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.

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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."

Designing the Learning Materials

PEDAGOGICAL CONSIDERATIONS FOR THE SMITHSONIAN SCIENCE FOR GLOBAL GOALS

Developing a Habit of Local Action

The need for local action on the SDGs, although easy to understand, is not always embedded into SDG efforts. Certainly, some SDG progress can be achieved through governmental actions (particularly in, for example, Goal 16, Peace, Justice and Strong Institutions). However, governmental actions alone are insufficient to achieve the goals. Many of the goals include facets that require substantial effort that is specific to individuals in local contexts. For example, achieving goals related to pollution require individuals to change their waste management and recycling practices (Target 6.3) or achieve goals related to preserving natural habitats, which require action at local levels to limit habitat degradation (Target 15.5). Although governments may spearhead efforts on these goals, individuals will need to take action and change behaviors themselves. This need for individual action and engagement with the SDGs is an important foundation of the Smithsonian Science for Global Goals community research guides.

Education supporting empowerment and action is a critical part of nurturing students' dispositions and skills so they are ready to take action to address global issues in their communities. This conclusion mirrors that of the Workshop on Education for Sustainable Development (ESD) and Achieving SDGs (Aichi-Nagoya 2016). Focusing specifically on the education needed to achieve the SDGs, some of their recommendations include using experiential learning, proposing "a fundamental shift in education systems with students involved at the centre of designing them around their core values/desires for the future," and supporting leadership development and empowered communities (Aichi-Nagoya 2016: 222). These recommendations all center on the need to empower students and communities to define their own values and engage in applied, real-world learning. The Workshop Group on Educators identified an unmet need for a bank of knowledge/resources and a focus on pedagogy, process, and content. Smithsonian Science for Global Goals community research guides address those identified needs, by providing accessible, no-cost resources that help to nurture a self-directed, engaged group of students.

A number of groups have pointed out the importance of local-level engagement with the SDGs and the associated need for education in this area. For example, Maarten Hajer and colleagues (2015) tout the possibilities of using a growing "energetic society"—a broad group of actors worldwide committed to taking action—and focusing their efforts on the SDGs. Both national and international governments are still learning to efficiently utilize this energetic society (Hajer et al. 2015). Some argue that this lack of engagement and utilization has limited efforts for SDG implementation. Specifically, some criticize the SDGs and related implementing agencies for being too focused on governmental action (for example, Spangenberg 2017). There is a belief that "the SDGs need a concerted and coordinated effort to move from internationally driven development projects to locally and regionally driven operations" (Patole 2018: 1). The dominance of the governmental focus can mean missing opportunities for action at the local level in order achieve the goals. In a joint report about transitioning from MDGs to SDGs, the United Nations and the World Bank pointed out the need to build local capacity to take actions on the SDGs, stating, "Investments to build the capacities of civil society organizations and local communities, particularly young people, can ensure durable results" (United Nations CDP 2015: 22). The Smithsonian Science for Global Goals community research guides attempt to address this need for local capacity building and are thematically guided by the concept of "Local Action for Global Goals." The aim is to provide student-centered, action-oriented learning materials that can serve as a resource for encouraging global sustainable development in classrooms around the world.

As students use Smithsonian Science for Global Goals learning progression (detailed below) to determine and implement actions, they learn the skills of how to do so in the future. These skills should outlast the fixed term of the SDGs and lead to continued, informed action to address global challenges. Research in civics has shown that students who engage in actions they deem efficacious are more likely to participate in further forms of civic engagement (Alviar-Martin et al. 2008). The work of Paolo Freire details how "human activity consists of action and reflection: it is praxis; it is transformation of the world" (Freire 1996: 106). He details how both action and reflection are necessary—action without reflection is ineffective and reflection without action is useless. In order to transform the world through the SDGs, students need to develop skills of reflective action. In Smithsonian Science for Global Goals, through the process of taking informed action, students develop habits of responding to problems by first understanding them and then taking action based on that understanding.

Making Complex Subjects Accessible

However, achieving a deep understanding of complex topics is often a challenge for students. If the SDGs could be solved easily, it is reasonable to believe that they would have already been solved. By their very nature, therefore, the SDGs represent difficult topics. Achieving SDG goals and targets involve dramatic changes to human structures, hierarchies, and behaviors. For example, achieving Goal 5 (Gender Equality) or Goal 13 (Climate Action) require dramatic changes in everyday behaviors and cultural norms. Even goals that seem more environmentally focused, such as Goal 14 (Life below Water) require understanding of a wide variety of pollution behaviors, conservation structures, and economic livelihoods (e.g., fisheries). Therefore, it is impossible to understand these complex topics without using lenses provided by multiple disciplines.

Different disciplines add not only new perspectives but also help build a more holistic view of global issues. For example, the field of inquiry-based science provides an opportunity to understand the scientific nature of issues, how to assess needs for data, how to construct arguments based on evidence, and how to use scientific methods to assess possible solutions. However, scientific reasoning often leaves out the messy human dimension. This dimension, which includes human motivations, ethical constraints, and cultural norms, must be included in order to gain a realistic view of the local situation. This local situation includes attitudes toward global topics and the potential actions to address the SDG-related problem. For this process, there is a need to turn to the social sciences. Social studies education, including the disciplines of economics and history, helps to elucidate human motivations and behaviors. Global citizenship education (GCE) helps to build awareness about how a problem may vary between locations, the importance of understanding different perspectives, and the connection between global and local concerns. Other disciplines straddle the two worlds of science and social studies, offering views on how the two may interact. These disciplines include education for sustainable development (ESD), socio-scientific issues (SSI) education, and place-based education. Used together, these disciplines provide tools to unpack the complexities inherent in SDG-related issues specifically and global challenges in general.

To place this need for multidisciplinary tools and perspectives into a concrete example, if a group examined the problem of access to water in their community, different disciplines bring different understandings to the topic. Science could help build a deep understanding of existing water resources, water quality, the water table, and interactions with the local environment. Social studies subjects such as history might help provide an understanding as to why the situation exists and how past actions have affected it and how this may dictate future choices. Economics could help students determine how economic needs and wants dictate current water access situations. GCE could provide a window into understanding how water access at the local level relates to water access at regional or global levels. SSI and ESD constructs might help support students as they attempt to make sense of the plethora of information needed and support the construction of an evidence-based set of possible actions. Finally, place-based education grounds these understandings in the specificities of students' local environments. Pulled together, these multiple disciplines not only provide a richness of understanding, they also help elucidate complexity by looking at a situation in multiple ways.

Using a variety of disciplines also puts a variety of tools in the hands of learning material designers and teachers for use in investigations. Scientific understanding of a problem is essential for clear comprehension of the nature of the problem itself and grasping possible limitations of solutions. Scientific experiments and investigations can help build this understanding in a robust way. However, the social sciences also provide tools to build understanding of local contexts and communities. For example, social science-based participatory action research uses tools such as focus groups, interviews, and observations to help a local community build understanding of itself, its values, and its goals. In addition, GCE uses tools to help students examine their own perspectives and those of others. Having a variety of tools to consider a problem means that the problem can be explored more thoroughly and from multiple angles, helping to understand its complexity.

Using multiple disciplines is undoubtedly important in order to build a true picture of the scope of a problem and possible solutions. However, it is unrealistic and unfair to expect teachers to have a deep understanding of the pedagogy of so many different subject areas. Therefore, rather than expecting teachers to seek out different pedagogies to support their students, Smithsonian Science for Global Goals embeds activities and constructs of multiple disciplines within the community research guides. This gives teachers the tools to pry apart complex issues into manageable chunks that can be examined one at a time and then build these manageable chunks into a larger holistic understanding. The structures supporting this process of making complexity accessible are a key part of the learning progression detailed below.

Building Sustainability Mindsets for Long-Term Engagement

The hope for all learning is that it continues beyond the classroom. In the case of Smithsonian Science for Global Goals, the premise is that by learning about global issues in a deep and immediately applicable way, students develop new habits of thought—mindsets—that encourage them to continue their engagement with making the world a better place. The development of these mindsets is an integral part of the learning progression detailed below. Through activities and discussion, students develop mindsets related to global interconnection, empowerment and agency, open-mindedness and reflection, and equity and justice.

The global interconnection mindset focuses on connections between the global and local aspects of contexts, systems, impacts, and problems. Also included is the human element—connections between an individual and others at all levels, from classroom peers to people around the globe. These mindsets are largely developed by the structure of the community research guides, explicitly linking big global issues with local contexts, as discussed further below. However, systemic understanding is also supported by the guide's structure, which helps students appreciate other aspects of global interconnection, not only the connection between global and local but also the connection between different aspects of the system at a local level.

The mindset of empowerment and agency is highlighted through the focus on action, which is a crucial part of the guides. By engaging in not only action but decision making leading to that action, students develop empowered ideas of their ability to affect change. This sense of personal power to make choices is the essence of the agency students develop through the guides. For this reason, it is critically important for teachers not to make decisions for students but to allow them the space and freedom to follow their own ideas to fruition. Teachers can guide students by helping them explore constraints and consequences. However, in the end, the ability to make individual and group choices and to see the impacts of those choices is a hugely important part of students developing a mindset focused on empowerment and agency.

Open-mindedness and reflection are critical, and sometimes overlooked, parts of making informed, empowered decisions. This mindset is nurtured throughout the learning progression, as detailed below, but especially as students explore different root causes and systemic understandings of the problem they are exploring. The nature of the process should help to support students in developing the idea that gathering knowledge and understanding the aspects of a system are an iterative process. At no point is understanding complete, so each new piece of information or perspective that is added helps to build out a fuller picture. Understanding these additional perspectives and becoming flexible to changing ideas in response to new information are essential for developing open-mindedness. Reflection is also critical to this process: as different perspectives are shared, students are challenged to reflect on their own ideas and whether they still are appropriate given the changing information available. The learning structure deliberately separates exploration and understanding from decision making to support students in developing open-minded, reflective understandings without feeling pressured to support a specific idea before that understanding is mature.

The equity and justice mindset is steeped in the ideals of social and environmental justice. There is a strong ethical component of this mindset with students encouraged to examine their own values and determine the ethics of actions. Questions such as whether human well-being is more important than environmental impacts, finding a balance between the needs of different groups of humans, and understanding systemic inequities are explored. This mindset is particularly developed through the decision-making process leading to action, as detailed below. As students try to determine what aspects of the global problem should be prioritized for the purposes of decision making, they are essentially assigning differential values to varied parts of the system. This process of determining what is most important and how that measures up with other potential actions focuses on equity and justice. Through making hard choices during the decision-making portion of Smithsonian Science for Global Goals, students grapple with what equity and justice look like in practice.

Throughout the Smithsonian Science for Global Goals learning experience students build habits of thought that will enable them to engage with the world's problems in a more robust, active way. These sustainability mindsets do not focus on a specific content area but rather nurture the dispositions necessary to engage in sustained action in the future. Students have a lifetime in front of them in which, it is hoped, they will fully commit to improving some of the difficult situations present in the world today. Developing these mindsets of global interconnection, open-mindedness and reflection, empowerment and agency, and equity and justice should help support them in that process.

Making the Abstract SDGs Relevant to Local Situations

Since people around the globe need to be ready to take local action in order to accomplish the aims of the SDGs, resources for education are necessary for all contexts, across geographic locations, cultures, and socioeconomic situations. In the interests of equity, as well as progress on the SDGs, it is important to make SDG-aligned resources, particularly ones inspiring action, broadly available. One possibility to serve this need would be to develop a set of resources specific to each context. However, contexts vary so widely and are so numerous that this solution is not practicable. If a set of resources were to be developed for each context, some contexts, probably those less well resourced, would inevitably be left out. Excluding anyone from developing the skills to take action and engage with the SDGs would be not only ethically problematic but also ultimately self-defeating given the aim of broad implementation and the need for local engagement in order to make substantial progress (United Nations CDP 2015). Therefore, Smithsonian Science for Global Goals attempts to be universally equitable and is available via the internet for anyone to access.

However, designing universal learning materials brings a set of specific challenges on how to make a worldwide resource relevant enough to local contexts to inspire action: how to keep materials from being unconsciously exclusionary by embedding location-specific values and attitudes and how to create local relevance to inspire action and engagement within the construct of a resource designed for a global audience. Smithsonian Science for Global Goals must be flexible enough to fit into different contexts, which means precluding aspects that are specific to one culture, as discussed further below. All aspects of the guides must be created in a way that they can be accessible to a wide variety of cultural contexts, without creating invisible barriers.

In addition, since the aim of Smithsonian Science for Global Goals is to engage students and guide them to see connections between their actions and the global goals, the challenge is nurturing this engagement while providing culture-agnostic (i.e., not tied to specific cultural constructs), location-agnostic (i.e., not tied to a location) resources. Engaging students often takes place by focusing on something important to them (Duhn 2012), but the generic nature of the learning materials makes it impossible to determine what aspect of the problem would be most relevant to any specific local context. Smithsonian Science for Global Goals solves this problem by allowing students to add their own place-specific contexts in a planned, explicit way, as discussed further below. The answers to these design challenges were found by examining different areas of pedagogical thought, including culturally responsive pedagogy and place-based education, with the goal of making Smithsonian Science for Global Goals globally applicable but still locally relevant. Further discussion of this topic can be found in the section on "Developing Learning Materials Relevant to All."

The SDGs detail extraordinarily ambitious goals, such as No Poverty by 2030 (Goal 1), which may seem out of touch with local contexts. This seemingly impossible goal perversely may encourage individuals to feel disengaged from the SDGs because there is a disconnection between the SDGs and the reasonable potential for change they see in their local contexts. Therefore, it is necessary to explicitly link specific aspects of the goals with local contexts by investigating how the SDG topic impacts and is impacted by the local environment.

For example, imagine students exploring the topic of appropriate nutrition, which is related to Goal 2 (Zero Hunger), Goal 3 (Good Health and Well-Being), and Goal 12 (Responsible Consumption and Production). If students are in an environment where achieving enough daily calories is a struggle, the goal for Zero Hunger may seem to be an impossibly optimistic one. However, by shrinking this goal to how it relates to the local context and investigating the relationship between that context and the goal, students may find that there are points of leverage to help address the issue in a tangible way.

Taking the same topic to another context, one in which problems related to overconsumption of calories is the norm, students may feel little connection to the idea of Zero Hunger. However, by developing a deep understanding of the scientific nature of nutrition and investigating what aspects of their local environment play a role in this overconsumption, students can frame this abstract concept concretely into their daily life and local context. Students can then make decisions and take action on these topics on the basis of their local needs.

Finally, these local actions can be reconnected explicitly to the global SDGs, building an understanding of how local actions have global impacts. Students can also build connections with other classrooms and contexts and see how place influences the nature of the problem and efforts to address it. This helps build an understanding of the connections between the global issues and local contexts.

Abstract ideas can be difficult to use to engage students. Therefore, Smithsonian Science for Global Goals takes the abstract goals embodied by the SDGs and uses an exploration of local contexts in order for students to self-customize them and make them applicable. Smithsonian Science for Global Goals attempts to be culture and location agnostic but includes space and activities for students to personalize the community research guides to make them hyperlocal.

STRUCTURING A FRAMEWORK FOR ACTION ON GLOBAL ISSUES: THE GLOBAL GOALS ACTION PROGRESSION

Identifying the Need and Characteristics of a Learning Materials Framework for the SDGs

There is a need for a deeply considered learning progression focused on the goals of building habitual action, deeply understanding complex topics, creating mindsets for continued engagement, and connecting the abstract to the concrete. Given the multidisciplinary approach required by the SDGs, there are a natural set of tools and frameworks from a variety of disciplines. However, there is no single framework bringing together scientific, economic, civic, and ethical thought specifically on global issues with a focus on finding consensus for immediate and con-

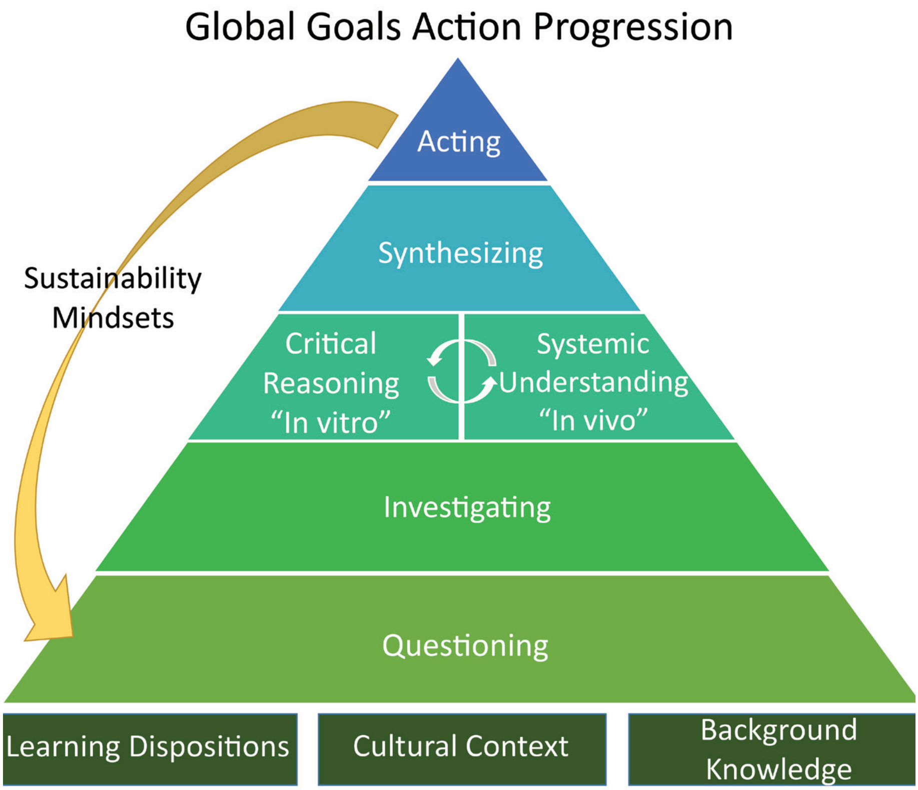

FIGURE 1. Global Goals Action Progression. (Diagram designed and created by Heidi Gibson, Katherine Blanchard, Andre Radloff, Brian Mandell, Jean Flanaghan, and Carol O'Donnell. © Smithsonian Institution.)

tinuing local action. Therefore, it was necessary to create a new framework—the Global Goals Action Progression (Global GAP). See Figure 1 for an abbreviated visual version and Appendix A for an extended visual version. The Global GAP brings together inputs from work in a variety of other disciplines.

The framework acts as the structure for Smithsonian Science for Global Goals. First, the structure acknowledges that students bring learning habits or dispositions, cultural contexts, and individual background knowledge to the learning experience. The Global GAP then leads students through five stages: questioning, investigating, critical reasoning and systemic understanding, synthesizing, and acting. In addition to ultimately achieving empowered, informed action, the Global GAP is designed to build mindsets that will support future engagement.

Through the Global GAP, students develop mindsets focused on global–local interconnection, empowerment and agency, open-mindedness and reflection, and equity and justice, as previously discussed. These mindsets then enable students to engage with future topics in an even richer, more nuanced way, continuing to build habits of action and sustained engagement.

Entry Points

The first issue to examine is how students and teachers enter the learning experience. The Global GAP includes three important entry points to examine: learning dispositions, cultural context, and background knowledge. Each of these characteristics can vary widely between locations or even within a group.

In the Global GAP, *learning disposition* is defined as the best way for a student to access knowledge. Dispositions vary among cultures and students. Some students work best using tools such as drama or interactive discussions, whereas others learn best by studying results or readings, pondering them, and then sharing written reflections with their group. In some cases, learning dispositions are related to cultural norms. In other cases, learning dispositions are related to preferences and styles of individual students. Understanding and acknowledging these different ways of learning are important aspects of making learning materials accessible to students (Gay 2013).

Cultural contexts can also affect how students will best access materials, which of those materials will make the most intuitive sense to them and which concepts will require more support to reach understanding. For example, if a learner comes from a cultural context in which plants are highly valued as a resource and has grown up knowing the names of hundreds of plants (see, for example, the discussion of E. Smith Bowen by Claude Lévi-Strauss 1962: 4–7), it may be easy for that learner to understand some of the reasoning behind valuing biodiversity. However, if a student has grown up in an environment where many plants are labeled "weeds" and monocropping farming practices predominate, the need for a biodiverse environment may be less obvious to them. For a more detailed discussion of the relationship between learning dispositions and cultural contexts and how it is approached within Smithsonian Science for Global Goals, please see the section on "Developing Learning Materials Relevant to All."

Students and teachers bring their own cultural context and learning dispositions as individuals living in that context. They also bring their own existing content-specific background knowledge. Background knowledge includes not only scientific and other academic concepts but also students' knowledge of their own community and its workings. For example, students may have extensive knowledge of the physical layout of their community, values within the community, interactions between members of the community, and effective ways to share information within the community. This type of knowledge can be very significant when it comes to designing sustainable actions to address a problem. Capitalizing upon the existing knowledge that the students bring to the table is an important practice in Smithsonian Science for Global Goals. This approach emphasizes the place-specific customization that needs to happen for each learning environment.

In some cases, teachers may not immediately recognize some background knowledge as legitimate since it may arrive in the guise of nonstandard knowledge. For instance, indigenous and community knowledge systems sometimes differ fundamentally from the "modern" system of scientific knowledge (Snively et al. 2001). Students may present information based on these types of knowledge systems. Rather than rejecting these other ways of understanding the world, Smithsonian Science for Global Goals incorporates these understandings as background knowledge. This serves several purposes. One, it grounds the guides into a local context and understanding. Instead of distancing the guide from local ideas, their incorporation helps the guides feel applicable to the lived world of students. Two, it empowers students by recognizing the resources with which they enter the learning experience. Three, by acknowledging and incorporating local understandings, it increases the likelihood that students can determine a community-relevant and sustainable action to take on the global issues. Thinking through the knowledge that exists within the students and within the community at large is recognized as an important factor in both investigations and decision making (Colucci-Gray et al. 2006). Therefore, recognizing students' existing knowledge, in whatever form it presents, is not only important for the development of individual empowerment but also for the ability of students to develop sustainable actions.

However, knowledge should not be accepted without critical examination. As new understandings are formed later in the learning progression, students are encouraged to critically examine those findings. Similarly, students need to engage critically with their existing background knowledge and cultural contexts. One method of doing so is to explicitly direct students' attention to their own values, knowledge, and assumptions through activities such as identity mapping. As these aspects of identity become clear to students, they can recognize them as relative (i.e., not absolute for everyone) and can choose to retain aspects of their values, knowledge, and assumptions or discard them.

Building an understanding of identity is part of developing critical consciousness and subsequently changing attitudes and increasing civic engagement (Berg et al. 2009). By engaging in self-reflection, students develop social-emotional learning (SEL) skills (Collaborative for Academic, Social, and Emotional Learning [CASEL] n.d.) and the ability to consider other worldviews (Farrington et al. 2012; Zeidler 2016). This self-reflection is a key part of nurturing the dispositions needed for later stages in the Global GAP. It also develops the open-mindedness and reflection mindsets for future engagement. Smithsonian Science for Global Goals allows for customization to permit varied places of entry, balancing the need to provide structure and content with the imperative to allow for flexibility and localization.

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 pursue 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 (Buşoi 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.

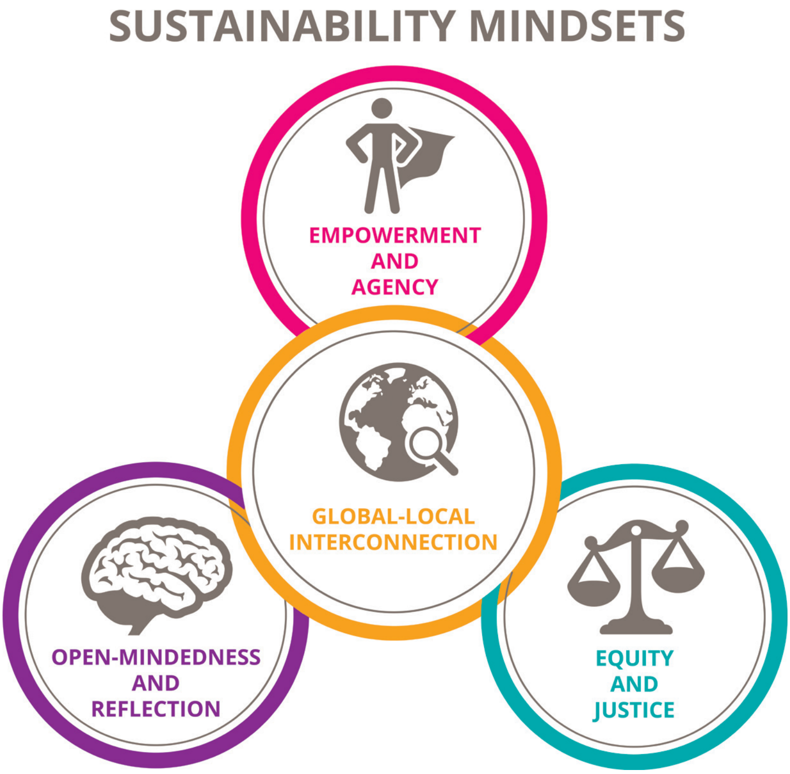

FIGURE 2. Focus areas of student mindset: empowerment and agency, open-mindedness and reflection, global–local interconnection, and equity and justice.

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.

Developing Learning Materials Relevant to All

Designing learning materials available for use in contexts around the world and making those resources relevant to all of those contexts are considerable challenges. Two main aspects must be considered. One is how to make the materials not tied to a particular location and cultural context, or in other words, materials that are place and culture agnostic. This means being careful about addressing unconscious cultural biases and thinking about ways in which the materials might inadvertently exclude some students. The second main challenge is to make materials not tied to a specific place or culture also relevant enough to students that they will engage with the materials and invest their energies and efforts toward problem solving. In many ways, this will involve adding specific places and cultural contexts back into the materials. These two ideas seem mutually exclusive; however, Smithsonian Science for Global Goals solves this problem by creating place and culture-agnostic guides and then creating structures within Smithsonian Science for Global Goals for students to add in their own places and cultural contexts as a method of self-customization.

DELINKING LEARNING MATERIALS FROM PLACE AND CULTURE

Attempting to remove place and culture specific references and assumptions from within learning materialsis very difficult. The most readily apparent place and culturally specific aspects of learning materials are items such as photos used that clearly belong to one place or culture or text referring to places or concepts that are overly specific. For example, if all photos depict Americans, this may feel exclusionary to users in other areas of the world. Or, if an activity referred to a place-specific holiday (like the Fourth of July) or to a store found only in certain locations (like Walmart), that might cause barriers of access for people in different contexts. In addition, things that may appear to be universal to learning material designers, such as what a street or playground looks like, may, in fact, be place specific. Although vigilance is needed, these explicit references or depictions are reasonably easy to exclude from appearing within materials.

More difficult to excise are thoughts and assumptions by learning material designers that are based on their own experiences and cultural norms. Many of these may include assumptions such as the best way to learn, what knowledge consists of, what individuals value the most, or even what a classroom experience is like. Since, for most people, these assumptions remain below the "horizon of awareness"—the line between conscious and unconscious thought (Sapir 1985)—they are very difficult for designers to think about in an explicit way. Nonetheless, those desiring to build place- and culture-agnostic learning materials need to be exceptionally mindful about how these unconscious assumptions can influence the learning materials to limit accessibility to all.

Lessons Learned

To determine best practices for culture- and location-agnostic learning materials, it is important to see how learning materials have been transferred between different locations and contexts in the past. In the field of international development, curriculum developed in one place is sometimes transferred to another. It is not difficult to find examples where this wholesale transfer has gone awry. Thomas O'Donghue (1994) was particularly scathing about the thoughtless transfer of curriculum designed for one location but used in another location without any regard to different cultural context. He advocated a thorough cultural understanding of different ideas of schooling and learning (e.g., rote learning v. learning for understanding, school as an impetus toward critical thinking v. school instilling social and moral norms). Other experts use the concept of attempting to understand the "life-world" of the students and how they affect broad aspects of curricular-related areas (Rasi et al. 2015). Specifically, concepts with an assumed universal understanding (e.g., what the concept of "international" means) may, in fact, differ according to culture. Different academic traditions, such as the basis of what constitutes scientific understanding, also may vary by location, as will be discussed further below. Gleaning from the field of international development, clearly indiscriminate transfer from one specific context to another will result in difficulty, and specific attention should be paid to different assumptions related to conceptual notions and the nature of learning itself. For the purposes of Smithsonian Science for Global Goals, the most important thing to realize is that transfer of American-centric learning materials to a worldwide audience will not work.

Considering Cultural Values and Identities

Understanding cultural variations is a good place to start to understand how learning materials can be unconsciously influenced by the culture of the designers. Research about cultural value orientations details how different cultures approach universal problems in unique ways. For example, one classification of cultural value orientation is based on three broad sets of values: relations to boundaries between a person and the group, how to guarantee responsible behavior that preserves the social fabric, and the management of relations between the human social world and nature (Schwartz 2006). In different cultures, individuals might be apt to address issues related to these areas in different ways, manifesting their approaches as cultural values.

For example, cultures that value autonomy readily distinguish between the individual and the group, whereas those who value embeddedness may focus more on group goals and actions. Cultures valuing mastery focus more on individual achievements, and those valuing egalitarianism focus more on equality. These values are not hierarchical, that is, one value is not better than another, but these different values do affect approaches to learning. For the purposes of worldwide pedagogical design, it is less important to understand how specific countries fall on a scale of cultural value orientations and more important to understand both the breadth of opinion and the possible areas of major diversity in thought and values.

Placed into the context of a hypothetical classroom, if discussing climate change, a person from a more autonomous cultural value orientation might be more inclined to take individual action, while those from a more embedded orientation might prefer to take action as part of a larger group initiative. Another example might be that those of a mastery cultural value orientation might be inclined toward individual achievements in a market-based economy as a way of achieving progress on poverty and economic development. Those from a more egalitarian cultural value orientation would be more concerned with structures to guarantee equity and address inequality when considering this topic (Schwartz 2006).

This research provides a useful lens to further examine assumptions made when developing universal learning materials. Understanding and appreciating the diversity of thought processes and values is crucial. In practice, this means that space needs to be created within the learning materials to accommodate these different orientations. One way to create this space is to allow time for students to explore their own cultures and identities. Following this process, students can explicitly look at sites of contention based on value orientations, which allows students to further understand their own cultural assumptions, deepening the materials in a personalized way. This exploration will be a critical part of the work of learning material designers as well, to examine how they might unconsciously embed their own cultural value orientations into the learning materials.

Beyond these cultural values, there is wide variation in conceptions of citizenship and its rights and responsibilities across cultures, many of which are very relevant to discussions of global topics. Cultural values, political climates, and historical contexts may affect how teachers discuss civic topics (Alviar-Martin et al. 2008). There are two possibilities to address this variation within Smithsonian Science for Global Goals. One possibility relies on the fact that the guides are flexible enough that teachers can approach civic-related topics in a variety of ways depending on their own comfort and context. However, another possibility is for teachers to use the opportunity of teaching difficult topics to examine their own values and assumptions and encourage the students to do the same. Rather than just use a variety of approaches, teachers can use the discussion as a learning opportunity to examine values and cultural norms.

Ideally, students and teachers both explore and affirm their own identities, while critically examining them for assumptions. This critical examination allows for the possibility of new solutions to the SDG-aligned problems. For example, if access to water is a problem in a community, this may be exacerbated by cultural assumptions about who should access water and when. If students can unpack these assumptions, there may be scope for exploring new solutions to the existing situation, such as questioning a hierarchy that could lead to more equitable access to water or understanding assumptions about rights to water that could lead to further conservation efforts. Within Smithsonian Science for Global Goals, students and teachers are encouraged to determine their own solutions to problems but only after examining their existing assumptions, including those related to cultural values. Challenging students in this way is one way that Smithsonian Science for Global Goals connects global concepts such as human rights and gender equality to local contexts, helping to make universal guides locally relevant.

Clearly, there are wide differences in approaches and worldviews embedded into cultures that affect how to approach designing learning materials available for worldwide use. There is difficulty in finding pedagogical approaches that fully respect this complexity, but some information can be used from work in international development and cultural values. Firstly, international development work has shown that it is inappropriate to import curriculum from one context, including "model countries," without respecting local contexts (Kelly 2013). Secondly, it is important to note the variety of value orientations when designing learning materials so that they can allow for flexibility of approach. Equally, it is important for learning material designers to understand their own value orientation biases lest they overpower the curricula. Finally, students and teachers should be encouraged to both explore and critically reflect on their identities and values, with the goal of allowing additional scope for action and connecting local contexts to global conversations.

CREATING SPACE FOR DIFFERENT EPISTEMOLOGICAL BELIEFS

Variations between cultures and places can also impact universal learning materials design because cultures can have varied "ways of knowing"—that is, different ways of proving, understanding, and accessing information and concepts. Understanding this diversity can be challenging since assumptions are often made about the characteristics of "logical" thought. Reasoning systems can vary between cultures, as detailed by Zeidler et al. (2013), who determined three aspects that affect personal epistemology: beliefs about the nature of knowledge and science, beliefs about the nature of knowing how to evaluate and judge, and beliefs about the goals of scientific learning across disciplines. For the purposes of worldwide design, there is a need to leave flexibility in the learning materials to accommodate this variation among ways of knowing, but there is a real challenge for designers trying to allow for these varied ways of knowing while still trying to put concrete concepts into the learning materials.

The problem of accommodating different ways of knowing is particularly acute for science, as seen from the list above. Some researchers critique the widespread idea that science, or what they call "modern Western science," is a noncultural, neutral set of epistemologies. For instance, Noel Gough contended that "the global reach of European imperialism has given Western science the appearance of universal truth and rationality, and it is often assumed to be a form of knowledge that lacks the cultural fingerprints that seem much more conspicuous in knowledge systems that have retained their ties to localities" (Gough 2007: 40). Essentially, he argued that all forms of knowledge bear "cultural fingerprints" from when and where they were constructed, and Western science is no different; but unfortunately, students only rarely analyze the cultural origins of knowledge systems. Since modern Western science is so widespread, the cultural fingerprints of Enlightenment Europe are not always obvious, although they are present.

To break down this critique of modern Western science even further, one can examine some of the basic tenets of science itself. Western science has distinct ideas about the method of proving an idea (hypothesis) and how to use empirical evidence to do so. This represents a world view that “presupposes that the natural world can be decomposed and understood in sets of independent variables” (van Eijck and Roth 2011: 836). Not all students may share that worldview, which makes it a challenge for them to access Western scientific thoughts and processes.

Carlos Tejeda et al. (2003) pointed out that true neutral meaning is impossible because understandings emerge out of the logic of different ideologies and include dimensions (social, cultural, and historical) that are place specific. They argued that not only is it limiting to only use Western science to understand all aspects of the world and phenomena, but also, because of its origins, it tends to exclude certain peoples and knowledge systems necessary for addressing important issues globally (Snively et al. 2001; Laughter and Adams 2012).

Other issues accessing science and scientific concepts may arise out of the way it is presented. In particular, standard school science can be difficult to access for diverse students due to challenges “decoding the signifiers that make sense in scientific discourse” (van Eijck and Roth 2011: 827) and cultural assumptions embodied in scientific representations used in science and textbooks. For example, something as simple as an arrow used in a representation of scientific process may, in fact, not be universally understood. Representations of microscopes or beakers may be unfamiliar to students from certain contexts. Bearing in mind the plurality of experiences is important in order not to unconsciously exclude people from certain contexts.

Given the importance of universal access to SDG-related education, as established above, this potential for exclusion leads to a Smithsonian Science for Global Goals design challenge. How can robust learning materials be created that includes evidence, reasoning, and data, while promoting access by accommodating a diversity of ways of knowing and proving claims? The challenge for designers is to accommodate different cultural and epistemological beliefs but still create rich content and allow for customization to specific contexts.

Customizing Learning Materials to Context

Work in the field of culturally relevant science pedagogy can help provide an answer to this challenge. Culturally relevant science pedagogy is a field that examines the different cultural values and experiences of students and how they affect the way these students access science curriculum. Some researchers suggest specific design considerations to make science curriculum more accessible.

For example, Michiel van Eijck and Wolff-Michael Roth advised embracing the novelization of science education, specifically making room for heterogeneity and different forms of knowing and understanding outside the norm (van Eijck and Roth 2011). One example of this type of pedagogy in science education is shown by teachers who, instead of using the discourses of laboratory science, "emphasized the value of 'coming to knowing' that validates cultural knowledge" (Roth and Lee 2004: 273). In this model, students engage in activities in immersive, authentic experiences where they gain knowledge through inquiry. Instead of ensuring that this knowledge is transmitted or accessed in a specific way (e.g., listing hypothesis, results, conclusion), the teachers allow for flexibility of gaining and transmitting knowledge. Roth and Lee (2004: 274) emphasized,

> the value of multiple interpretations rather than argumentation, formation of alliances to defeat alternative interpretations, and disagreement. Thus, in the classrooms involved in our studies, students characteristically helped one another in gathering data, understanding details of their collections, interpreting the data, and in formulating future plans of actions.

According to Roth and Lee, the emphasis on different ways of knowing allows different representations of phenomena in line with a variety of cultural norms. The researchers found that the curriculum with this focus was particularly relevant to a variety of marginalized groups including girls, First Nations, and students with learning disabilities and allowed students in a variety of developmental stages to access it. An emphasis on cooperation and different ways of accessing knowledge is a key to breaking down barriers for these groups.

Since the problems presented by the SDGs affect everyone, it is important that all students can participate in conversations about these problems. Not only is this the equitable thing to do, inclusion brings real practical advantages since "diverse forms of knowledge, including science, can be brought to bear on the important issues all the while making it possible that some participants are far less competent in canonical science than others" (van Eijck and Roth 2011: 841). In other words, by allowing a diversity of ways of thinking, rather than ensuring that all students adhere to a specific evidentiary norm, a more diverse group of students can engage in the discussion. Individuals with different perspectives on what constitutes knowledge, may present information or opinions that enrich the whole group since additional concepts and ideas are explored. Even if individual students or even an entire classroom does not have strong existing content knowledge, by supporting these different ways of knowing or showing evidence, there is an alternate route to knowledge and discussion that may engage students.

Using techniques somewhat similar to those used to explore and examine personal values, students can explore epistemological beliefs. Allowing for a diversity of thought and thought processes within a classroom, everyone can access the conversation, deepening and enriching learning for everyone. In addition, by critically examining their own thought processes, students may gain deeper insights or metaphorically cross borders between thought areas to further understandings.

Supporting Different Cultural Contexts as Part of Learning Material Design

Insights into how to make learning accessible to students from a variety of cultural contexts can be gained from culturally responsive (sometimes termed culturally relevant or sustaining) pedagogy. Culturally responsive pedagogy is a thought area focused on different cultural values and experiences and how they impact diverse students within classrooms. Geneva Gay (2013: 49–50) described the aim of this pedagogy as "using the cultural knowledge, prior experiences, frame of reference and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them."

Gay detailed three principles of culturally responsive pedagogy. The first concept used a variety of perspectives to analyze educational problems and explore intersectionality (Gay 2013). This concept basically ensures students have access to different points of view and can compare how they are the same and how they may differ. Smithsonian Science for Global Goals community research guides already deliberately incorporate different perspectives, but teachers and designers need to be aware of this as an important basis for creating a guide that can be accessed from different cultural contexts.

Secondly, Gay suggested using different instructional strategies to achieve common learning outcomes for all students (ranging from collaborative groups to oral histories to peer coaching; Gay 2013). This principle is grounded in the idea that students from different cultural backgrounds may access information presented in different ways and reaching all students requires a variety of instructional techniques. These different types of instructional strategies should be incorporated as options into Smithsonian Science for Global Goals community research guides—they already are organically present in the interdisciplinary approach. Learning takes place not only through experimentation and academic research, for example, but also through interactions with community members. However, each Smithsonian Science for Global Goals module should deliberately incorporate a wide variety of instructional strategies.

Lastly, Gay advised developing skills to cross cultural borders (Gay 2013). In identifying this as a principle, Gay underlined the fact that students from a nondominant culture may already be crossing cultural borders by accessing classroom materials. Unpacking this crossing explicitly and encouraging a cross back (e.g., for dominant culture students to cross into the cultural understanding of a nondominant culture student) is a method to build skills for students to explore their cultural borders. Although designed for diverse classrooms largely in the US context, Gay's principles of culturally responsive pedagogy are pertinent to the challenge of creating learning materials that can be relevant across cultures. Universal learning materials need to include a variety of voices and perspectives, instructional techniques, and explicit exploration of cultures, their values (as detailed above), and borders. The perspectives needed for sustainable action require both crossing and crossing back across cultural borders, and the consensus building during the synthesizing stage of the Global GAP should be mindful of the necessity of respecting these cultural perspectives.

Using these techniques helps students build the sustainability mindsets necessary for long-term engagement. For example, underlying all of these culturally responsive education principles is an emphasis on empowerment and agency, built by helping students access knowledge in a way that is relevant to them and their own contexts (Ladson-Billings 2014). Culturally responsive education can be seen as a method of empowerment contrasted against the neoliberal idea of education as simply economic skill building (Aronson and Laughter 2016). Culturally responsive education is not solely confined to building skills that students will need to succeed in a global marketplace; it also incorporates ideas of social justice and equity, helping to build the equity and justice mindset. Students develop this mindset by exploring situations where activities and ideas presented in a singular "standard" way may not be equitably accessible to all students. For example, a student from a background without frequent access to academic writing might find that writing style difficult to interpret. Exploring why this might be so and learning about other styles of writing are important parts of understanding equity and justice.

The open-mindedness and reflection mindset is developed as students are given opportunities to access information in different ways, increasing their sense of perspective. Finally, as students learn skills about cultural borders and how to cross them, they develop mindsets related to global–local interconnection.

Adding the Specificity of Place

In addition to creating flexibility within the learning materials to allow for and support cultural diversity of values, epistemological beliefs, and learning styles, there is also a need to make the materials less generic and more applicable to the location where the learning takes place. For this task, inspiration is found in place-based education, which focuses on the idea of grounding education in the local place where the learning happens (Smith 2002). This type of education offers both relevance of learning and fosters a sense of connectedness with the natural world.

A place-based focus can be related to culturally responsive teaching in that both the physical and sociohistorical contexts are crucial in tailoring learning experiences that are relevant to students (Barton 2002).

Students value learning when it is connected to their own personal geographies and histories (Birmingham et al. 2017). Therefore, the more scope for customization available within Smithsonian Science for Global Goals, the greater the amount of student investment in the guides. As Gregory Smith (2002: 586) stated, "valuable knowledge for most children is knowledge that is directly related to their own social reality, knowledge that will allow them to engage in activities that are of service to and valued by those they love and respect."

Using existing personal and community knowledge as a catalyst for hands-on multidisciplinary learning increases engagement in learning and builds a sense of connection to the human and ecological communities surrounding the learner (Harada 2016). Place-based education adds a new dimension to relevant academic knowledge—namely, knowledge of the natural world and community structures surrounding the students. This knowledge is highlighted as part of the entry points to the Global GAP. The multidisciplinary focus required by place-based education works in tandem with the multidisciplinary perspectives needed to make complex subjects accessible, as previously discussed, and the need for using different ways of knowing to access a problem, as discussed in the section on culturally responsive pedagogy.

Place-based education can help develop connections between students and the natural environment. In the modern context, virtual connections can lead to a decreased affinity with location and a lack of connection to nature (Sloan 2013). However, place-based education's focus on the natural environment surrounding the learner can lead to an increased sense of attachment and stewardship toward their local area (Sloan 2013). Creating investment in their local areas is a critical part of fostering student connection to ecological problems, such as those of the SDGs.

However, place-based education has evolved beyond just a connection to the natural world and now often includes a focus on a connection with the local community (Karrow and Fazio 2010). Place-based education can encompass understanding the "students' place-based sociocultural practices and funds of knowledge" (Mendoza 2018: 419). This aspect of place-based education echoes the requirements of culturally responsive education by empowering students to use their own perspectives to access material. Smithsonian Science for Global Goals supports this through the Global GAP structures that recognize students' own background knowledge, learning dispositions, and cultural contexts. Place-based education includes a local exploration of spaces and connecting them to global contexts (Duhn 2012), something that is explicitly part of the Global GAP. The identities and knowledge that students bring to their learning experiences are crucial inputs for building their local understanding of a global issue.

This precise notion of place-based education is relevant in answering the design challenge of providing universally available learning materials. It is impossible for designers to determine the local situation in every place where Smithsonian Science for Global Goals materials might be used. Instead of attempting to do so, students can instead customize Smithsonian Science for Global Goals guides with their own sense of context, making the abstract SDGs concrete within their lived realities. Empowering students to add local context grounded in their own place transforms the place- and culture-agnostic Smithsonian Science for Global Goals into a learning experience that is locally relevant, which increases students' long-term engagement with their own communities. This kind of applied learning relevant to a local community is precisely the power of place-based education (Harada 2016).

OVERVIEW OF TECHNIQUES FOR REACHING ALL STUDENTS

With all of this scholarship in mind, there are three recommendations to ensure local relevance of learning materials available worldwide. One, Smithsonian Science for Global Goals should provide experts, texts, activities, and examples from a variety of cultural contexts to allow students and teachers to access the material from a context relevant to them, as recognized through the work of culturally responsive education. Two, Smithsonian Science for Global Goals should create opportunities for individuals with different "ways of knowing" to engage and learn. The multidisciplinary nature of the learning experience and allowing time and space for different perspectives help support a culturally responsive science pedagogy. And three, Smithsonian Science for Global Goals should make space for place-specific educational contexts and allow for this flexibility to define values from within the materials. Students bring their own knowledge, skills, and contexts to Smithsonian Science for Global Goals, which needs to be flexible enough to allow for their customization.

These recommendations work together, allowing diversity of thought and situation to drive the learning toward local relevance. Instead of privileging one discipline or way of thinking over another, Smithsonian Science for Global Goals community research guides, through their multidisciplinary nature, explore how each way of knowing can add richness to understanding and lead to student empowerment as students' own experiences and views are valued and validated.

The overall pedagogical considerations discussed above actually reinforce the design considerations required for Smithsonian Science for Global Goals to solve the conundrum of how have locally relevant worldwide learning materials. Both the goal of accessing complexity and the need for a variety of epistemologies and methods to provide cultural access lead to the multidisciplinary nature of the community research guides. The need to ground the abstract SDGs into local relevance and the need to provide place-based content for place- and culture-agnostic learning materials dictate the choice to have students add their own local content and contexts. This customizes the guides and grounds them in the place where they are being accessed. Building a habit of local action is not solely an important pedagogical consideration but is also an important part of grounding Smithsonian Science for Global Goals into a specific place and context. Finally, long-term sustainability mindsets are nourished not only through the Global GAP structure of Smithsonian Science for Global Goals, but also by making the guides culturally responsive and place based. Working together, Smithsonian Science for Global Goals becomes embedded in local places with local action taken for the global goals of the SDGs.

Conclusion

Creating Students Ready to Take Action

Issues enumerated by the SDGs, such as climate change, will not magically fix themselves without efforts at all levels, from international to local. Therefore, it is crucially important for all individuals to learn how to contribute to the mitigation of global problems. This is especially true for the rising generation, who will be the most affected by whether global challenges are met or ignored. The skills to engage with and act on these complex, difficult issues are by no means simple to teach or to learn. However, this teaching and learning challenge does not suggest that educators should shy away from the problem.

Addressing the issues raised by the SDGs will take time and persistence. Guiding the preparation of students to contribute to that effort also will require concerted, long-term investment. It may mean engaging families to build understanding. It may require teacher professional and personal growth. It may mean time and efforts devoted to these skills over years and across disciplines. Even with these challenges, students still deserve the opportunity to help solve the problems that will deeply impact their lives. It is a moral imperative to give them these skills, not just for their efforts today but for their long-term engagement. Students need these skills for their own sakes and the sake of previous and future generations.

The enormity of the task is precisely the reason the Global GAP and Smithsonian Science for Global Goals have been developed. Rather than hoping that educators can spend the time and attention to deeply understand each global issue, Smithsonian Science for Global Goals provides the background knowledge necessary as a starting point. Rather than hoping teachers can singularly design a pedagogy for transformative action, they can use the tool of the Global GAP. The Global GAP structure guides teachers to help students build deep understandings of global and local issues through investigations, think critically about those results, place them in a systemic context, generate consensus, and build a habit of action. As students engage in this process again and again, they develop the skills and mindsets needed to take informed action to address global issues, such as those raised in the SDGs.

Students, teachers, families, communities, and learning material designers all play an important role in preparing students for this important work. Students need to move from a passive approach to learning to an empowered one, bringing their creativity, critical thinking skills, and their local knowledge to deeply engage with the learning experience. This is challenging for many since it may represent a new idea of what it means to be a student. Students most familiar with standardized tests and multiple-choice answers may struggle to envision themselves as actors to address real-world problems. Smithsonian Science for Global Goals challenges students to move from knowledge regurgitators to knowledge creators, an important and necessary skill, but a too-often unfamiliar one. However, the skills developed through the Global GAP are consistent, meaning that the first time engaging with Smithsonian Science for Global Goals will be the most challenging. As students work through subsequent guides, they will use and strengthen the same set of skills, readying them to take action with sustainability mindsets.

The challenge for educators is different; they must leave aside the tempting notion of themselves as knowledge imparters and move to a more amorphous role of supporter and guide. This is an act of faith for many educators, allowing students to head in unknown directions and without predetermined solutions. Educators willing to embrace this challenge put their faith in the abilities of their students and the idea that good decisions come from pluralistic perspectives and diverse potential solutions. Educators struggling with unmotivated students may be reluctant to start educating in this way. However, research has shown that students focused on real-world issues find learning engaging (van Eijck and Roth 2007). Moving from a standard classroom environment to one focused on inquiry and action may permit previously unengaged students to bring existing expertise (Smith 2002; Mendoza 2018). Educators are also challenged to respect knowledge and opinions that may contradict what they know or believe. In addition, some educators may feel uncomfortable teaching unfamiliar, complex topics. This discomfort becomes more manageable as educators relinquish the role of the central holder of knowledge and instead view themselves as guides and coinvestigators into topics that will impact them as well as their students.

Families and communities also may find themselves in unfamiliar roles as the Global GAP is implemented. Unlike many centralized and standardized curricula, Smithsonian Science for Global Goals focuses on the knowledge families and communities hold about local places, spaces, and possibilities. In some cases, families and communities may have placed little emphasis on this knowledge and may, in fact, privilege more academic discourse and ways of knowing. Too many communities have felt discounted and left behind for too long. Watching their children start to focus on the knowledge, needs, and customs of the community as a starting point may run counter to what ignored communities may view as "schooling." As some of the work on decolonization teaches, there must be a freeing of the mind (Johnson 2012). Among communities accustomed to the schooling norms instigated during a colonial past, there may be a need to unlearn ways of thinking and unconscious attitudes of bias against themselves. Challenging and empowering families and communities to see themselves as the key to sustainable change is crucial.

Finally, learning material designers face peculiar challenges when designing Smithsonian Science for Global Goals for worldwide use. As detailed in the section "Developing Learning Materials Relevant to All," designers must explicitly exclude images, scenarios, or references that are only relevant to one specific space. In addition, they also must engage in the more challenging work of examining their own assumptions about what learning looks like and how we build knowledge. This requires critical contemplation and continual practice to limit the impact of their own "cultural fingerprints" on the guides (Gough 2007).

Building a better understanding of the details of how to succeed in shifting the attitude and skills for each of these groups in practice is beyond the scope of this paper, but it is highly desirable. Likewise, engaging in longitudinal research to determine the eventual impacts of educating for action through the Global GAP would help to elucidate the persistence of sustainability mindsets and whether there is a minimum number of times students need to be exposed to the Global GAP learning progression for sustainability mindsets to continue into adulthood.

Beyond the need to address the specific pressing global issues listed in the SDGs, there is an ongoing need to help students develop the skills necessary to act to improve their local communities and the larger world. As the Global GAP recognizes, empowering students and communities to understand global issues within their own context and determine their own solutions is a precondition of sustainable change. This author sincerely hopes that, as a community of teachers and learners, we can understand that each of us holds both identities within ourselves—the knowledge and skills needed to teach others and the openness and curiosity needed to learn. The key to progress is within. Collaborating together we can move from ideas to action and build a global culture ready to work together to ensure our planet and our species survive and thrive.

Acknowledgments

This project would have been impossible without the support, advice, brainstorming, and assistance from the team at the Smithsonian Science Education Center (SSEC). I specifically wish to thank Andre Radloff, science curriculum developer, who conceptualized a great deal of the journey of this curriculum before I formally mapped it, and Katherine Blanchard, program manager for Leadership Development and International Programs, who was an active participant in shaping the learning progression and an important source of guidance, ideas, and advice. In addition, Carol O'Donnell, SSEC director, and Brian Mandell, division director of Curriculum and Communications, were noteworthy for their consistent encouragement and useful insights, and Jean Flanagan, science education research specialist, for her in-depth knowledge on inquiry-based science. I am grateful for Jim Williams, George Washington University (GWU) professor of international education and international affairs, who slogged through my early draft, providing extremely useful feedback and reassurance.

I appreciate the many people who took time out of their busy schedules to talk to me and share their expertise, especially Karen Lee, social studies teacher at Thurgood Marshall and GWU adjunct professor, for sharing her useful comments. And finally, I wish to thank my family who were unselfishly willing to forego bedtime stories, movie nights, and Frisbee games so I could do this work.

Appendix

The Global GAP is a learning progression focused on the goals of building habitual action, understanding complex topics, developing mindsets for continued engagement, and connecting the abstract to the concrete (Figure A1). This framework acts as a guide for the Smithsonian Science for Global Goals community research guides. The important features of each stage shown in Figure A1 are summarized below the figure, starting from the bottom.

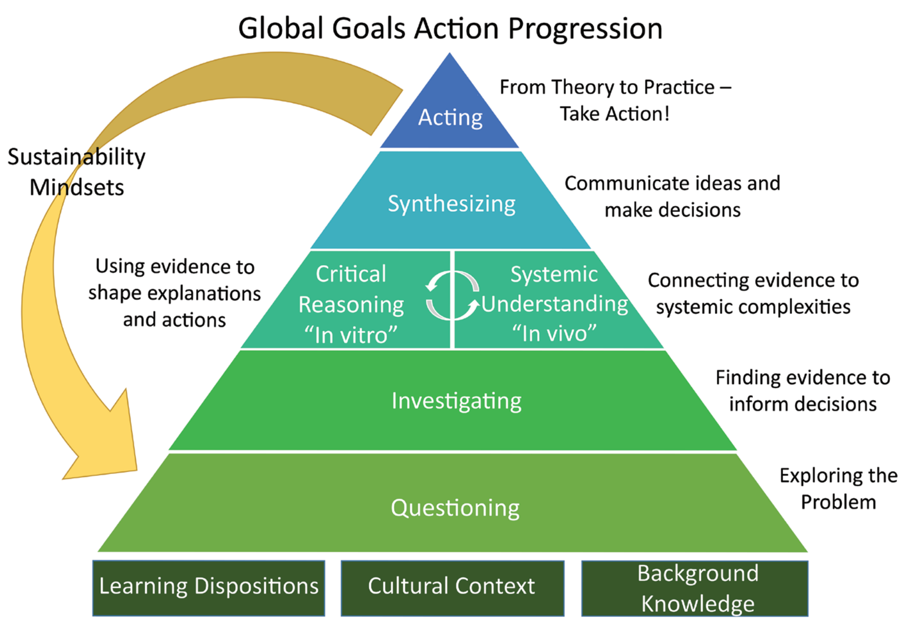

FIGURE A1. Global Goals Action Progression, unabridged. (Diagram designed and created by Heidi Gibson, Katherine Blanchard, Andre Radloff, Brian Mandell, and Jean Flanaghan. © Smithsonian Institution.)

Entry Points (Learning Dispositions, Cultural Context, and Background Knowledge)

- Acknowledgement of the experiences, skills, and individuality young people bring to the learning experience.
- Learning dispositions are the best way for each individual to access knowledge.
- Cultural contexts are the culture and values that inform an individual's worldview.
- Background knowledge is the content and community knowledge held by an individual.

Stage 1: Questioning—Exploring the Problem

- Identify the problem locally and globally.
- Formulate and prioritize questions.
- Explore the importance of the problem in local and global contexts.
- Determine data requirements.

Stage 2: Investigating—Finding Evidence to Inform Decisions

- Plan methods of investigation.
- Gather data from a variety of sources.
- Find information through research.
- Enhance understanding through experimentation.

Stage 3.1: Critical Reasoning—Using Evidence to Shape Explanations and Actions

- 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.

Stage 3.2: Systemic Understanding—Connecting Evidence to Systemic Complexities

- 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.

Stage 4: Synthesizing—Communicating Ideas and Making Decisions

- 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.

Stage 5: Acting—From Theory to Practice—Taking Action!

- Implement actions.
- Carry out practices to mitigate the identified problem.
- Engage with community.
- Review and reassess strategic plan, modifying as necessary.

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About the Author

Heidi Gibson is a curriculum developer for the Smithsonian Science for Global Goals community research guides at the Smithsonian Science Education Center (SSEC). This follows her prior work as an SSEC research fellow helping to develop the structure of the guides and aligning them to ideas from socio-scientific, place-based, participatory action, and civic and global learning research. She is passionate about engaging young people to realize their own power to transform the world. She has a Master of Arts degree in international education from George Washington University. She previously directed the Global Schools First program at Childhood Education International. She also has researched global education programs, such as the District of Columbia Public Schools' study abroad program. Diverse perspectives and experiences are exemplified by her background, which includes serving as a foreign service officer at the U.S. Department of State, teaching experiential civics to middle and high school students through the Close-Up Foundation, and receiving a Bachelor of Science degree in biology from the College of William and Mary.

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.

Heidi Gibson is a curriculum developer for the Smithsonian Science for Global Goals program at the Smithsonian Science Education Center.

Smithsonian
Scholarly Press

https://scholarlypress.si.edu

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

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