Global and local dynamics navigating grand challenges

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Heewoo Lee[1]; Troy Sadler[1]; David Fortus[2]; Rebecca Lesnefsky[1]; Keren Dalyot[2]; Nannan Fan[1]; Zhen Xu[1]; Shira Passentin[2]; Natasha Segal[2]

1: The University of North Carolina, Chapel Hill

2: Weizmann Institute of Science

I. Statement of Problem

The current science standards and curriculum are shifting towards incorporating real-world issues (Millar, 2006; National Research Council, 2010; OECD, 2004). Scientific literacy has evolved to encompass socioscientific issues. Basic science content knowledge and investigation skills for many decades represented the core of scientific literacy. But the focus now includes linking science with other disciplines to cultivate informed individuals (Aikenhead, 2006; DeBoer, 2000; Roberts & Bybee, 2014; Zeidler & Sadler, 2010). Consequently, students encounter various issues within their curriculum and science classes. This underscores the importance of socioscientific issues (SSI)-based teaching, which touches on facets of society like politics, economics, and daily life (Eastwood et al., 2012). In science class, students are encouraged to explore, inquire, and integrate multiple disciplines to comprehend and tackle these complex issues. Employing SSI benefits students and teachers by enhancing science content knowledge, data analysis, reasoning skills, and understanding of science's nature (Eastwood et al., 2012; Klosterman & Sadler, 2010; Sadler, 2011). This approach bridges the gap between scientific knowledge to real-world applications, rendering learning relevant and meaningful. Moreover, it fosters student enthusiasm and motivation for science learning (Ke et al., 2020).

To facilitate authentic learning experiences, it's crucial to incorporate issues of varying scales, both global and local, into classroom learning opportunities. However, the selection of issues demands careful consideration. Global issues can resonate with students, motivating them to inquire, engage, and actively seek solutions (Holbrook & Rannikmae, 2017). Food insecurities due to the growing population and limited resources, unequal accessibility of fresh water, and endangered aquatic species from mismanaged plastic pollution are universal issues highlighting the urgency of addressing such complex issues. Given the scope and interconnectedness of these challenges, the term 'Grand Challenges (GCs)' aptly captures the essence of these multifaceted issues that extend far beyond geographical boundaries (Bhargava, 2006). It's essential to recognize that these concerns aren't confined to specific countries; they impact every nation and, indeed, every individual on our planet. The countries cannot be isolated from these global issues; thus, individuals cannot be considered in isolation either. The impact of these global problems extends into various aspects of daily life, encompassing the economy, society, environment, politics, and culture. Moreover, these challenges do not exist in isolation; they intertwine across different social dimensions, amplifying their influence twofold or even threefold. As these challenges affect both individuals and nations, handling them requires efforts at personal and transnational levels. As members of society, students have a vital role; they need to engage with these issues, develop problem-solving skills, and actively contribute to solutions. Therefore, integrating global issues into the science classroom and fostering the development of scientific thinking and decision-making skills are essential steps in empowering individuals to address these challenges actively. The nature of grand challenges entails complex, global effects, such as climate change, which necessitates presenting situations that have a global scope. However, connecting global-scale issues to students' local experiences is pivotal in optimizing SSI implementation in classrooms. When students are able to situate science within the context of their lives, it becomes more familiar to them (Pomeroy, 1994). Contextual education has been proven to develop students' social-emotional skills and enhance engagement (Lee & Roth, 2003). Students are more inclined to resolve problems in their communities than in other countries (Bouillion & Gomez, 2001; Greeno, 1998). This brings the importance of localizing science education. Simultaneously, understanding how one’s actions can impact the world is crucial for grasping grand challenges. The aggregation of minor issues can catalyze global problems.

Consequently, addressing and presenting interwoven global issues in the science classroom is paramount.

The Grand Challenges project proposes a long-term goal to reshape middle school science education. This involves introducing global issues and linking them to local contexts, nurturing informed students equipped to take action. Breaking down grand challenges into smaller components tied to local contexts offers benefits for students, educators, and curriculum developers alike. Our roundtable presentation outlines a potential approach to designing lessons that encompass both global and local dynamics, highlighting the intricate interplay between the two. Additionally, we delve into the expected benefits of the GCs project, particularly focusing on the imperative of establishing local connections in addressing grand challenges.

II. Design

Among many features of the grand challenges, our team prioritized two representative dimensions: long-standing complex issues rooted in science and society, and global issues with local connections. Within this framework, we selected three global phenomena. The Grand Challenges project has three units that focus on diverse grand challenges: the availability of clean water, fossil fuel as a factor of climate change, and potential solutions for sustainable diets. What sets the Grand Challenges project apart is its focus on issues across different scales, ranging from the global to the local level. This scale shift occurs multiple times during the lesson. Each unit starts with a global grand challenge, offering students and teachers the chance to explore the local facets of the issue, constantly transitioning between global and local perspectives as the lessons unfold. This pedagogical approach enables students to delve into global issues while maintaining a local viewpoint, fostering a comprehensive understanding of science's role within their society.

During the development stage, our team deliberated on which global issues should be incorporated into the project. The selected themes needed to be urgent and compelling for middle school teachers to teach effectively. Another critical criterion for choosing three themes from a myriad of global issues was an alignment with standards. Given the project's goal of integrating Socio-Scientific Issues (SSI) into the science curriculum, we had to ensure that the selected themes could be taught alongside science standards in the unit. Each unit begins with anchoring phenomena and a central driving question pertaining to grand challenges. Starting from a global perspective facilitates an overarching comprehension of the magnitude of issues that might impact students' local environments. This approach raises students' awareness of global events and issues beyond their immediate surroundings. As the overarching phenomena are deconstructed, they link to scientific concepts and local concerns. Shifting to a localized approach enables the development of more focused and tailored curriculum materials, addressing specific issues within smaller, region-specific contexts. Incorporating localized issues into the classroom is particularly emphasized as we focus on science practices.

In the ‘Quenching a Thirsty Planet’ unit, the transition between global and local approaches is iterative (Table 2.) The anchoring phenomenon of the global water crisis initiates an exploration of water sources, naturally leading to the investigation of local water sources and expanding to encompass the Earth's entire water system. Then the source of water leads to an examination of various water uses at personal, community, and global levels. The exacerbation of water scarcity due to overuse, population growth, and climate-induced severe weather is substantiated by data from different countries, underscoring the need to address the global water crisis. Progressing from analyzing individual community levels to systematically comparing

countries in contrasting situations iteratively highlights the dynamics between global and local approaches. Finally, by reflecting on their acquired knowledge, students initiate a search for solutions grounded in the diverse strategies implemented by different countries. Equipped with resources, students apply these strategies within their local contexts, bringing the unit to a meaningful conclusion.

Table 2

Sequence of global and localized approaches in water unit

Activity	Description	Scale
Relationship to water	relationship to water differs place to place, culture, accessibility	Global
Local water source	a watershed in the community	Local
Water stored & moves	the scientific idea of water storage/movement	Global
Daily water use	personal level of usage	Local
Global water use	agriculture, industrial, municipal	Global
Developed vs. developing countries'	comparison uses of water among countries and making an argument	Global
Use of water in NC	overview of local data	Local
Simulated situation modeling	impacts on city development, land use on keeping rainfall	Local
Deforestation & the water cycle	using data from Borneo Island	Global
The World & its water	resources available: economic/natural/technological	Global
Views in desalination	cultural difference makes different result	Global
Decision-making for water supply	using specific county situation	Local

While some students might initially perceive global issues as disconnected from their daily lives, others can establish connections between global and local concerns and identify symbiotic relationships between the two. Exploring these issues at both levels fosters more authentic and meaningful inquiries. Unlike units that touch on SSI only once or twice, this project adopts a more extensive approach, spanning approximately 20 hours per unit. With three to four weeks dedicated to each unit, there's ample room to incorporate a wide range of data from both global and local sources, thereby maximizing the educational impact of the project.

III. Significance

Science education plays a pivotal role in equipping students living in the globalized era with essential transnational problem-solving skills and cultivating their interest in grand challenges. Encouraging students to perceive global issues from diverse perspectives, fostering their scientific problem-solving abilities, and guiding them to make informed decisions in context are not just choices; they are imperative. Simultaneously, the need to localize these challenges is equally crucial, enabling students to relate to immediate concerns and encouraging their active involvement in addressing these issues. The essence of meaningful learning lies in its alignment with students' lives, encompassing school, family, and community contexts. Knowledge becomes more transferable when it is closely related to the student. The Grand Challenges project adeptly navigates between global and local approaches, providing a

comprehensive framework that avoids the limitations of solely focusing on either scale. This approach proves beneficial for students, teachers, and curriculum designers alike.

Primarily, students are afforded numerous opportunities to engage in science practices, which have recently gained prominence. Studies indicate that active participation in the practices employed by scientists and engineers significantly contributes to understanding for students (e.g. NGSS). By introducing real-world issues into the classroom, more avenues emerge for employing science practices. Not only do students construct their water cycle models, but they also employ these models to explain how real-world scenarios influence the presented issues. Empowering students by teaching them how to apply their models enables them to effectively utilize their knowledge and skills in tackling real-world inquiries and making predictions concerning diverse phenomena. Accessing and using public data is another highlighted science practice of the project. Public data from global and local levels accurately portrays authentic situations and events where students live. Incorporating this data enriches their learning experience, as they engage with real-world data to explore complex scenarios. The inclusion of public data in argumentation provides a solid foundation for students to build compelling and well-rounded arguments, considering both global and local facets.

Secondly, localizing grand challenges serves as a catalyst for students to take tangible actions. Recognizing that global issues can emanate from local sources or global challenges can have direct local consequences, the project encourages students to embrace their roles as responsible citizens. While addressing global issues is essential, effecting change often necessitates addressing local concerns. This approach contributes to solving broader challenges incrementally. The regional scale provides a suitable arena for middle school students to engage in meaningful problem-solving, enabling them to initiate change and create impact at a manageable level. By initiating with global perspectives and culminating in activities geared towards personal and community solutions, students are empowered to take ownership of the issues.

Third, the localization approach also involves teachers, offering them a crucial role in shaping the project. Acknowledging that grand challenges transcend geographical boundaries, the intention is to ensure the longevity of these projects beyond school implementations. Furthermore, the adaptable nature of the project accommodates regional nuances and invites teachers to contribute community-based narratives, even updating data to reflect real-world changes. This collaborative approach ensures the project's resilience and sustainability, empowering teachers to tailor the curriculum to suit their contexts.

Fourth, interdisciplinary approaches become imperative due to the intricate and multifaceted nature of grand challenges. These challenges span diverse domains, encompassing science, societal issues, economics, and technology. Encouraging students to engage in interdisciplinary projects centered on these challenges holds immense value. By affording teachers the flexibility to design their approach, the project widens the scope of classroom content and possibilities.

In conclusion, the Grand Challenges project bridges global and local perspectives, fostering students' problem-solving skills, promoting action, involving teachers, and embracing interdisciplinary learning. By embracing these principles, education becomes a powerful tool to equip the next generation with the competence and motivation to address the complex challenges of our interconnected world.

References

Aikenhead, G. S. (2006). *Science education for everyday life: Evidence-based practice*. Teachers College Press.

Bhargava, V. K. (Eds.). (2006). *Global Issues for Glabal Citizens: An Introduction to Key Development Challenges*. Washington, DC: World Bank.

Bouillion, L. M., & Gomez, L. M. (2001). Connecting school and community with science learning: Real world problems and school-community partnerships as contextual scaffolds. *Journal of Research in Science Teaching*, 38(8), 878-898. https://doi.org/10.1002/tea.1037

DeBoer, G. E.(2000). Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching*, 37(6), 582-601. https://doi.org/10.1002/1098-2736(200008)37:6%3C582::AID-TEA5%3E3.0.CO;2-L

Eastwood, J. L., Sadler, T. D., Zeidler, D. L., Lewis, A., Amiri, L., & Applebaum, S. (2012). Contextualizing nature of science instruction in socioscientific issues. *International Journal of Science Education*, 34(15), 2289-2315. https://doi.org/10.1080/09500693.2012.667582

Greeno, J. G., & Middle School Mathematics through Applications Project Group. (1998). The situativity of knowing, learning, and research. *American Psychologist, 53*(1), 5–26. https://doi.org/10.1037/0003-066X.53.1.5

Holbrook, J., & Rannikmae, M. (2017). Context-based teaching and socio-scientific issues. In K. S. Taber, & B. Akpan. (Eds.), *Science Education: An international course comparison*. (pp. 279–294). Sense Publishers. https://doi.org/10.1007/978-94-6300-749-8_21

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

Klosterman, M. L., & Sadler, T. D. (2010). Multi-level assessment of scientific content knowledge gains associated with socioscientific issues-based instruction. *International Journal of Science Education*, 32(8), 1017-1043. https://doi.org/10.1080/09500690902894512

Lee, S., & Roth, M. W. (2003). Science and the "good citizen": Community-based scientific literacy. *Science, Technology, & Human Values*, 28(3), 403-424. https://doi.org/10.1177/0162243903028003003

Millar, R. (2006). Twenty first century science: Insights from the design and implementation of a scientific literacy approach in school science. *International Journal of Science Education*, 28(13), 1499–1521. https://doi.org/10.1080/09500690600718344

National Research Council [NRC]. (2010). Conceptual framework for new science education standards. Retrieved from http://www7.nationalacademies.org/bose/Standards_Framework_Homepage.html.

Organization for Economic and Co-operation and Development [OECD]. (2004). Scientific literacy. In J. Gilbert (Ed.), *The RoutledgeFalmer reader in science education* (pp. 39–52). London and New York: RoutledgeFalmer, Taylor and Francis Group.

Pomeroy, D. (1994). Science Education and Cultural Diversity: Mapping the Field. *Studies in Science Education*, 24(1), 49-73. https://doi.org/10.1080/03057269408560039

Roberts, D. A., & Bybee, R. W. (2014). Scientific literacy, science literacy, and science education. In S. K. Abell, & N. G. Lederman (Eds.), *Handbook of research in science education* (Vol. 2, pp. 545–558). Routledge. https://doi.org/10.4324/9780203097267-38

Sadler, T. D. (2011). Socio-scientific issues-based education: What we know about science education in the context of SSI. In *Socio-scientific issues in the classroom: Teaching, learning and research* (pp. 355-369). Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-94-007-1159-4_20

Zeidler, D. L., & Sadler, D. L. (2011). An inclusive view of scientific literacy: Core issues and future directions of socioscientific reasoning (pp. 176–192). In C. Linder, L. Ostman, & P. Wickman (Eds.), *Promoting scientific literacy: Science education research in transaction*. New York: Routledge/Taylor & Francis Group.