Annual Report
January - December 2022
Snapshot of Accomplishments

Sims Developed and Improved

In 2022, numerous simulations have been developed or improved with full or partial support from this grant. **We now have 96 sims in HTML5 (plus 7 prototypes), all CC-BY licensed.**

- **Geometric Optics** (published)
- **Geometric Optics: Basics** (published)
- **Build a Nucleus** (prototype published)
- **My Solar System** (prototype published)
- **Buoyancy** (in late development, temporarily on hold)
- **Models of the Hydrogen Atom** (designed, in early development)
- **Sound** (in early clean up of code contribution from community)

In addition, we have 7 other simulations in process funded from other sources: Number Play (prototype published), Number Compare, Calculus Grapher, Center and Variability (prototype published), Mean Share and Balance (prototype published), Greenhouse Effect (prototype published), and Quadrilateral.

PhET Fellowship

30 (of 32) PhET Fellows have begun their 12-month Professional Leadership projects, which extend from November 2022 to November 2023.

PhET Translator Network

- **Africa Translator Network** (April - June 2022)
- **Global Translator Network** (September - December 2022)

Funding from the Yidan Prize Foundation supported strategy development of both Translator Networks, and funded a portion of the Global Translator Network.

New Funding

2022

- **NSF IUSE $96,000 (+ $504,000 to collaborators)** To study and improve students’ understanding of measurement uncertainty & variability.
- **NSF POSE $300,000** To explore building open source communities around PhET’s codebase and translation utilities.
- **Bill & Melinda Gates Foundation $275,000** To instrument chemistry simulations for advanced use in platforms.
- **New Relic $15,000** To utilize a global network of servers for dissemination.
- **WT Grant Foundation $92,000 (+ $508,000 to collaborators).** To research the impact of sim-based early math instruction, for emergent-bilingual students.
- **Hewlett Foundation $50,000** To launch PhET’s Diversity, Equity, Inclusion, and Belonging (DEIB) in STEM Education initiative in the United States.
- **100Kin10 / Tides Center $10,000** To identify 2 STEM teachers as STEM Equity Advocates and to co-create an equity framework for PhET processes and programs.

2021 (reported last year)

- **Mastercard Foundation $1.5M**
- **Gordon and Betty Moore Foundation $2.25M**
- **Schmidt Futures $500K**

Virtual Workshop

Virtual Workshops carried out in Nigeria (Q3 & Q4), Ecuador (Q2), Lesotho (Q2), and Rwanda (Q2).

144 teachers certified!
Research

Goal 1: Build the research base on simulation-supported STEM expertise development.

To carry out new research to examine and further advance the educational value of PhET simulations

Research update from Dr. Lora Kaldaras, a research associate funded by the Yidan Prize funds.

Publications

1. **Virtual Learning Environments**  
   (Accepted for publication)

   This book chapter focuses on the historical overview of computer simulations, augmented reality, digital games, and virtual labs.

   (Under review)

   This reflection paper focuses on outlining ways in which PhET simulations can support learners at different levels of cognitive development.

Learning Sequences and Assessment Instrument

Learning sequences that promote blended math-sci sensemaking were piloted with 50 physics and chemistry freshmen in courses at CU Boulder. These students also piloted the associated assessment instrument. Data is under analysis.

Sequences that have been piloted:
- Limiting Reagent (Chemistry)
- Heat Capacity (Chemistry)
- Coulomb's Law (Physics)
- Gas Laws (Chemistry)
- Faraday's Law (Physics)
- Geometric Optics (Physics)

Dissemination

Lora presented her findings about math-sci sensemaking at North Carolina State University College of Education.

Mentorship

Lora continues to mentor undergraduate student researcher Gabriel Murillo González at Stanford University. He is now working to expand Lora's cognitive framework to upper level physics courses.

Grant Proposal

A grant proposal was submitted to the National Science Foundation’s division of Improving Undergraduate STEM Education (IUSE). The proposal focuses on developing and piloting instructional sequences in undergraduate introductory science classrooms, leveraging PhET simulations to support math-sci sensemaking.

Visit bit.ly/3jRAH5T to read the pre-print.

Cognitive Framework for Blended Mathematical Sensemaking in Science

Lora Kaldaras1, Carl Wieman2

1University of Colorado Boulder, Lora.Kaldaras@colorado.edu
2Stanford Graduate School of Education, cw@stanford.edu

Background

Blended mathematical sensemaking in science (“Math-Sci sensemaking”) involves deep conceptual understanding of quantitative relationships describing scientific phenomena and has been studied in various disciplines. However, no unified characterization of Math-Sci sensemaking exists.

Methods

We developed a theoretical cognitive model for blended Math-Sci sensemaking grounded in prior work. The model contains three broad levels representing increasingly sophisticated ways of engaging in Math-Sci sensemaking: 1) deriving qualitative relationships among relevant variables describing a phenomenon (“qualitative level”), 2) deriving mathematical relationships among those variables (“quantitative level”), 3) explaining how the mathematical operations used in the formula relate to the phenomenon (“conceptual level”). Each level contains three sublevels. We used PhET simulations to design dynamic assessment scenarios in various disciplines to test the model. We used these assessments to interview undergraduate students with a wide range of math skills.

Findings

Interview analysis provided validity evidence for the cognitive model. It also revealed that students tend to perform at the same level across different disciplinary contexts, suggesting that blended Math-Sci sensemaking is a distinct cognitive construct, independent of specific disciplinary context.
PhET is working towards incorporating a variety of localized characters and scenery across its simulations. In addition, we have made major advancements in the infrastructure needed to support in-sim language change.

We will be completing the User Interface controls and internal code architecture for a common code character and language selection menu, and publish the first sims with these features soon.

*Character sets funded by MCF; language infrastructure partially funded by Yidan Prize Foundation.

Translation Efforts

1,140+ new HTML5 native African language translations.
509 new translations in non-African languages.

The PhET Translator Network is currently funded by a combination of the Mastercard Foundation (MCF) and Yidan Prize Foundation, with MCF funding the African languages.

PhET has called for coordinated, crowd-sourced translations efforts, prioritizing its HTML5 simulations, followed by Teacher Tips (1-2 page overview documents), and the PhET webpage.

- **Africa Translator Network** (April - June 2022)

- **Global Translator Network** (Sep. - Dec. 2022)

**Teacher Tips**
As simulation sets get fully translated, efforts are now turning to translating teacher support guides.

**Native African Language Coverage (HTML5 sims)**

<table>
<thead>
<tr>
<th>Language</th>
<th>Before MCF</th>
<th>Current</th>
<th>Expected</th>
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</thead>
<tbody>
<tr>
<td>Igbo</td>
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<tr>
<td>Swahili</td>
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<td>Yoruba</td>
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<td>Amharic</td>
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<td>Hausa</td>
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<td>Chichewa/Nyanja</td>
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<td>Sotho/S. Sotho</td>
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<td>Ganda/Luganda</td>
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<td>Tswana</td>
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<td>Wolof</td>
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<td>Xhosa</td>
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<td>Afrikaans</td>
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<td>Kikuyu/Gikuyu</td>
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<td>Arabic (Morocco)</td>
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<tr>
<td>Arabic</td>
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</tbody>
</table>

**Significant Advancements in Other Language Sets**

- New Locales
  - Bislama
  - Burmese
  - Chinese (Hong Kong)
  - Kikuyu
  - Luganda
  - Maltese
  - Nepali
  - Tagalog
  - Wolof
Teaching Materials

Goal 3: Create simulation-based lessons and teaching materials.

To create high-quality simulation-based lessons and teaching materials for each next-generation PhET simulation with a co-design approach which involves experienced secondary physics and chemistry teachers from US, Canada, Latin America, and Africa regions.

- **Latin American Webinar Series “Enseñando con PhET”:** With its focus on sim-specific teaching approaches and high demand by individuals to present, PhET is requiring all webinar speakers to first submit an acceptable lesson plan to the PhET Activities collection for public distribution. These materials are shared on the PhET website and through social media.

- **PhET Fellow Lesson Development:** 32 PhET Fellows have created one of each of the following products:
  - Whole-Class Inquiry protocol
  - Interactive Lecture Demonstration student prediction worksheet
  - Concept Question set
  - Student worksheet-based lesson

  Fellows shared their implementation outcomes with their colleagues as part of their Fellowship requirements.

- **Compendium of Activities and Interactive Lecture Demonstrations Based on PhET simulations,** produced by the Autonomous University of Ciudad Juárez (UACJ).

  Teachers from the UACJ worked with the PhET team to design 6 Student worksheets and 7 prediction sheets for ILD strategies that cover almost all of the Conceptual Physics course. The material was tested and followed PER research in 2 groups, with excellent results in students' engagement and knowledge. These results were sent for publication to the Latin American Journal of Physics Education. UACJ now is designing a compendium for the second course of Conceptual Physics.
Activity Submission and Vetting Improvement

PhET carried out an extensive user survey to better understand how teachers use the PhET website and what resources they access, including the PhET Activity database. As a result of users' expressed needs, PhET is undertaking the following actions:

- Re-design of the Activity submission page
- Re-design of the Activity information page
- Establishment of a peer review process

Virtual Workshop: Website and Coursera

In addition to publishing the PhET Virtual Workshops online, PhET successfully developed the workshops into a Coursera Specialization, allowing PhET to scale its impact and generate income to support ongoing global efforts beyond the life of existing grants.

- Accessible on the PhET website (no log-in required).
- Integrated into the PhET website Translator Utility.

- Recognized as an official Coursera course.
- Tracks progress (require log-in).
- Anyone may audit the course.
- Specialization certificate (free for PhET PD partners, at-cost for other users).
Global Professional Development

Goal 4: Support global dissemination and teacher professional development.

To enhance offline dissemination and access of PhET simulations globally and create a network of partnerships between PhET and global, regional, and local partners with an ultimate reach of at least 2,000 STEM teachers through the train-the-trainer (T-T) model.

Africa

Professional Development MOUs
- **D.R. Congo:** Investing in People (Virtual Workshop date TBD)
- **Ghana:** YouthBridge Foundation – T-T Model (date TBD)
- **Lesotho:** SMEF-Thakakoali - T-T Model (Virtual Workshop held April 7 - May 27) (45 participants, 13 certified)
- **Rwanda:** ACEITLMS - University of Rwanda (Virtual Workshop held June 29 - September) (72 participants, 28 certified)
- **Nigeria:** BiSTEM24 (Virtual Workshop held July - September) (250 participants, 52 certified)
- **Nigeria:** EdVes (Virtual Workshop date TBD)
- **South Africa:** Dr. CL Smith Foundation (Virtual Workshop date TBD)

EdTech Partnerships
- **Kenya:** Kytabu
- **Kenya:** Litemore/Zeraki
- **Lesotho:** SMEF-Thakakoali
- **Nigeria:** EduTAMS
- **Nigeria:** EdVes
- **Nigeria:** Hitch
- **Rwanda:** O’Genius (PhET iO)
- **South Africa:** Dr. CL Smith Foundation
- **South Africa:** Siyavula (PhET iO)
- **Snapplify:** South Africa

Some examples of our outreach (# attendees)
- **ADEA:** Status of STEM Education in Africa (414), Triennale Workshop (60)
- **COMSTEDA:** Intro to PhET sims (314)
- **Nigeria:** Intro to PhET Sims (97 + 6 + 19)
- **Kenya:** KGSA, Intro to PhET Sims (8)
- **U.S. International University:** Intro to PhET sims (11)
- **Zambia:** Intro to PhET Sims (26)

Teachers in Nigeria show off their Virtual Workshop completion certificates. Credit: Saadiyyah Baba

Commercial partnerships are underwritten by the Mastercard Foundation, and support regional activities funded by the Yidan Prize Foundation.

TechGirls
PhET Director, Kathy Perkins, served on a panel for the TechGirls initiative with a group of adolescents and young women from Africa, the Middle East, and Central Asia to support their interest in tech-related fields.
Facebook Community of Educators
PhET maintains a Facebook group, linked to its main page, to create a space specifically for the English-speaking African PhET community.

"Share and Discuss" Webinar Series
The monthly webinar series began in April 2022!

The Africa "Share and Discuss" webinar series is currently funded by the Mastercard Foundation, but the research and strategy was accelerated by the Yidan Prize Foundation.

5,569 African educators reached through webinars!

Changes in PhET Sim Use in Africa
PhET observed 2.1 million online sim accesses from Africa, a 24% increase over the year prior.
(Additionally, surveys suggest that more than 50% of usage in Africa takes place offline.)
Africa (continued)

Learn more about PhET’s activities in Africa! Visit https://medium.com/phets-global to read the stories.
Some examples of our outreach (# attendees)

- **Chile**
  - FRAD, Academy of Sciences (19)
  - Metropolitan University for Educational Sciences (42)

- **Colombia**
  - Medellín, Teaching Astronomy with PhET Sims (110)
  - MOVA (60)

- **Costa Rica**
  - EARTH University, Intro to PhET (8)

- **Mexico**
  - Córdoba, Veracruz, Use of PhET Sims, (20-hr course) (7)
  - DF, Strategies for Teaching with Sims (25)

- **Peru**
  - Fundación Ser Maestro Perú (36)

- **Uruguay**
  - CEIBAL Congress (60)

**Facebook Community of Educators**

PhET continues to maintain a Facebook group, linked to its main page, to create a space specifically for the Spanish-speaking Latin America PhET community.

"Enseñando con PhET" Webinar Series

With its launch in February 2022, this webinar series takes a topical approach to exploring PhET simulations, with 16,000+ attendees/views this year. Due to increased demand by audience members and presenters alike, webinars are now offered approximately twice per month.
Latin America (continued)

Learn more about PhET’s activities in Latin America! Visit https://medium.com/@phet-global to read the stories.

Let’s Learn at the Stoplight: PhET on the Streets of Mexico
Ariel Cruz Castillo is a chemistry teacher in Querétaro, Mexico, but much of her leadership as a PhET Fellow...

A Response to Hurricanes In Honduras: PhET and a Pitch of Love
Emy Soledad Reyes Corea is a PhET Fellow who understands that educators must support any...

Connecting El Salvador’s Pre-Service Teachers through PhET
A foundation of high-quality teaching begins with pre-service education. PhET Fellow Claudia Amaya is a...

A Celebration of Mathematical and Computational Thinking in Costa Rica
Jesús Alexander Matamoros Meraz loves integration. In addition to teaching math and science classes in Alajuela, Costa Rica, he is...

Learning through Play in the Bolivarian Republic of Venezuela
Jesús Eduardo Villamizar Rincón is a teacher and PhET Fellow in Ciudad Rubio, Bolivarian Republic of...

Active Learning with PhET in Urban and Rural Colombia

Students as Protagonists in the Learning Process in Ecuador
Student-centered learning is a passion for PhET Fellow Rael Clemente, a secondary school chemistry teacher...
Other / Global Activities

Press Coverage

PhET was featured in various international media outlets.


https://www.weforum.org/agenda/2022/07/learning-crisis-solutions/

PhET Interactive Simulations: Putting Students In The Driver’s Seat Of STEM...

It’s hard to find a physics or chemistry teacher that doesn’t use PhET Interactive Simulations, a free online science and math simulations platform found...

The Hong Kong Economic Journal (HKEJ) published a piece written in Traditional Chinese on the 2022 Yidan Prize Summit and included a photo of live Q&A with the PhET team.

Kathy Perkins speaks with Phoenix TV.

https://ishare.ifeng.com/c/s/v006v07EFxXlpR2wpjHYM9rMkhw2CqEio75hPTEr3oPEWz5qia3lvL2ywKZiC3-Ajw?spss=np&channelId=
Letters | Hong Kong schools should integrate simulations into STEM teaching  8 December 2022

Simulations can improve students’ learning outcomes in STEM (science, technology, engineering, mathematics) subjects, helping them visualise abstract scientific concepts and processes. Founded by Professor Carl Wieman, a Nobel Prize and Yidan Prize laureate, the PhET Interactive Simulations project offers simulations on a range of science topics to the global STEM education community free of charge through Creative Commons Licences.

Supported by the Hong Kong-based Yidan Prize Foundation, the PhET team is expanding simulation content and access and offers professional development programmes for teachers.

The Education Bureau should issue clear guidelines for local schoolteachers to use PhET simulations in the classroom and provide more training for teachers to join the PhET team to further develop PhET learning materials. The pedagogical benefits of computer simulations have been acknowledged in the bureau’s curriculum guidelines on science subjects, which include a reference to simulations in connection with self-directed learning.

However, research indicates that students can benefit from simulations more effectively under a teacher’s guidance. In response to my inquiries, the bureau says various learning and teaching resources, including scientific investigations, practical work, design-and-make activities and self-directed learning activities, have been developed for teachers’ reference. Yet, the use of simulations in local schools was not reviewed in the Inspection Annual Reports, suggesting a lack of data about how teachers actually use simulation tools.

Not only should the bureau monitor more closely how teachers follow its guidelines in using state-of-the-art e-learning technology, including simulation, but it should also encourage more teachers to develop course material based on simulations. Since the PhET team welcomes teachers developing and sharing activities by following its approach to guided inquiry, the bureau should invite more teachers to contribute simulation-based activities to the PhET website as well as the EDGyft platform. The Committee on Professional Development of Teachers and Principals should offer courses for both pre-service and in-service schoolteachers on adopting simulation tools in STEM classroom teaching.

Oiji Wang, Kowloon Tong

https://www.scmp.com/comment/letters/article/3202361/hong-kong-schools-should-integrate-simulations-stem-teaching

South China Morning Post

Train Hong Kong's teachers to teach science transformatively

I refer to the letter, “Hong Kong schools should integrate simulations into STEM teaching” (December 8). 22 December 2022

I am currently teaching at an international school in Hong Kong. Scientific thinking skills are 21st-century skills every student should possess and teachers should be trained to teach these skills to Hong Kong students.

Throughout their careers, our students will face intellectual and technical challenges that will call upon their ability to think creatively and propose innovative solutions to scientific problems. Local school administrators should be considering how they can equip students with these essential skills.

In developing reasoning skills among the local student population, we need to make them think like scientists. Unfortunately, there exists a massive gap between what our scientists are doing and what our students are doing. Our scientists are creating, but our students are consuming. Our scientists are discovering, but our students are verifying. Our scientists are reasoning, but our students are recalling.

PhET Interactive Simulations can transform how we teach science to young minds. Using these simulations, teachers can teach all the concepts and science process skills (asking questions, predicting results, making hypotheses, and so on) mentioned in the Key Learning Area Curriculum Guide for science education prepared by the Curriculum Development Council.

In Hong Kong, there is a need for professional development in this regard. Using simulations to teach is a pedagogy in itself, and the Education Bureau could organise professional development sessions for teachers to learn this pedagogy.

There are thousands of these simulations available, but schools could also train teachers to develop lessons based on the learning needs of specific schools.

Having worked in the field of education and with these simulations for a long time, I am willing to offer my expertise regarding this pedagogy free of cost to local schools.

The simulations are free, and teachers can easily use their laptops, tablets and computers to engage students in the inquiry process, thus helping them develop much-needed skills and preparing them for the 21st century. I envisage Hong Kong school graduates with these skills. It would be great to have students acquiring all these skills by using these simulations.

Ravi Lall, Ma On Shan

Professional development of STEM teachers should be approached systemically

In a recent letter, “Hong Kong schools should integrate simulations into STEM teaching” (December 8), your correspondent urged the Education Bureau to explore how to better support STEM teachers with free digital resources.

As a former schoolteacher myself, I have observed how simulations not only help students grasp concepts more easily, but start to shift classroom instruction towards student-centred, active learning. Such approaches nurture interest and curiosity, develop scientific and critical thinking skills, and foster student ownership of learning.

However, simulations are most effective when intentionally paired with student-centred, active learning strategies. The adoption of such strategies in maths and science classes may be new for some teachers and learners. At times, it can feel impossible to teach all of the content expected in annual exams in ways that make room for student exploration.

As a result, support for teacher professional development to practise these skills is essential. It also aligns with the chief executive’s 2022 Policy Address, which says: “At least 75 per cent of the publicly-funded primary and secondary schools should arrange their teachers to undergo professional training on STEM within two school years.”

I would encourage educational leaders across Hong Kong to consider establishing systemic approaches to meet the discipline-specific professional development needs of STEM teachers. Teaching and learning maths and science is a challenging task, but it can be made much easier when using vetted resources and evidence-based approaches.

Dr Rebecca Veyra, associate director of Global Initiatives, PhET Interactive Simulations, University of Colorado Boulder
Outreach
The PhET Global team also continues to increase the visibility of PhET resources and pedagogies.

Outreach
• USA
  • New Physics and Astronomy Workshop (35 new faculty)
  • American Association of Physics Teachers (48)
  • Broward International University (700+)

• Asia
  • Asian Development Bank summit

• Australia
  • International Conference on Physics Education (50)

• Azerbaijan
  • In process of signing an agreement with AGMA (Azerbaijan national teaching society) in collaboration with the Ministry of Education to engage translators and promote the Virtual Workshop.

• Uzbekistan
  • Currently engaged in conversations through the Asian Development Bank to provide professional development and translation support to the Ministry of Education.

DEIB in STEM Education
PhET selected two professional consulting agencies and 14 advisors to provide guidance on PhET’s Diversity, Equity, Inclusion, and Belonging (DEIB) in STEM Education Initiative. Additionally, PhET submitted a $1M grant proposal to the National Science Foundation to do research on the effect of PhET teacher professional development on sense of STEM belonging.


DEIB in STEM Education

PhET in STEM Education

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Face-to-Face Conferences
PhET continues to establish and deepen relationships by being present at in-person events.

Virtual Educa Colombia

Yidan Prize Summit Hong Kong

TeachUNITED Costa Rica

eLearning Africa Rwanda

ADEA Triennale Mauritius