



PLACES & SPACES

M A P P I N G S C I E N C E

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“Places & Spaces: Mapping Science” is a science exhibit that aims to demonstrate the power of maps to navigate and manage physical places and abstract spaces. This document provides a general introduction of the goals for this exhibit, along with a technical description of its contents.

1. Exhibit Goals

Humanity’s knowledge and our means to share it are increasing at an accelerating rate. Yet, our perceptual and cognitive abilities stay nearly constant. We are expected to know more works than we could possibly read and understand in a hundred lifetimes. As a consequence, experts become highly specialized and isolated. Science continues to fragment, to duplicate, and to re-invent itself.

Today, we use search engines to access all of humanity’s knowledge and expertise. Search engines retrieve facts from a growing sea of information. However, how big is this sea? How can we efficiently navigate to the useful islands of knowledge? How is knowledge interlinked on a global scale? In which areas is it worth investing resources? We don’t know.

This is not the first time mankind has faced this type of question. However, it is the first time that there is an opportunity to coordinate efforts across cultures and disciplines to provide answers.

Cartographic maps of physical places have guided mankind’s explorations for centuries. They enabled the discovery of new worlds, while also marking territories inhabited by unknown monsters. Without maps, we would be lost.

Domain maps of abstract semantic spaces (Börner et al 2003, Shiffrin & Börner 2004) aim to serve today’s explorers in navigating the world of science. These maps are generated through scientific analysis of large-scale, scholarly datasets in an effort to connect and make sense of the bits and pieces of knowledge they contain. They can be used to objectively identify major research areas, experts, institutions, collections, grants, papers, journals, and ideas in a domain of interest. Local maps provide overviews of a specific area: its homogeneity, import-export factors, and relative speed. They allow one to track the emergence, evolution, and disappearance of topics and help to identify the most promising areas of research.

The Places & Spaces exhibit has been created to demonstrate the power of maps. The exhibit has two components: the physical part supports the close inspection of high quality reproductions for display at conferences and education centers (see Figure 1). It is meant to inspire cross-disciplinary discussions on how to best track and communicate human activity and scientific progress on a global scale. The online counterpart at <http://scimaps.org> provides links to a selected series of maps and their authors/creators, along with explanations of why these maps work. It also has an exhibit schedule of physical showings, information on how to order maps, as well as information on the exhibit Advisory Board.

Figure 1: Exhibits



Exhibit at the Institute for Research Information and Quality Assurance, Bonn, Germany



Additional elements of the exhibit at the Monroe County Public Library, Bloomington, IN, USA



Exhibit at The National Science Library at the Chinese Academy of Sciences, Beijing, China



Science Express Train Exhibit, Germany

Places & Spaces was first shown at the **Annual Meeting of the Association of American Geographers in April 2005**. Since then, the physical exhibit has been displayed at more than 50 national and international venues including:

- The Institute for Research Information and Quality Assurance in Bonn, Germany (Dec. 20, 2008 – Present)
- Storm Hall, San Diego State University in San Diego, CA (Aug. 14, 2007 – Present)
- National Science Foundation in Washington, DC (Feb. 9, 2006 – Present)
- Marston Science Library at the University of Florida in Gainesville, FL (Jan. 15 – May 31, 2010)
- University of Alberta in Edmonton, Alberta, Canada (Nov. 10, 2008 – Feb. 26, 2009)
- Science Express Train (in more than 60 towns and cities across Germany) (April 24 – Nov. 24, 2009)
- Stanford University in Stanford, CA (April 15 – Dec. 18, 2009)
- The National Science Library of the Chinese Academy of Sciences in Wuhan, Chengdu, Lanzhou and Beijing, China (July 17 – Nov. 15, 2008)
- National Research Council in Ottawa, Canada (April 3 – June 27, 2008)
- American Museum of Science and Energy in Oak Ridge, TN (Sept. 7, 2007 – Jan. 7, 2008)
- 233rd American Chemical Society (ACS) National Meeting & Exposition in Chicago, IL (March 25 – 28, 2007)
- New York Hall of Science in Queens, NY (Dec. 9, 2006 – Feb. 25, 2007)
- Science, Industry and Business Library of The New York Public Library in New York, NY (April 3 – Aug. 30, 2006)
- The National Center for Supercomputing Applications (NCSA) in Urbana-Champaign, IL (Nov. 3 – 5, 2005)
- ESRI International User Conference in San Diego, CA (July 25 – 29, 2005)

The complete schedule and images of the different exhibits are available at <http://scimaps.org/flat/exhibitions>.

Visitors of the exhibit are surprised to see their own field of research from a new perspective. They are interested in learning more about the data and techniques that went into creating these maps, and their comments on the different metaphors that might be used to map the structure and evolution of science are invaluable for the design of more efficient visualizations.

2. 10 Iterations in 10 Years

The Places & Spaces: Mapping Science exhibit is envisioned as a 10-year exhibit. Each year, 10 new maps are added—resulting in 100 maps total by 2014.

The First Iteration: *The Power of Maps*

This exhibit compares and contrasts the first maps of our entire planet using the first maps of science as we know it (see Figure 2 below). Both types of maps were/are not perfectly correct. As for the maps of science, we know that we don't yet have the data to map science completely and accurately. However, maps do help people orient and navigate physical places and semantic spaces.

Figure 2: *The Power of Maps*



The Second Iteration: *The Power of Reference Systems*

This exhibit aims to inspire discussion about a common reference system for all of mankind’s scientific knowledge. Scientists in many disciplines battled to agree on standardized reference systems, such as the electromagnetic spectrum, the periodic table of elements, geographic mappings, and the celestial reference systems (shown in Figure 3 below). These standardized systems are invaluable for indexing, storing, accessing, and managing scientific data efficiently. Note that each of the six potential reference systems - from the one-dimensional time-based system, to the geospatial system, to the semantic system - could be used potentially to identify the “location” of an author, paper, patent or grant, or to show the dynamics of an author’s trajectory or contribution, as well as the impact of a particular work. All reference systems need to be learned. However, once they are learned, they may be used as a ‘base map,’ or common reference point, over which information may be laid.

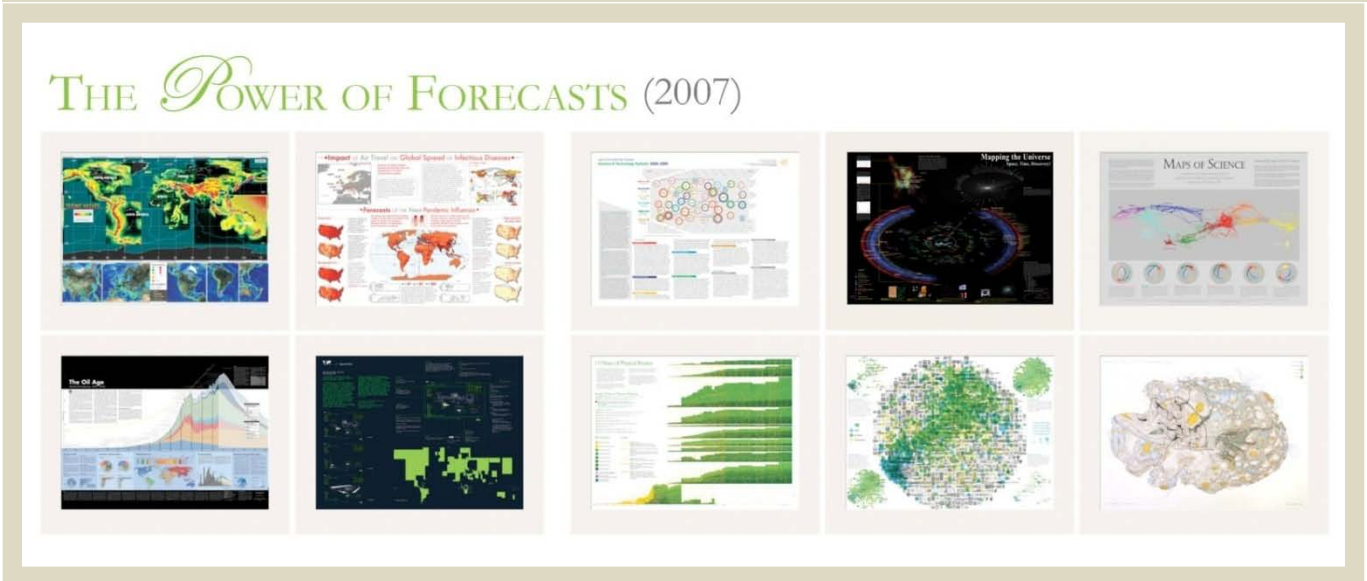
Figure 3: *The Power of Reference Systems*



The Third Iteration: *The Power of Forecasts*

This exhibit explores the idea of forecasting science. The inspiration for this series of maps is the development of weather forecasting maps. Just as it is possible to map past trends in weather and use those trends to predict future weather patterns, we believe it will eventually be possible to map future trends in scientific research (see Figure 4 below).

Figure 4: *The Power of Forecasts*

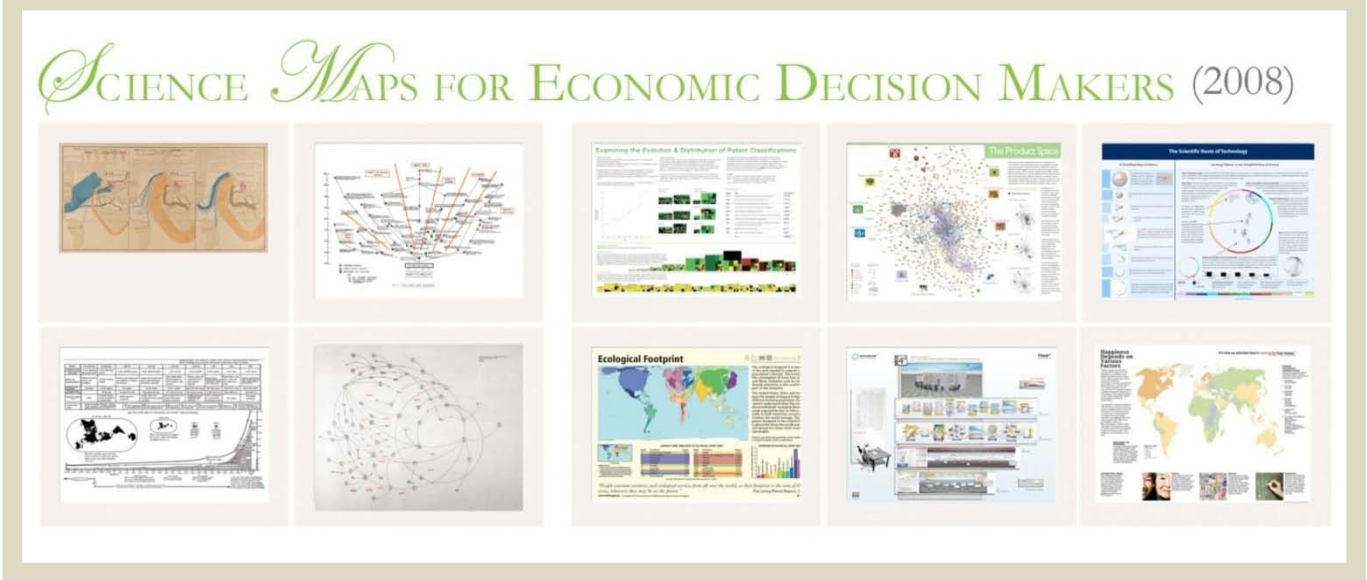


The Fourth Iteration: *Science Maps for Economic Decision Makers*

This is the first of six iterations that explore the utility of science maps for different stakeholders. The maps presented in this iteration target the needs of economic decision makers (see Figure 5 below).

These maps aim to answer questions such as: What is the impact of war on global trade flows? How do accelerating communication and transportation speeds impact our lives? What events and time lags occur from basic research to product sale? What are the (social) networks behind illicit deals and laundered money? What intellectual property space is claimed by whom; and what growth is expected? What is the ecological footprint of a country and how sustainable is it? How does the 'Product Space' determine the economic development of nations? How to visually empower strategy formation and value creation in organizations? How are publications linked to patents in different areas of science? What factors impact the happiness of citizens and which countries do well?

Figure 5: *Science Maps for Economic Decision Makers*



The Fifth Iteration: *Science Maps for Science Policy Makers*

This iteration shows science maps for science policy makers as well as citizens interested in understanding national priorities, spending, and achievements. Featured are two early maps, two maps of observation and sensor data, and six maps of scholarly data (see Figure 6 below).

Figure 6: *Science Maps for Economic Decision Makers*



The Sixth Iteration: *Science Maps for Scholars*

This is the third of six iterations that explore the utility of science maps for different stakeholders. The maps presented here target the needs of scholars (See Figure 7 below).

Figure 7: *Science Maps for Scholars*



Four more iterations are planned each year until 2014

- Science Maps as Visual Interfaces to Digital Libraries (2011)
- Science Maps for Kids (2012)
- Science Forecasts (2013)
- How to Lie with Science Maps (2014)

Additional Elements

The exhibit also features three **WorldProcessor Globes**: 1) *Foreign US Patent Holders* (#294); 2) *Patterns of Patents & Zones of Invention* (#286); and 3) *Shape of Science* (all shown in Figure 8 below), in addition to an **Illuminated Diagram** display (see Figure 9 on page 7), and **Hands-On Science Maps for Kids** (see Figure 10 on page 7).

Figure 8: *WorldProcessor Globes*



Illuminated Diagrams (ID) add the flexibility of an interactive program to the incredibly high data density of a print. This technique is generally useful when there is too much pertinent data to be displayed on a screen but the data is relatively stable. The computer can direct the eye to what's important by using projectors as smart spotlights, animating stories in the static data (such as the spread of an idea's influence), giving a radar-like "grand tour" of science, or highlighting query results (as when you touch the lectern) with an overlay of moving light. The ID lets visitors select major inventors and scientists and indicates their physical location on a map of our planet and their scientific contributions on a map of all of science. See video of the ID at: http://scimaps.org/flat/exhibit_info/video.

Figure 9: Illuminated Diagrams & Touch Screen Lectern



Hands-On Science Maps for Kids

Hands-On Science Maps for Kids were created by Fileve Palmer (painting), Julie Smith (data acquisition), Elisha Hardy and Katy Börner (graphic design). We would like to thank Stephen Miles Uzzo, Director of Technology and Michael Lane, Director of Exhibit Services at the New York Hall of Science for manufacturing the physical maps.

Figure 10: Hands-on Science Maps for Kids



Of the *Hands-on Science Maps for Kids*, one shows our world and the places where science gets done. The other shows major areas of science and their complex interrelationships. The maps invite children to see, explore, and understand science from a new perspective. Both maps also appear in the *Illuminated Diagram* display. Drawings by Fileve Palmer were added to make different continents as well as different areas of science more tangible (see Figure 10: *Hands-on Science Maps for Kids* in the Appendix on page 12).

Children and adults alike are invited to help solve the puzzle by sliding major scientists, inventors, and inventions into their proper places. Start by selecting either of the two maps. Decide if you want to place famous people or major inventions first. Turn the map over when you are done and start again. Look for the many hints hidden in the drawings to find the perfect place for each puzzle piece. Pick-up one of the handouts and make your very own map of science. What science experiments do you like best? Where would your favorite science teachers go? What area of science do you want to explore next?

More information about *Hands-on Science Maps for Kids* is available at <http://scimaps.org/kids>, including maps, puzzle keys, detailed information about inventors, and a coloring book.

Video & Enhanced Podcast

A video of the New York Public Library (NYPL) exhibit was recorded that features a walk-through of the exhibit, as well as interviews with major map makers. The video comes with the exhibit and is available for sale at: http://scimaps.org/flat/exhibit_info/video.

An enhanced podcast of the exhibit is linked from <http://scimaps.org/flat/host> (select "Audio-Visual Tour" from the left-hand menu). It is meant to provide a guided tour of the NYPL exhibit.

3. Physical Exhibit

The physical exhibit is comprised of an introductory panel, high-resolution maps (60 maps in 2010, 70 maps in 2011), three *WorldProcessor Globes*, *Illuminated Diagrams*, and two *Hands-on Science Maps for Kids*. The exhibit is shipped in seven specially made crates (see Appendix).

4. Web Site

The Places & Spaces website can be found at <http://scimaps.org>. It provides information on the maps and their authors/creators, compares and contrasts maps, lists upcoming venues, and provides information about the Places & Spaces advisory board. Additionally, a customized web site is created for each specific venue (e.g. Stanford site at: <http://scimaps.org/flat/exhibitions/stanford>).

5. Reading List

A list of related scholarly works is available at <http://scimaps.org/flat/references>.

A book of the first three iterations of the exhibit, entitled *Atlas of Science: Guiding the Navigation and Management of Scholarly Knowledge*, was published by ESRI in 2010. More information is available at <http://scimaps.org/atlas>.



6. Local Organization

Depending on the exhibit space, some or all of the items listed below should be considered in conjunction with the exhibit:

- Opening reception
- Speaker series
- Press releases (see NYPL release at <http://www.nypl.org/research/calendar/exhib/sibl/siblexhibdesc.cfm?id=421>)
- Advertising posters or banners
- Work station to access exhibit Web site
- Related books on display or for sale in near-by book stores (see reading list)
- Television with DVD player to play the exhibit video

7. Contact Information

If you are interested in hosting the exhibit or if you would like to receive more information, please contact the curators of the exhibit:



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We will be happy to work with you on an installation for your visitors and their information needs.

8. Exhibit Advisory Board Members



Kevin Boyack, Chief Technical Officer at Scitech Strategies (Maps of Science)



Peter A. Hook, Doctoral Student at Indiana University, Bloomington and Librarian at the Maurer School of Law at Indiana University



Chaomei Chen, Associate Professor at the College of Information Science and Technology at Drexel University and Visiting Professor in the School of Information Systems, Computing and Mathematics at Brunel University



Deborah MacPherson, Director for the 501(c)(3) nonprofit organization, Accuracy & Aesthetics in Vienna, VA



Bonnie DeVarco, Senior Researcher for the NSF funded, Interactive Earth 2 Project, led by WorldLink Media, TERC, NASA Goddard, and the World Resources Institute (WRI)



André Skupin, Assistant Professor of Geography at San Diego State University



Sara Irina Fabrikant, Associate Professor of Geography and Head of the Geographic Information Visualization and Analysis (GIVA) group at the University of Zurich, Switzerland and Programme Committee member of GIScience 2010



Michael J. Stamper, Senior Graphic Designer, Cyberinfrastructure for Network Science Center

Further information about individual advisory board members can be found on the Places & Spaces Web site at: http://www.scimaps.org/flat/advisory_board.

9. References

Börner, Katy. 2010. *Atlas of Science: Visualizing What We Know*. Cambridge, MA: The MIT Press.

Börner K., Chen C., Boyack K. 2003. Visualizing Knowledge Domains. In *Annual Review of Information Science & Technology*, ed. B Cronin, pp. 179-255. Medford, NJ: Information Today, Inc./American Society for Information Science and Technology.

Paley W. B. 2002. *Illuminated Diagrams: Using Light and Print to Comparative Advantage*. Presented at IEEE Information Visualization.

Shiffrin R. M., Börner K., eds. 2004. *Mapping Knowledge Domains*, Vol. 101 (Suppl. 1): PNAS.

Appendix: Technical Specifications

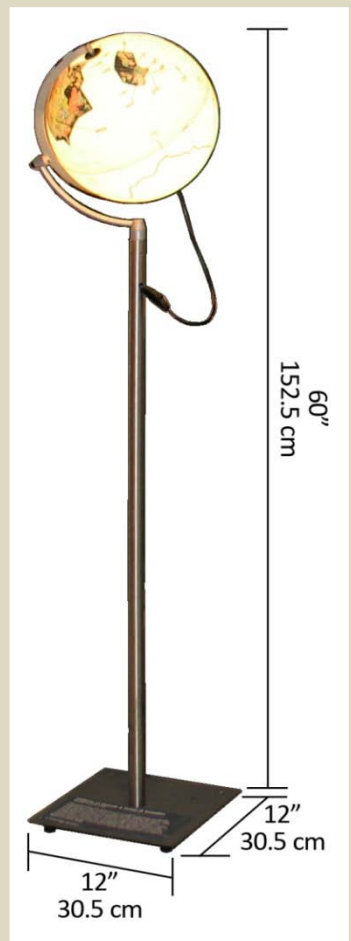
Museum quality maps are printed on premium luster paper in a size of 30 inches (76.2 cm) x 24 inches (60.96 cm) and mounted on foam core (see Figure 11 for a typical layout of a set of 10 maps). Maps can be ordered online at <http://scimaps.org/flat/store>.

The *WorldProcessor Globes* have a diameter of 12 inches (30.48 cm) and a height of 5 feet (1.53 m). This invites the ‘spinning’ of the globes by visitors (see Figure 12 below).

The *Illuminated Diagrams (ID)* are comprised of two high-resolution prints on cling paper that is then attached to two LCD screens (see Figure 9 on page 7). **The LCD screens must be rented on-site**, and cling prints must be attached. A touch screen lectern allows a user to interact with the LCDs (see Figure 13 on the next page). The LCDs and lectern are run by 3 Mac Minis (provided by us).

The *Hands-on Science Maps for Kids* should be displayed on a table. They are 18 inches (45.72 cm) tall, 12 inches (30.48 cm) deep and about 33 inches (83.82 cm) wide (see Figure 14 on the next page).

Figure 12: Standing Globes



The exhibit is complete with an **introductory panel** that typically needs to be recreated for each venue, as it also lists the changing set of (local) sponsors. Plus, there are **didactic panels** (one per iteration) and **labels** for all elements of the exhibit. Map panels and labels are mounted on foam core. If needed, we can adapt the map labels to your venue (at an extra cost).

Figure 11: Typical Layout of 10 Maps

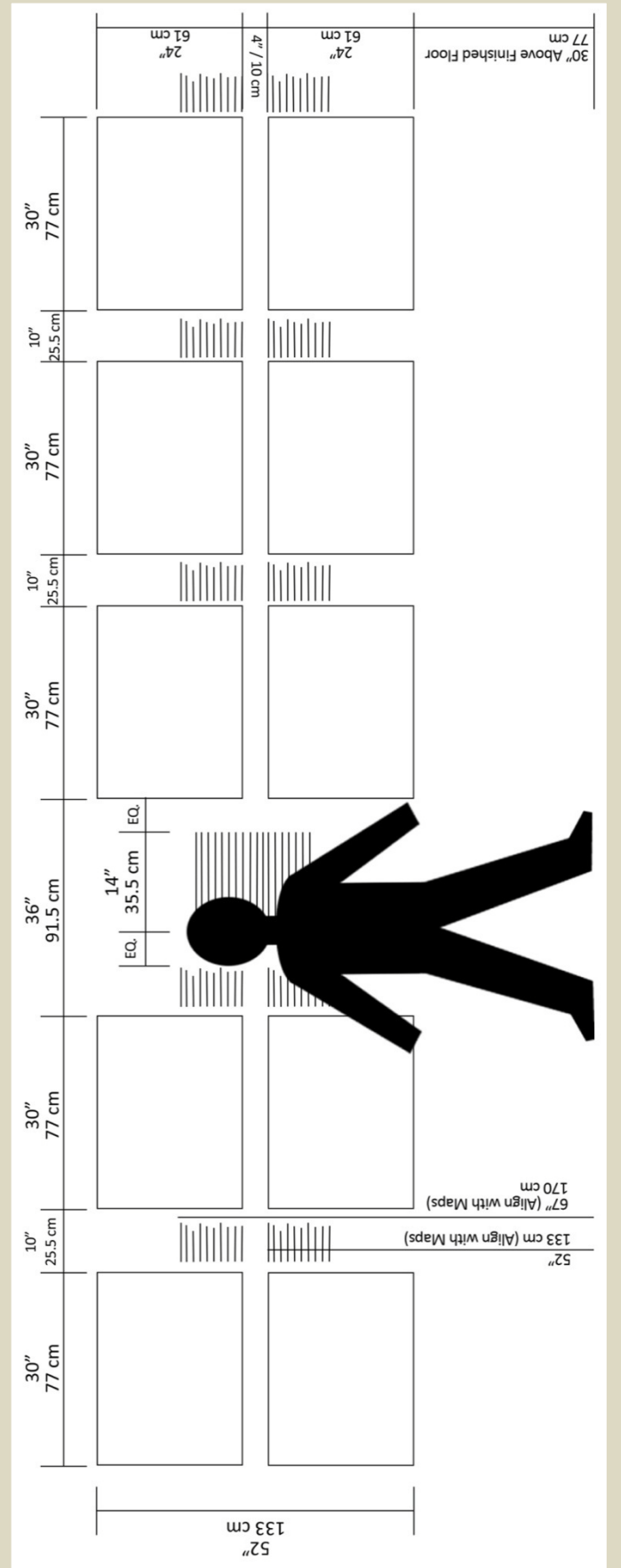
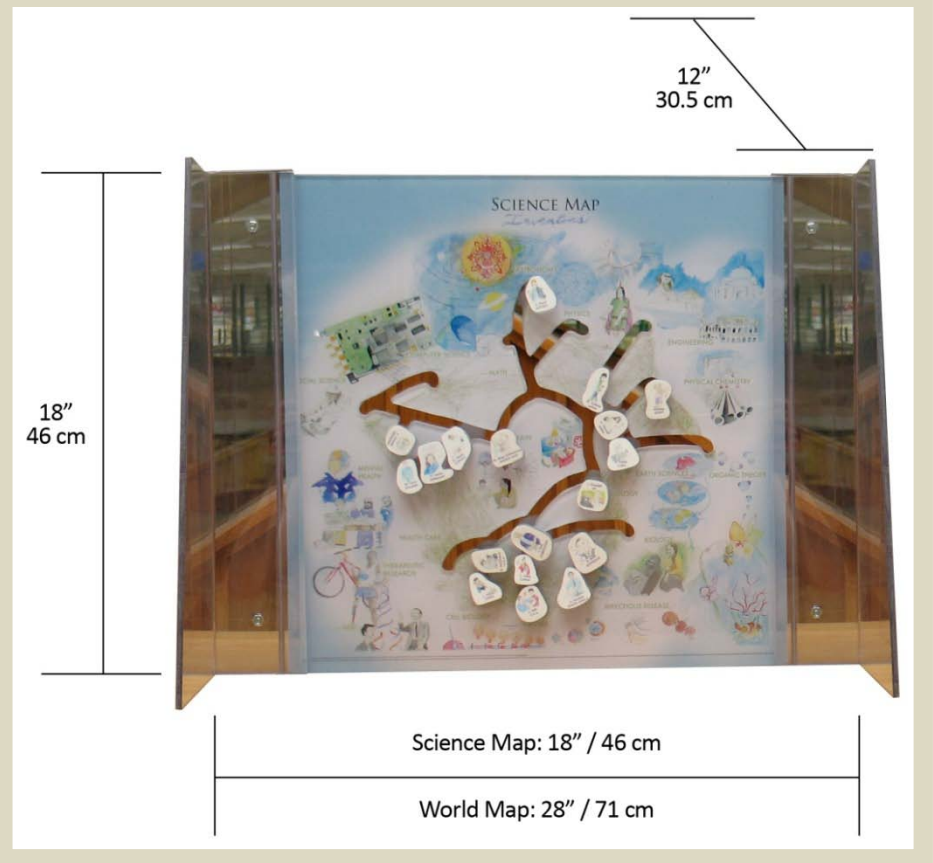


Figure 13: Freestanding Touch Screen Lectern for the *Illuminated Diagrams*



Figure 14: *Hands-on Science Maps for Kids*



Appendix: Unpacking & Set-up



Crate #1

Dimensions: 50" x 44" x 42" (127cm x 112cm x 107cm)

Weight: 310 Lbs (141 kg)

Contents:

- 1 Touch panel podium
- 2 Children's Maps
- 24 Map Labels
- 22 Hanging cleats for Maps



Crate #2

Dimensions: 72" x 36" x 30" (183cm x 91cm x 76cm)

Weight: 280 Lbs (127 kg)

Contents:

- 20 Maps
- 4 Map Labels



Crates #3, 4, 5 and 6 (identical)

Dimensions: 45 3/8" x 35" x 34 1/4"

Weight: 82 lbs (38 kg) each

Contents:

- 10 Maps
- 10 Labels
- 10 Cleats

Globe Crate

Dimensions: 24" x 23" x 39" (61cm x 58.5cm x 200cm)

Weight: 60 Lbs (27 kg)

Contents:

- 3 *WorldProcessor Globes*
- 3 Globe Labels
- 3 Tripods and weights

Crate #7

Dimensions: 45 3/8" x 35" x 34 1/4"

Weight: 120 lbs (54 kg)

Contents:

- 10 Maps
- 10 Labels
- 10 Cleats
- 3 Mac Minis

Approximate Total Crate Weight: 1391 lbs (631 kg)

It is strongly suggested that when considering the full-physical version of the exhibit that shipping logistics are taken into account, such as loading dock locations, the heights of loading/unloading platforms (this will determine the need for a truck equipped with ramps, or an adjustable liftgate), and suitable storage areas for crates.

Needed Materials for Exhibit Set-up

- Hammer (depending upon wall material)
- Velcro (depending upon wall material)
- Cordless drill
- Tape measure
- Level (laser if possible)
- Screws or nails
- Wall mount blocks

Itemized List of Exhibit Contents

- 1 Introduction Panel
- 60 Wall Mounted Maps (70 after September 2011)
- 6 Compare and Contrast Panels
- 3 *WorldProcessor Globes*
- 2 *Hands-on Science Maps for Kids*
- 2 *Illuminated Display Maps*
- 3 Mac Minis
- 1 Customized Lectern (with touch screen)
- 67 Map Labels
- 1 Video (DVD)
- 1 Guest Book

List of Insurable Items

Total Cost of Insurable Items: \$38,939

1.) Insurable components of the 60 maps: \$14,714

Item	Cost Per Item	Number of Items	Total Cost
Maps	\$200	60	\$12,000
Introduction Panel	\$300	1	\$300
Compare & Contrast Panel	\$150	6	\$900
Map Label	\$25	60	\$1,500
Exhibit Video (DVD)	\$14	1	\$14

2.) Insurable components of *WorldProcessor Globes* by contributing artist Ingo Günther: \$15,075

Item	Cost Per Item	Number of Items	Total Cost
WorldProcessor Globe	\$5,000	3	\$15,000
Globe Label	\$25	3	\$75

3.) Insurable components of *Illuminated Diagram* displays by contributing artist W. Bradford Paley: \$5,100

Item	Cost Per Item	Number of Items	Total Cost
ID Map on Cling Paper	\$100	2	\$200
ID Map Label	\$25	2	\$500
Mac Mini	\$800	3	\$2,400
Customized Lectern with Touch Screen	Replacement value approx. \$1,500	1	\$1,500
Embedded Viewsonic VP201b monitor, s/n: A21034301217			
Embedded MicroTouch touch screen, s/n: 587449			
Miscellaneous Cables	Replacement value approx. \$500		\$500

4.) Insurable components of the *Hands-on Science Maps for Kids*: \$4,050

Item	Cost Per Item	Number of Items	Total Cost
Map	\$2,000	2	\$4,000
Map Label	\$25	2	\$50