystems, they face ethical choices; for instance, do they believe that humans are more important than other organisms? Answers to questions such as these dictate what actions students may deem appropriate. Therefore, if students can critically examine their own beliefs, they may have additional possible avenues of action open up. Student's individual work of modifying their existing beliefs in response to compelling evidence is a key part of critical reasoning.

Finally, the activities of this section build argumentation. Engaging in open classroom discussions is crucial for fostering civic engagement (Nie et al. 1996). The scientific community has also recognized argumentation as valuable because of its characteristics such as position taking (SSI), dialogue (socio-ecological issues), and emotional and moral reasoning (SSI) (Zeidler et al. 2005; Colucci-Gray et al. 2006). This type of argumentation helps students understand the relationship of a claim and supporting data and the general epistemological basis of science (Grooms et al. 2014). By grounding this stage in interpretation and evaluation of the data collected, students become accustomed to the relationship between evidence and argument.

Reflecting on their own positions and assumptions as they think critically about individual aspects of the global problem can help students think flexibly and develop mindsets of open-minedness and reflection. This attribute is reinforced by the need for students to actively listen to alternative theories or proposed actions. In addition, in this stage students develop skills of empowerment and agency related to their critical examination of data to use in argumentation and their ability to construct their own understandings of the issue. Having the ability to construct personal understandings, rather than predetermined "right" answers set out by a textbook or curriculum, is a key part of empowerment. Developing these mindsets is an important part of Smithsonian Science for Global Goals.

Connecting to Complexity: Systemic Understanding

It is not enough to examine phenomena in isolation, however, and so the other section of this stage is systemic understanding, which focuses on connecting the pieces examined in critical reasoning with each other (see Table 4). The complex, social issues addressed by the SDGs cannot be fully understood microscopically but must be viewed holistically, in relationship to each other, as they occur in the real world. Students and teachers must connect the pieces together through their in vivo stage of systemic understanding. Bridging the gap between the oversimplification of concepts present in many classrooms and the complexity of real-world systems is an important function of education (Colucci-Gray

TABLE 4. Global GAP Stage Overview: Systemic Understanding.

Connecting Evidence to Systemic Complexities	Inspiration from Other Disciplinary Frameworks[a]
• Explore differences in perspectives and the values they represent • Examine different ways of knowing and thinking about the problem and potential solutions • Map the connections between place, culture, individual situations, communities, and perspectives • Appreciate the complexities involved in understanding the problem and placing it into a global context	**Perspective taking** • Recognize multiple forms of inquiry (SSI) • Accept ambiguity (SSI) • Examine others' perspectives and identify what influenced them (GCE) • Recognize and express their own perspective and identify influences on that perspective (GCE) • Reason (SSI) • Accept and preserve indigenous knowledge (ESD) • Emotionally and morally reason (SSI) • Maintain open-mindedness (SSI) • Empathize (SEL, GCED) • Appreciate diversity (SEL) • Respect others (SEL) • Understand ethical underpinnings of choices (sustainability and environmental education) **Systemic understanding** • Use models (NGSS) • Be socially aware (SEL) • Identify basic, common needs (socio-ecological issues) • Confront ethical dimensions (SSI) • Negotiate social dimensions (SSI) • Use cognitive skills in systemic thinking (ESD) • Understand relationship between identity and science (SSI) • Understand interrelationships (socio-ecological thinking) • Articulate how differential access to knowledge, technology, and resources affects quality of life and perspectives (GCE) • Understand the global impacts of local actions (socio-ecological thinking) • Recognize complex systems and associated uncertainty (socio-ecological thinking)

[a] Abbreviations and sources:
ESD = Education for sustainable development (Aichi-Nagoya 2016);
GCE = Global competence education, using a framework developed by the Asia Society (Boix-Mansilla and Jackson 2011);
GCED = Global Citizenship Education (UNESCO 2015);
NGSS = Next Generation Science Standards, an example of inquiry-based science (NGSS 2013);
SEL = Social-emotional learning framework (CASEL n.d.);
socio-ecological thinking = Kronlid and Öhman (2012);
SSI = Socio-scientific issues (Zeidler et al. 2005).

et al. 2006). The exploration into connectedness includes an examination into perspective taking. Students map connections and complexity by engaging with different perspectives and systemic thinking. In these ways, students can understand not only their own community in a more comprehensive way but can also appreciate links to a complex global community.

The ability to understand multiple perspectives is seen as valuable in a wide array of disciplines. For example, the concepts of examining others' perspectives found in GCE (Boix-Mansilla and Jackson 2011) or "recognizing multiple forms of inquiry" (Zeidler et al. 2005: 358) discussed in SSI thought. Examination of sustainable development issues needs a holistic approach, considering multiple aspects and perspectives of the same problem. The need for many perspectives stems from the fact that reality is complex and can best be understood by using the lenses of many individuals to shed light on different aspects (Colucci-Gray et al. 2006). Holistic thinking has been linked to sustainability knowingness, and understanding and examining a plurality of ideas has been linked to sustainability-related behavior (Pauw et al. 2015). Debates about sustainability are not easily resolved using a purely scientific approach but instead require assessing the impacts using a variety of disciplines including social, economic, and environmental (Robottom 2012).

In this section, students can see how their opinions about the issues examined in the critical-reasoning section compare with the perspective of others. In the critical-reasoning section, students examine their own individual assumptions and values as part of self-reflection. In the systemic understanding section, students are encouraged to engage with a multiplicity of opinions as an exploration of possibilities rather than a competition for the best opinion. This helps develop SEL attributes such as "appreciating diversity" and "respect for others" (CASEL n.d.). Students look holistically at the opinions and thoughts shared by other students in discussions, to further understand how the system in which they operate affects these opinions. Part of this process is understanding the ethics behind students' thoughts and opinions. True understanding of another's perspective requires engaging with the ethical underpinnings behind that perspective (Kronlid and Öhman 2012).

For example, if studying genetically modified organisms (GMOs), one student during the critical-reasoning section might develop an understanding of the potential of GMO agriculture to provide a more stable and prolific food supply. Another student might focus on the potential for GMOs to disrupt ecosystems in unknown ways. The systemic understanding section brings these two perspectives together. Students can explore how these perspectives might be reflective of ethical choices (e.g., an emphasis on the primacy or human needs or an emphasis on the equality of the needs of all living things). Using these different perspectives, students build a more holistic view of different aspects of the global problem. Through this process, students develop the mindset of open-mindedness and reflection by learning how to respect others' perspectives and the mindset of equity and justice by considering the ethics behind those perspectives.

Systemic thinking, linking both information from a variety of disciplines and different aspects of the global problem itself, allows students to appreciate the real-world complexity of the problems they are examining. Systemic thinking is valued in a number of fields. It is prized because of its need for social awareness (SEL, SSI), the involvement of cognitive skills (ESD), its need for understanding interrelationships (socio-ecological), and its need for understanding the global impacts of local actions (socio-ecological, GCE) (CASEL n.d.; Colucci-Gray et al. 2006; Putnam et al. 2011; Zeidler et al. 2013; Kopnina and Meijers 2014; UNESCO 2015; Hoeg and Bencze 2017). Systemic thinking requires students to consider multiple aspects of a problem at once and place them in relationship to each other. This is a much closer approximation to the way problems work in real life and so examining issues in a systemic way helps paint a more accurate portrayal of the issue. Developing systemic thinking abilities helps to scaffold students to a greater understanding of the global problem they are examining.

In Smithsonian Science for Global Goals, students are encouraged to map connections between aspects of the global problem to more fully understand how one aspect of a problem can affect another. Looking at the whole problem is an important part of understanding it. Iris Duhn wrote about connections specifically as they related to place, "Understanding how these places are made through human and more-than-

human encounters creates entirely new ways of being and becoming" (Duhn 2012: 102). In addition, holistic thought can help ground students in a sense of connectedness to the world (Wang 2017), helping to make learning relevant. A deep understanding of systemic connections can be transformative for students by creating a sense of belonging with their natural surroundings.

Global–local interrelationships are a critical part of systemic thinking. The examination of the systemic relationships necessarily requires looking at the local aspects of the problem to fully understand it since they are an integral part of the system studied. However, fully understanding a problem is also impossible without considering how the local manifestation of the global problem is related to global patterns. For example, if students are studying the impacts of climate change in their local area, they must understand the effects that climate change has on their own daily lives including aspects related to agriculture, weather, and infrastructure. However, they cannot fully understand that system, root causes and potential mitigating actions, without embedding it within the larger system of the global climate-change issue.

Understanding systems can help encourage students to move away from a competition-driven paradigm to one more focused on cooperation. Students can shift their orientation both toward the natural environment and present and future generations (Bușoi 2015). Developing these understandings of connections and possibilities for cooperation helps build mindsets related to global interconnections. In addition, as students build a systemic understanding, they start to see parts of a system in relation to each other and consider the ethics of those relationships. This builds the equity and justice mindset.

Mutual Reinforcement: Critical Reasoning and Systemic Understanding

Together the two dimensions (critical reasoning, "in vitro," and systemic understanding, "in vivo") work together to allow groups of students to metaphorically take apart the engine (the global SDG-aligned problem), examine each part to see how it works, and rebuild it again. As they go through this process, students gain a greater understanding

not only of the mechanics of each individual aspect of the problem but also the interconnections between the pieces. This equips them to propose more intelligent and useful mitigating actions and fully explore the expected impacts of those actions.

Stage 4: Synthesizing

The fourth stage of the Global GAP is synthesizing. In this stage, the students find consensus and make decisions. Enabling students to collaborate to find consensus, identify areas of common ground, seek to understand the perspectives of others, evaluate options, and make decisions about the action they would like to take to address the global problem are the goals of the synthesizing stage (see Table 5).

This time of consensus building and decision making is deliberately separated from the analyzing and understanding period that precedes it. This separation is precipitated by a need to build consensus rather than debate. Laura Colucci-Gray and colleagues (2006) conducted research over a decade on the most effective way to approach socio-ecological issues, and while they initially focused on argumentation and then persuasion, they found in both cases that students became too focused on their own viewpoints rather than actively listening to others. It was only when they changed the model with the goal of finding consensus that student interactions were truly effective. The authors noted that "the complexity of reality does not allow for simple and straightforward answers to problems, but many voices are needed and so are deep listening and a respectful interaction among participants"(Colucci-Gray et al. 2006: 246). This emphasis on peaceful conflict resolution is not only a central skill of global citizenship (UNESCO 2015) but is also specifically part of the SDGs through SDG 16 (Peace, Justice and Strong Institutions), particularly target 16.7, "ensure responsive, inclusive, participatory and representative decision-making at all levels." Modeling this type of real, peaceful decision making at a classroom level should encourage participatory citizenship at higher levels (Keating 2015).

The importance of collaborative decision-making skills is highlighted in a number of different thought areas, including SEL, GCE, and SSI education (CASEL n.d.; Zeidler et al. 2005; Boix-Mansilla and Jackson

TABLE 5. Global GAP Stage Overview: Synthesizing.

Find Consensus and Make Decisions	Inspiration from Other Disciplinary Frameworks[a]
• Collaborate to find consensus through a respectful interchange of ideas • Identify areas of common ground through active listening • Seek to understand the perspectives of others • Evaluate and analyze options as part of strategic plan • Determine decision-making criteria	• Make decisions (SSI) • Assess options and plan actions based on evidence and potential for impact (GCE, GCED) • Make responsible decisions (CASEL, GCED) • Solve problems (CASEL) • Design solutions (NGSS) • Plan strategically (ESD) • Analyze cost-benefit • Communicate interculturally (ESD) • Listen to and communicate effectively with diverse people (GCE) • Actively listen (socio-ecological issue) • Recognize and express how diverse audiences perceive meaning and how that affects communication (GCE) • Use relationship skills (communication, social engagement, relationship building, teamwork) (SEL) • Reflect on how effective communication affects understanding and collaboration in an interdependent world (GCE) • Build consensus (socio-ecological) • Select and use appropriate technology and media to communicate with diverse audiences (GCE) • Communicate information (NGSS) • Use social inclusion and justice (ESD) • Understand that community involvement is necessary for determining sustainable answers (socio-ecological, PAR) • Communicate (4 Cs) • Collaborate (4 Cs) • Communicate cross-culturally (NEA, 4 Cs)

[a] Abbreviations and sources:

CASEL = CASEL (n.d.);

ESD = Education for sustainable development (Aichi-Nagoya 2016);

4 Cs = Twenty-first-century skills (National Education Association, 2012);

GCE = Global competence education, using a framework developed by the Asia Society (Boix-Mansilla and Jackson 2011);

GCED = Global Citizenship Education (UNESCO 2015);

NEA = Twenty-first-century skills (National Education Association 2012);

NGSS = Next Generation Science Standards, an example of inquiry-based science (NGSS 2013);

PAR = Participatory Action Research (YPAR Hub n.d.);

SEL = Social-emotional learning framework (CASEL n.d.);

socio-ecological thinking = Kronlid and Öhman (2012);

SSI = Socio-scientific issues (Zeidler et al. 2005).

2011). In addition these skills are tagged as critical for the twenty-first century by the National Education Association (National Education Association 2012). Through the collaborative decision-making process, students develop important communication skills, both to represent their own opinions and to understand the perspectives of others. General and intercultural communication, open dialogue, and perspective-taking skills are also part of frameworks in GCE (Boix-Mansilla and Jackson 2011; UNESCO 2015), SEL (CASEL n.d.), and the NGSS (NGSS 2013). These skills were also identified as important by the ESD for the SDG workshop (Aichi-Nagoya 2016) and as part of the "4 Cs" (National Education Association 2012). Learning how to incorporate different perspectives and to arrive at the best decision for a group with inclusion and without negative conflict are key parts of this stage. This process builds mindsets related to equity and justice, by ensuring the voices of all are heard, and also open-mindedness and reflection, by encouraging students to consider the opinions of many in order to arrive at the best plan.

Finally, the strategic planning necessary for this stage is identified as important by thought leaders in ESD (Besong and Holland 2015) and SEL (CASEL n.d.). Skills for strategic planning are needed to understand the longer-term impacts of potential solutions but also to understand how to implement the actions determined by the group. Likewise, SEL identifies goal setting and organizational skills as key attributes for students to develop. All of these skills are needed to organize and implement a plan, a task that is mapped out in this stage.

During this stage, students work together to find peaceful resolutions and determine the most effective way to act in their own local context. Through this process of finding consensus and strategic planning for the implementation of their determined action, they build the mindset of empowerment and agency. Unlike many school situations, students are given the responsibility for self-determination of decisions and actions. This means that students are empowered to use the understandings that they have developed and to exercise their agency by addressing the problems identified by those understandings.

Stage 5: Acting

The culminating stage and one of the primary goals of the Global GAP is acting. During this stage, students implement actions—practices to provide solutions to the manifestation of the global SDG-aligned problem in their local environment (see Table 6). These actions are based around their understanding of the global problem and the identification of solutions to address it on a local level. These understandings and solutions have been built by previous stages of the Global GAP. Students also reflect, review, and reassess their action during this stage.

Taking action on identified issues is a critical part of global citizenship (Davies 2006; Boix-Mansilla and Jackson 2011; UNESCO 2015; Jimenez et al. 2017), socio-scientific education (Presley et al. 2013), the C3 framework (NCSS 2013), participatory action research (Berg et al. 2009), and ESD (Besong and Holland 2015). UNESCO (2017: 4) states "students should be

Table 6: Global GAP Stage Overview: Acting.

From Theory to Practice	Inspiration from Other Disciplinary Frameworks[a]
• Implement actions • Carry out practices to mitigate the identified problem • Engage with community • Review and reassess actions, modifying as necessary	• Identify and create opportunities for personal and collaborative action to improve conditions (GCE) • Act, personally or collaboratively, in creative and ethical ways to contribute to improvement and assess impact of actions taken (GCE, GCED) • Reflect on capacity to advocate for and contribute to improvement (GCE, GCED) • Take informed action (C3) • Take action (PAR, GCE, GCED)

[a] Abbreviations and sources:

C3 = College, Career & Civic Life Framework for Social Studies State Standards (National Council for the Social Studies, NCSS 2013);

GCE = Global competence education, using a framework developed by the Asia Society (Boix-Mansilla and Jackson 2011);

GCED = Global Citizenship Education (UNESCO 2015);

PAR = Participatory action research (YPAR Hub n.d.).

provided with actual experiences and opportunities to develop, test and build their own views, values and attitudes and to learn how to take actions responsibly." Learning about problems without making a habit of acting reinforces undesirable behavior in local, national, and global citizens (Ladson-Billings 2014). Critical change for sustainability can only take place through action and by learning through and for action students develop for this competence (Pauw et al. 2015). Research on teachers has found that they are more likely to engage as positive agents of change when they have participated in action-oriented research (El-Deghaidy 2012) and future student activism is encouraged through motivation gained by "guided research-informed activism mini-projects" (Bencze et al. 2012: 146). These compelling arguments build the case for the importance for students not only to learn about and understand global problems but to take the essential last step of taking action to address these problems.

Taking action and working together toward a more just and sustainable world is a valuable goal itself. However, taking action on global problems also builds invaluable social justice and civic action dispositions in students (Westheimer and Kahne 2004; Cavieres-Fernandez 2014; Keating 2015). Jennifer Ponder and Amy Cox-Peterson believe in the importance of action-based projects to further civic and science knowledge and argue that "creating and implementing a plan of action to inform and influence social or scientific change will allow students to apply ecojustice principles and demonstrate valuable civic skills as the participate in civic life beyond the four walls of their classroom" (Ponder and Cox-Peterson 2010: 139). As students engage in actions to mitigate a global issue they see as a problem, they build a sense of self-efficacy (CASEL n.d.), which makes them more likely to take civic-related action in the future (Solhaug 2006; Alviar-Martin et al. 2008). This stage especially focuses on developing skills and mindsets related to empowerment and agency through the practice of real-world action. Through the process of being given the opportunity to participate in activism, students' motivation and sense of purpose is developed, which allows for a sustained intention to contribute to the world (Malin et al. 2015).

Finally, students are encouraged to reflect and reassess their problem. They need to answer questions such as whether there were unintended consequences to their actions and whether their actions had the intended result. Building this reflection into the Global GAP builds the

mindset of open-mindedness and reflection by providing space and time to reassess. It also emphasizes the cyclical and iterative nature of taking action on global problems. These problems are not solved by one action but by sustained engagement. Taking time to reflect, students should understand this aspect of the nature of global problems and can then use the mindsets they built through the Global GAP to remain engaged with taking informed action on global problems in the future.

LONG-TERM ENGAGEMENT: DEVELOPING SUSTAINABILITY MINDSETS

Although learning the specific area content and taking action to start to address the SDGs in the local community is crucially important, even more critical are the sustainability mindsets that students develop through this process. ESD research shows that dispositions toward sustainability are important parts of promoting sustainable action (Besong and Holland 2015). One of the goals of Smithsonian Science for Global Goals is to build long-term student engagement to address global problems. This aim requires students to be able and inclined to take informed action. This disposition toward action does not build itself: "Unless students are taught to engage in their world, they will not know when and how they should act. People do not spontaneously take actions to resolve degraded conditions for communities or the environment without some knowledge or baseline of what is important, or what is healthy in our bodies, communities and ecosystems" (Mueller and Zeidler 2010: 119). Obviously, this process of changing mindsets, or habits of thought, is neither simple to approach or achieve. Because of the long-term nature of the challenge, developing new mindsets is embedded throughout the Global GAP. Students (and people, in general) need to be given multiple opportunities to learn new attitudes and apply them in novel situations. One advantage of the consistency of the Global GAP underlying every subject matter module of Smithsonian Science for Global Goals is the opportunity to support students to form and maintain the same sustainability mindsets over time and across subjects, hopefully leading to better long-term incorporation of these mindsets. Fostering mindsets related to empowerment and agency, open-mindedness and reflection, equity and justice, and global–local interconnection (see Figure 2) is a crucial part of nurturing engagement and building students' ability and desire to take informed action.

FIGURE 2. Focus areas of student mindset: empowerment and agency, open-mindedness and reflection, global–local interconnection, and equity and justice.

The four categories of sustainability mindsets students develop are drawn from literature from a number of different thought areas (see Table 7). Included as part of the category of empowerment and agency is becoming self-aware and reflective (ESD, socio-ecological, SSI, SEL) and a belief that personal action can lead to positive change (SEL, GCE, ESD, SSI). Open-mindedness and reflection includes being open-minded and flexible (GCE, SEL) and understanding different perspectives and contexts for knowledge (SSI, GCE). Global–local interconnection includes developing a sense of belonging to their local community and the world (GCE) and appreciating interdependence and connection (citizenship, SSI, ESD). Finally, equity and justice mindsets focus on social justice (SSI, socio-ecological, GCE, citizenship, UNESCO 2014) and respecting self, others, and the environment (SEL, UNESCO 2014, SSI) (Zeidler et al. 2005, 2013; Colucci-Gray et al. 2006; Davies 2006; Banks 2008; Kostogriz and Tsolidis 2008; Berg et al. 2009; Hardwick et al. 2010; Boix-Mansilla and Jackson

2011; El-Deghaidy 2012; Farrington et al. 2012; Kronlid and Öhman 2012; Robottom 2012; Ekborg et al. 2013; NCSS 2013; Ohlmeier 2015; UNESCO 2015, 2017). These mindsets nurture skills and dispositions needed for future action and engagement (Malin et al. 2015; Besong and Holland 2015) with a goal of ensuring that students become active, committed participants in building a better world for the future.

TABLE 7. Sustainable mindsets and other disciplinary frameworks.

Sustainable Mindsets	Inspiration from Other Disciplinary Frameworks[a]
Empowerment and agency	• Belief that personal action can lead to positive change (SEL, GCE, ESD, SSI)
Open-mindedness and reflection	• Open-mindedness and flexibility (GCE, SEL) • Understanding different perspectives and contexts for knowledge (SSI, GCE) • Self-awareness and reflectiveness (ESD, socio-ecological thinking, SSI, SEL)
Equity and justice	• Focus on social justice and ethical responsibility (SEL, SSI, socio-ecological thinking, GCE, GCED) • Respecting self, others, and the environment (SEL, GCED, SSI)
Global–local interconnection	• Develop a sense of belonging to local community and the world (GCE) • Appreciate interdependence and connection (GCED, SSI, ESD)

[a] Abbreviations and sources:
ESD = Education for sustainable development (Aichi-Nagoya 2016);
GCE = Global competence education, using a framework developed by the Asia Society (Boix-Mansilla and Jackson 2011);
GCED = Global Citizenship Education (UNESCO 2015);
SEL = Social–emotional learning framework (CASEL n.d.);
socio-ecological thinking = Kronlid and Öhman (2012);
SSI = Socio-scientific issues (Zeidler et al. 2005).

SUMMARY OF GLOBAL GAP GOALS

Smithsonian Science for Global Goals has four main goals: to develop habits of action, connect the global SDGs with local contexts, provide structures to help understand complex issues, and promote long-term engagement with solving global problems. The focus of the Global GAP is getting to action. As students become accustomed to deeply understanding issues and then addressing them through local actions, they should build a habit of taking informed action. This is supported by the local context of learning. The Global SDGs are brought into focus by looking at them through local investigations and then making student-determined decisions and taking local action. This helps the abstract SDGs become a concrete part of students' local context. The structure of the Global GAP is designed to help students understand complexity in an accessible way. Using a step-like progression, students slowly build understandings of aspects of a global problem and the complexity formed when those aspects interact. Finally, throughout the Global GAP students build sustainability mindsets that will help increase their ability and interest in staying engaged with global problem solving. Therefore, Smithsonian Science for Global Goals should help develop students who are ready to take action, connect the global to local, understand complexity and are able to engage in helping to build a more sustainable future for the world.

Transforming learning from a passive to an active endeavor is critically important in today's world. In 2015, the United Nations identified seventeen Sustainable Development Goals that represent a global consensus on the world's most pressing issues. Realizing these ambitious goals will require concerted action at all levels, including local action. Young people are valuable components of this, and their learning experiences should both inform and inspire them as current and future changemakers.

From Ideas to Action articulates the theoretical basis of Smithsonian Science for Global Goals, a series of socio-scientific community research guides that focus on achieving a systemic understanding of global problems and inspiring young people to take informed and sustained action to help address global issues.

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Scholarly Press

https://scholarlypress.si.edu

ISBN (online): 978-1-944466-49-7
ISBN (print): 978-1-944466-50-3