Anti-Racism Interactive Science to Expand Success (ARISES)

Introduction

Funding for Anti-Racism Interactive Science Education (ARISE) established that science teachers want and can implement anti-racism instruction in middle school classrooms. We propose *Anti-Racism Interactive Science to Expand Success* (ARISES) to respond to participating teachers' desire for additional anti-racism units, expand to new teachers, and reformulate designs for support as teachers grapple with localizing science for their students and their communities.

ARISE enabled us to integrate justice-centered science pedagogy (Morales-Doyle, 2017) with the Knowledge Integration (KI) framework (Linn & Eylon, 2011) to create a guiding framework for localizing OER curriculum design in science education. We seek to illuminate the impact of systemic anti-racism in science, and especially in the lives of science students. We tested a Curriculum Visualizer to enable productive conversations around using OER to address anti-racism in local contexts. In collaboration with teachers from 4 schools we demonstrated the gains students can make in integrating science and social justice as well as important questions that need attention as more teachers adapt ARISE units for their students (Billings et al., 2022; Bradford et al., 2022; Gerard et al. in press).

We propose Anti-Racism Interactive Science to Expand Success (ARISES) a Research Practice Partnership (RPP) to:

- Expand the Research Practice Partnership (RPP) from 4 to 6 schools;
- Expand and refine the instruction from 3 to 6 middle school science units featuring customizable interactive models and informative embedded assessments;
- Expand the Curriculum Visualizer to add features that support teachers in developing pedagogical content knowledge for teaching justice centered science units; and
- Develop a new workshop design that bridges the concerns of experienced and new teachers' to support localized customizations.
- Refine the Social Justice KI pedagogical framework and develop principles for design of science education that address systemic racism.

The ARISES RPP will refine the Social Justice KI pedagogy while leveraging insights from experienced teachers to reformulate the ARISE professional development; improving the Curriculum Visualizer to bring anti-racism science curricula to new teachers and schools; and designing new OER models and units to expand the curriculum. We will document these efforts using observations, embedded assessments, and logged data from students along with interviews, observations, and logged workshop comments from teachers.

Pedagogical Framework. ARISES combines *Social justice science pedagogy (Morales-Doyle, 2017) and Knowledge Integration (KI)* pedagogy to guide design of anti-racism science instruction. This pedagogy calls for a focus on *localized* social justice issues that are situated in the participants' community. It centers the exploration of science concepts in participants' lived experiences. It supports students to discover the impact of *science and social factors* on community-based outcomes. For example in the Asthma unit students test the relationship between pollutants from freeways and refineries and the incidence of Asthma among local residents. They distinguish between science factors such as how emissions contribute to Asthma and social factors such as constraints on housing choices. Students can evaluate the tradeoffs of proposed solutions for change in their local community. The unit *empowers* participants to integrate science and community-based knowledge to take actions for bringing about social change within their policy and individual spheres of influence

RPP process. In ARISES, the Social-justice KI pedagogy will guide the RPP between UC Berkeley, and approximately 18 middle school science teachers and their students [Albany Middle School, Madison Park, Montera Middle School, Fallon Middle School, *Anna Yates Middle in Emeryville, and Cal Prep in Richmond*]. Together we will design and study 3 new middle school science units featuring customizable interactive models, and refine the existing 3 units to respond to the student ideas from prior implementation and to localize the units for new contexts (see Table 1. Units). We will facilitate school site meetings prior to the RPP workshop to map how each of the ARISES units fits into the grade level's adopted curriculum sequence, so that teachers can give time to ARISES instruction while simultaneously meeting their school's curricular expectations. The partners will explore ways to use the social justice and KI pedagogy throughout the year, not just in these units. This design work will provide two units at each grade level. Thus, students will experience six units during at least three months of instruction over three years of middle school.

Expanding the RPP workshop design. We will redesign the RPP workshop to take advantage of new and returning teacher expertise. We will respond to comments from ARISE teachers that indicated desire for more self efficacy in teaching about social injustice and its historical development, compared to their self efficacy when teaching parts of the lesson focused on the science concept (Bradford et al., 2022). Teachers wanted ideas about how to guide and support student KI for social justice. For example, teachers wanted more evidence to help their students understand the difference in pollution levels and asthma rates between their local freeway (680) and the 880 freeway featured in the unit. They wanted tips from experienced teachers concerning ways to support their students to question their assumptions when interpreting health data that had been disaggregated by race. Teachers expressed a desire to explore articles and other resources to foster their own understanding of the racialized histories and policies that contributed to current disparities.

The RPP will jointly explore ways to create coherence across the units within a grade level at the first workshop. At subsequent workshops the RPP will create coherence across the grade levels for science topics and explorations of racial injustice. Students for example may revisit similar issues from a prior grade level in order to add layers of nuance and complexity e.g. introduce redlining during Urban Heat Islands in 6th grade and connect to health care access disparities in 7th grade. In addition, teachers will share ideas about how they expand anti-racism themes into other parts of their science curriculum.

Expanding the Curriculum Visualizer. We will expand and refine the Curriculum Visualizer to make the Social-justice KI pedagogy underlying the unit designs visible. This will support partners to build pedagogical content knowledge as they customize the new units in anti-racism science instruction. The Visualizer will enable the teachers to anticipate and evaluate the pedagogical implications of an envisioned customization design. It will also display prior student responses at specific parts of the unit to help teachers anticipate varied student concerns and consider how to guide future students.

Interactive Model designs. The Anti-racism interactive models in each unit will allow students to test their ideas about factors that impact their communities (see Table 1. Units). Logs of student work with the models will serve as informative embedded assessments, providing an in-the-moment summary of student investigations. We will investigate how the units strengthen opportunities for analyzing data and applying science ideas to understand and address racial justice in their community. We will extend the ARISE finding that students made significant gains in integrating their ideas about science and social justice (Billings et al., 2022; Bradford et al., 2022; Gerard et al. in press). We will expand the ways we help students understand and explore how factors like SES, race, and personal choices interact and impact the well-being of their communities. Our embedded assessments will capture student progress and communicate it to teachers.

The ARISES models will support students to understand how local conditions change the magnitude and impact of scientific phenomena such as combustion reactions, vaccine distribution, and local temperatures. For example, the amount of concrete, density of buildings, and vegetation can create urban heat islands that experience temperatures more that 15 degrees above those in suburban areas.

ARISES New and Refined Units

We propose the development of four additional ARISE units to bring our total set of units to seven, with two at each grade level plus a final capstone unit. The capstone unit enables students to explore a topic from ARISES in depth by connecting it to the other ARISES units and to social justice themes such as arbitrary algorithms for decision making. These units will build on the strategies used in tested ARISE units to connect social justice issues with NGSS aligned science content.

6th Grade: Genetic Inheritance, Healthcare, and the Lacks Family

Our proposed sixth grade unit uses the story of Henrietta Lacks to spur discussions of fairness, health, and the human impact of scientific discovery. The unit will build on the existing WISE unit *Genetic Inheritance.* We incorporate issues of healthcare and access to care into discussions about genetic inheritance, using Henrietta Lacks' family as an example of how unjust medical and healthcare practices have an impact on human lives. The unit will use a restorative justice approach, used extensively in the Oakland Unified School District, (Oakland Unified School District, 2021) to introduce students to how communities can work towards addressing historical wrongs made towards communities in the past. The unit will utilize OERs to support students in thinking about the human factors in science and health. For example, we will introduce an interactive pedigree model to trace inheritance and discover how these tools can be used to support care for families or cause individuals harm. Additionally, excerpts from various published articles about Henrietta's family will be used to discover how they were impacted and have advocated for better treatment for themselves and other Black people in the healthcare system.

7th Grade: Photosynthesis & Water Quality

We will build on our existing 7th grade Photosynthesis unit to design a new unit that features an investigation into water conservation. The current Photosynthesis unit prompts students to explore what resources are needed to sustain life. They engage with an interactive model to understand the role of water and light on plant growth. We will build on this activity by integrating an ARISES lesson that digs deeper into the necessity of clean water for sustaining human, plant, and animal life on Earth. Students will then explore two major threats to clean water access in their local communities: water contamination and drought. The unit will leverage students' prior knowledge of water quality crises, such as the crisis in Flint, MI, and their lived experiences with drought in California. Students will use the CAL Human Right to Water Interactive OER to explore data about water quality, accessibility, and affordability in California. Students will distinguish how various issues of equity intersect with issues caused by drought and water contamination. The lesson will culminate with students choosing to advocate for a change within their community such as: practicing individual conservation, raising community awareness, and advocating for district-wide water quality practices.

8th Grade: Henrietta Lacks, Cancer, & Privacy

Building on the 6th grade Genetic Inheritance, Healthcare, and the Lacks Family unit, our new 8th grade unit will incorporate the creation of the HeLa cell line into an existing WISE unit focused on cancer and cell division. This unit will use the development of HeLa cells, at the expense of Henrietta Lacks' autonomy, to discuss the human impact of scientific research and discovery. It will also provide students the opportunity to discuss privacy and health data use in the present day and how regulations have changed to further protect individuals privacy. In particular these units will build on ideas presented in the current ARISE unit,

COVID-19, Data Science and Equity, in supporting students to think about HOW we engage with science, WHO is impacted, and WHY we engage in discovery. We will incorporate a model that allows students to explore the costs and benefits, both scientific and ethical, of using different cell lines in experiments. This will provide students the opportunity to investigate how science is done with HELA cells, and what other cell lines are available to continue to do this work more ethically. Similarly to the 6th grade unit, resources from books and articles written about Henrietta and her family will be used to support students in exploring the human impacts of science and privacy.

8th Grade: Capstone Social Justice Unit

We propose a capstone social justice unit at the end of eighth grade that brings together ideas from prior ARISES units in the context of algorithms, bias, and the ethical use of technology. The capstone unit enables students to explore a topic from ARISES in depth by connecting it to the other ARISES units and to social justice themes such as the use of algorithms, ethics, and bias. This unit invites students to engage fundamental concepts of AI, machine learning, data interpretation, and programming, while thinking critically about the social and cultural components/implications of technological development. Over the course of the unit, students will - (1) learn how and why algorithms are designed, developed, and applied; (2) learn how human bias presents, and work to identify instances of human bias within algorithms; (3) use critical thinking and reasoning to model their own algorithms. The unit culminates with students creating their own algorithms to explore data from prior units to investigate possible solutions to systemic injustices related to the data. Students will select a topic such as how algorithms are used in housing loan decisions and healthcare diagnosis. For example, students could explore how a history of human prejudice and discrimination might be perpetuated technologically in the absence of intentional action. Students might choose to revisit data from the Chemical Reactions, Asthma and Alternative Fuels unit, and test algorithms to show how different policies for vehicle emissions standards or roadway restrictions would impact air quality in local communities.

Table 1. Unit + Grade + NGSS Standards + Interactive Model

Unit	**Grade**	**NGSS Standards**	**Model**
Global Climate Change and Urban Heat Islands	6th	MS-ESS3-3, MS-ESS3-5	Urban heat island model to test community design decisions for reducing temperature
Chemical reactions, asthma, and alternative fuels: Making change	7th	MS-ESS3-3, MS-ESS3-5 MS-PS1-1, MS-PS1-3, MS PS1-4, MS-PS1-5	Alternative Fuels Impact model to compare emissions and impact of varied fuel types
COVID-19, Data Science, and Equity	8th	SEPs: Planning and carrying out investigations. Analyzing and interpreting data. Obtaining, evaluating, and communicating information	Customize OER Data Explorer to analyze and graph COVID data to answer local questions

Genetic Inheritance, HELA, and Health (Modify 6th genetics)	6th	MS-LS4-5, MS-LS3-1, MS LS3-2, MS-LS1-5	Preventative Healthcare Model: Build a Family Pedigree
Photosynthesis & Water Quality	7th?	MS-LS1-6, MS-LS2-2, MS-LS2- 3, MS-LS2-4, MS-LS2-5	Plan Water conservation using WISE OER model to plan crop watering, Customize an OER model to explore water quality, access and affordability in CA community water systems.
Cancer, Treatment, and HELA Cells (Modify WISE Cancer unit)	8th	MS-LS1-1 MS-LS1-2 MS-LS3- 1 MS-LS4-5	Modeling science and ethical variables around
			decisions about using Cell Lines for research
Algorithms and algorithmic bias in analysis of databases including COVID infections, Fuels (Diesel, Gasoline, emission standards) and Cancer demographics.	8th	MS-ETS1-1, MS-ETS1-2, MS ETS1-3, MS-ETS1-4. (Also common core math)	SNAP! model: Build an algorithm, making decisions to help your community and fight injustice

Design and hold workshops

Prior to the start of the workshops, we will hold school site meetings with all of the participating teachers from each partner school. We will work with the teachers to map the ARISES units into their existing curriculum plan and consider how they can use the Social-justice and KI science pedagogy throughout the year, not just in the ARISES units.

We propose to hold two, 9-12 hour workshops in year 1 of ARISES and 1 workshop in year 2, to support partners in the design, refinement and implementation of the 6 units. The design of each workshop will follow the Social-justice KI pedagogy and build on our prior RPP workshop model (Gerard et al., in press). Activities will be refined with feedback from ARISES advisors and teacher partners. In general, the workshops will begin by *eliciting* teachers' prior experiences integrating social justice into their science teaching and establishing shared commitments that bring the RPP together. This will support each partner, and the partnership as a collective, to develop our positioning about teaching social justice in middle school science.

Teachers will then use the Curriculum Visualizer to explore the content of new units and revisit their reflections on units they have taught before. Experienced teachers will share their experiences in unit groups. The Visualizer will be personalized to contain sample student student responses, both written and overheard during classroom observations, from each teacher's classroom or a classroom similar to their own if they haven't yet taught the unit. This will support teachers to envision students' science and justice related ideas, concerns and questions, in response to the activities. The Visualizer will also denote activities that might be particularly sensitive or challenging for students and prompt teachers to consider their instructional approach. Teachers will work together in unit groups to brainstorm customizations and pedagogically aligned instructional moves in response to the student ideas captured in the Visualizer. Finally, teachers will work with researcher/designer partners to make customizations to the unit and identify assessments they will use to gauge student progress in linking their science and social justice ideas.

Investigating ARISES impact using OERs in schools

To investigate the impact of ARISES we will analyze teacher and student responses, building on our past success (Bradford et al., under review; Bradford et al., 2022; Billings et al., 2022; Gerard et al, in press). We will use embedded assessments and logs of student interactions with the units to inform teachers of student progress and refine the units. Specifically we will design embedded assessments that give teachers information about how students are integrating social justice and science. For example, these will include essays where students identify actions to address inequities. We will build on the success of items that enable students to identify implications and to advocate for actions (see Figure 1. Asthma item and Rubric). In addition, at workshops the RPP will study logs of student use of the interactive models and use the information to refine the models and the units.

We will study the design and impact of the workshops using observations, logs from the OER workshop units, customizations recorded in the Curriculum Visualizer, interviews and classroom observations. These investigations will help us understand how experienced teachers mentor new teachers and how the RPP builds understanding of social justice in science. Specifically we will study the development of teaching practices as teachers enact multiple anti-racism activities and discuss their experiences with their peers.

The ARISE classroom research revealed an emerging pedagogy combining Social-justice and Knowledge Integration to guide anti-racism science instruction. We will elaborate the framework as we study the trajectories of teachers and students using ARISES units.

Figure 1. Knowledge Integration Rubric for Pre- and Posttest item in the Chemical Reactions, Asthma and Air Quality Unit. The item asks students to explain whether or not all people are impacted the same amount by the effects of gasoline combustion.

KI score	Criteria	Example response
1	No answer; irrelevant; idk	idk
2	On topic, but nonnormative: all people are impacted the same; normative but vague (without explanation)	● Yes, climate change will effect everyone in the whole world. ● No, not ALL humans are effected by Climate Change in the same way but most are.

3	Partial link: one target idea ● [Place-based] ○ Depends on proximity to a source of pollution/low air quality ○ Different areas experience different impacts ● [Social Factors] ○ Current/historic policies have a role (redlining, or other policy) ○ Social factors like race, ethnicity or SES have a role ● [Health Impact] ○ An individual's health is impacted	● Yes, because if you have more freeways or factories where you live you could have more of the effects of incomplete combustion than places without many. If you live near refineries and places with fewer trees you will also be impacted more, though everyone is impacted to some extent.. ● Yes, because there are certain places where redlining is a thing and black people are fighting against that. ● Yes, depending where you live can effect your heath and stuff like of that
4	Full link: links two target ideas	● No, because chemicals in the air are very dangerous, and [Refinery City], and other black neighborhoods, have some of the highest chemicals. ● I think that people who are lower income are impacted by climate change more than people who aren't. I think this because they sometimes have to live closer to factories and other places where there could be harm.
5	Complex link: links three or more target ideas	● NO! Racially oppressed groups are affect more by climate change. These groups are in redlined communities which put near industrial areas which produce green house gases. These greenhouse gas emissions give you a higher chance to have asthma.

Timeline

Year 1 June-May 30

June 2022: School site meetings
Plan alignment of units with each school's curriculum sequence.

June 2022 Workshop 1: Forming commitments and Customizing for Fall
Forming community with new teacher partners + Anticipating student ideas and planning teaching for Fall units + Customizing the units and assessments (refining ARISE units or contributing design ideas for new ARISES units). Use insights to further develop the Social justice - KI pedagogy. [9 -12 hrs]

August 2022: Focus group or interviews with volunteer teacher design leads and ARISES advisors to review ARISES new units and assessments

August - Dec 2022: Implementation of Fall units with assessments in each school; data collection; data analysis

Jan 2023 Workshop 2: **Instructional Consultancies and Customizing for Spring** Consultancies on instructional dilemmas from Fall teaching + Planning implementation of Spring units [9- 12 hours]

Jan - June 2023: Implementation of Spring units with assessments in each school; data collection; data analysis

Year 2 June 1 - Nov 30

June 2023 Workshop 3: Reflecting on student work and teaching experiences to refine units and teaching strategies. Welcoming new teachers in each school. Linking units across grades and grade levels. Use insights to further develop the Social justice - KI pedagogy. [9 -12 hrs]

August 2023: Focus group or interviews with volunteer teacher design leads and ARISES advisors to review ARISES refined units and assessments

Sept 2023 - Nov 2023: Implementation of Fall refined units with assessments in each school; data collection; data analysis, dissemination.

References

Billings, K., Bradford, A., & Linn, M.C. (2022). Teacher noticing of middle school students' ideas about science and social justice. Paper accepted for presentation at the American Education Research Association annual meeting.

Bradford, A., Billings, K., & Gerard, L. (2022). Understanding the Challenges Teachers Face When Integrating Social Justice into Science Curricula. Paper accepted for presentation at the American Education Research Association annual meeting.

Gerard, L., Bradford, A., Wiley, K , Debarger, A., & Linn, M.C. (in press). Cultivating Teacher Efficacy for Social Justice in Science. *Science Scope*.

Linn, M., & Eylon, B.-S. (2011). Science learning and instruction: Taking advantage of technology to promote knowledge integration. New York: Routledge.

Morales-Doyle, D. (2017). Justice-centered science pedagogy: A catalyst for academic achievement and social transformation. *Science Education*, *101*(6), 1034–1060.