Use of TinkerPlots and Fathom in Math and Science Education—Concept and Curriculum

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Education

M.A. Physics, University of California Berkeley
B.A. Physics, Swarthmore College

Experience

2007--2008. Course developer for Teaching Statistics with Fathom, an online course offered by Key Curriculum Press with graduate credit through UC Berkeley Extension 2007.
2006--2009. Member of AIMS advisory board, University of Minnesota.
2005--2009. Consultant to the Model Chance project, University of Massachusetts, Amherst.
2002--2005. Consultant to Connecting Science and Mathematics Through Data, Epistemological Engineering.
2001--2004. Consultant to Visualizing Statistical Relationships, TERC, a leading education research and development organization.

Selected Publications

Finzer, Erickson, Swenson, & Litwin (2007). On Getting More and Better Data Into the Classroom. Technology Innovations in Statistics Education, 1(1)
Finzer W. (2006) What does dragging this do? The role of dynamically changing data and parameters in building a foundation for statistical understanding, in Proceedings of the Seventh International Conference on Teaching Statistics, Voorburg: International Statistics Institute.
Finzer W. (2006) Fathom Dynamic Data Software, Key Curriculum Press
Finzer, W., Schwartz, S., & Dever, H. (2005). Data Are Everywhere. Emeryville, CA: Key Curriculum Press.
Finzer W, Erickson TE. (2004) Curriculum Innovations Based on Census Microdata: A Meeting of Statistics, Mathematics, and Social Science, in Proceedings of the International Association for Statistical Education (IASE) Roundtable on "Curricular Development in Statistics Education", International Statistical Institute.
Finzer, William. “The Fathom Experience Is Research-Based Development of a Commercial Statistics Learning Environment Possible?” Proceedings of the International Conference on Teachings Statistics, (South Africa: 2002)
Finzer, William, et al. A Workshop Guide for Fathom. Emeryville, California: Key Curriculum Press, 2000
Finzer, William and Tim Erickson. “DataSpace A Computer Learning

Environment for Data Analysis and Statistics Based on Dynamic Dragging, Visualization, Simulation, and Networked Collaboration." Proceedings of the Fifth International Conference on Teaching of Statistics, Vol. 2 (Voorburg, Netherlands: International Statistical Institute, 1998).

Finzer, William and Nicholas Jackiw. "The Geometer's Sketchpad: Programming by Geometry," Watch What I Do: Programming by Demonstration. Cambridge: MIT Press, 1993.

Finzer, William and Dan Bennett. "From Drawing to Construction with The Geometer's Sketchpad." The Mathematics Teacher, Vol. 88(5) (1995) 428　431

Finzer, William, et al. "Sampling." Journal of Mathematical Behavior, Vol. 6(2), (1987), 149-156.

Finzer, William and Diane Resek.Strategy (Mirrors on the Mind). Boston: Addison　Wesley, 1986.

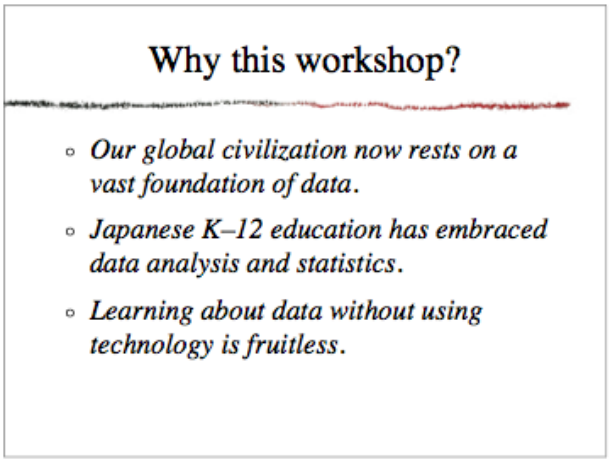
Finzer, William and Laura Gould. "Programming by Rehearsal." Byte, Vol. 9(6) (June 1984) 187-210.

This was a workshop presented at a meeting room of Bennesse Corporation on September 12, 2009. In attendance were statistics professors, high school teachers, curriculum developers, education researchers, and publishers. The purpose of the workshop was to acquaint those present with TinkerPlots and Fathom software and to discuss the integration of technology into statistics education.

photo

William Finzer, the workshop presenter leads the software development team for Fathom Dynamic Statistics Software at KCP Technologies. He is a close collaborator with Cliff Konold, the developer of TinkerPlots Dynamic Data Exploration Software.

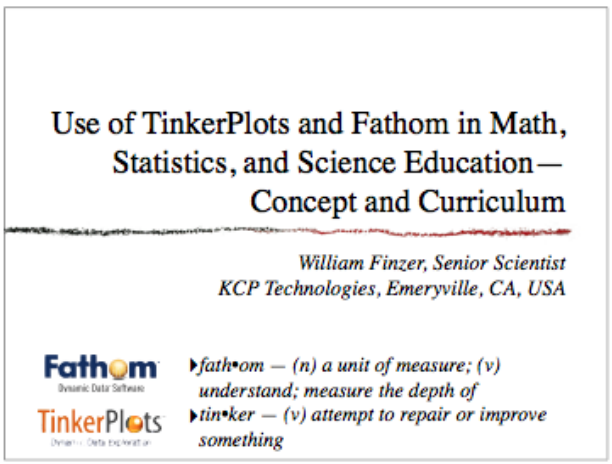
This is a critical period of time for society's dependence on data, the need for statistics education in Japan because of data analytic fluency among the populace, and because the Japanese ministry of education has mandated that data analysis and statistics be a part of K–12 education. Figuring out how to integrate use of technology is essential.



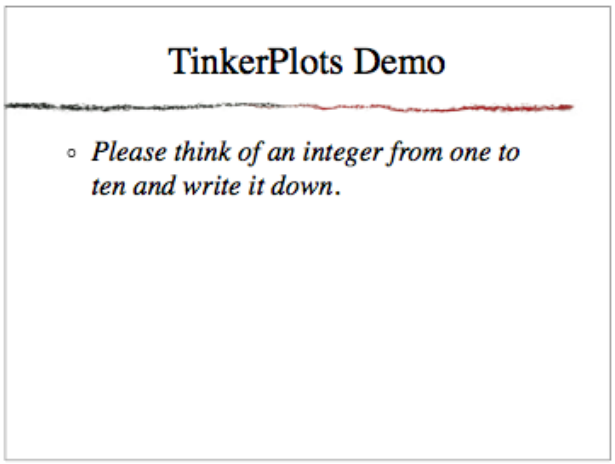
slide 2

In TinkerPlots the cases in a collection of data are directly manipulable in a plot. By using primitive operations—select, separate, stack, sort, and fuse, a great variety of data representations can be built by the learner. The learner can focus on data exploration first and forms of representation second.

Both TinkerPlots and Fathom can import

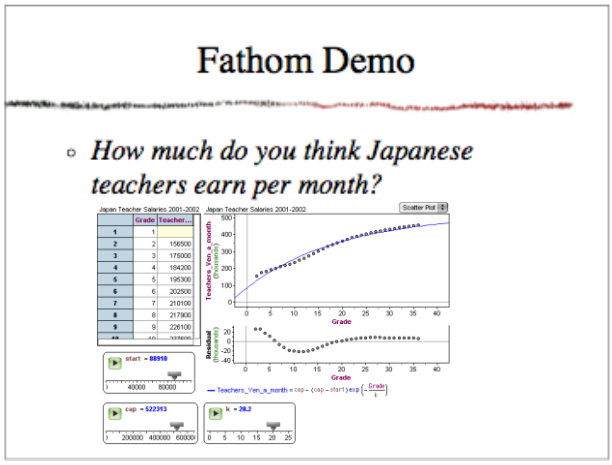


slide 1



slide 3

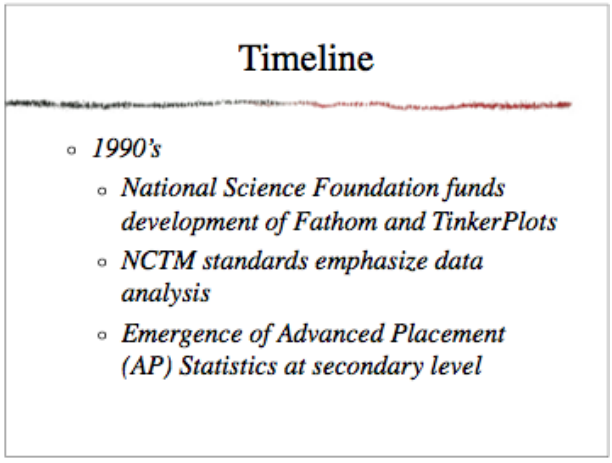
data directly from a Web page. slide 4 shows the data of teachers' earnings in Yen per month at salary grade levels from 1 to 36. A scatter plot suggests a functional relationship, perhaps an exponential curve with three parameters, modeled by sliders.



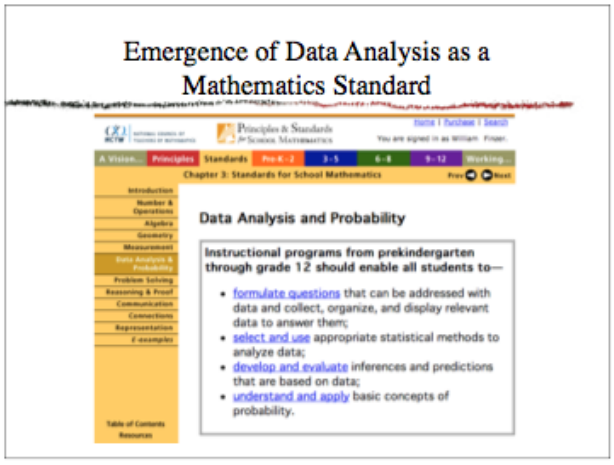
slide 4

Fathom and TinkerPlots development has been partially funded by the US National Science Foundation. Emphasis on data analysis in the US has increased dramatically in the last 20 years, and courses such as AP Statistics, taught at the secondary level, have placed the importance of data education squarely in front of mathematics educators.

Shown in slide 6 is a high level summary of the data analysis and probability standard from the NCTM. The shift in terminology from "statistics" to "data analysis" indicates recognition that there is much more to working with data than statistics and that the majority of people will need to analyze data, not just statisticians.



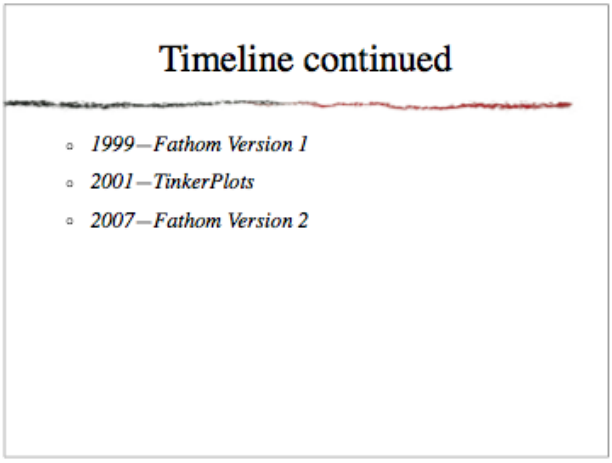
slide 5



slide 6

Fathom and TinkerPlots share a common framework developed at KCP Technologies. As a result there are many interface elements in common and improvements to the framework improve both pieces of software. TinkerPlots Version 2 will be released in the next year.

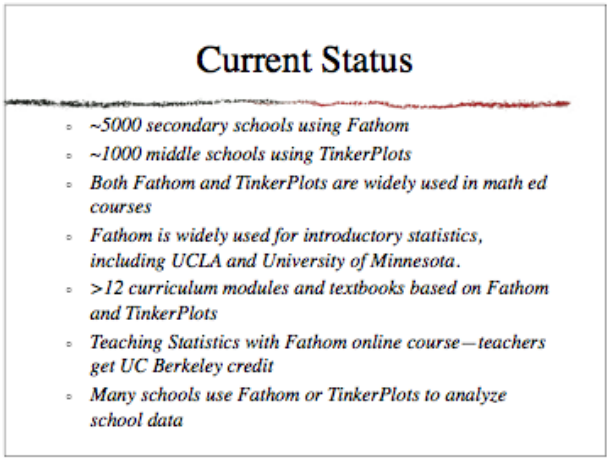
As shown in slides 5 and 7, with increased emphasis on data analysis and statistics by both the NCTM and National Science Foundation, plus the emergence of the AP Statistics course, Fathom was well



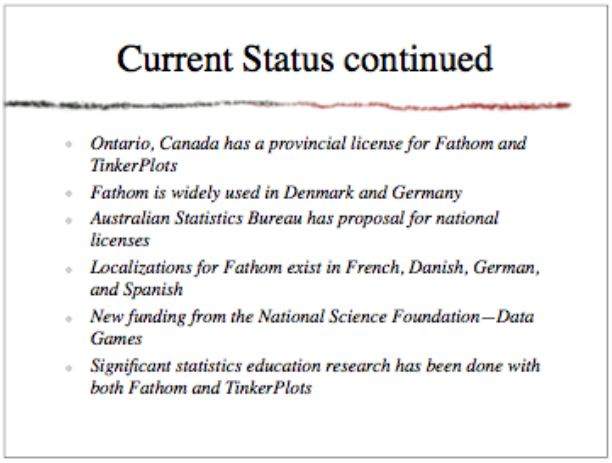
slide 7

positioned for the needs of secondary schools when published in 1999.

In the slide 8 and the slide 9, who are using the software we developed.

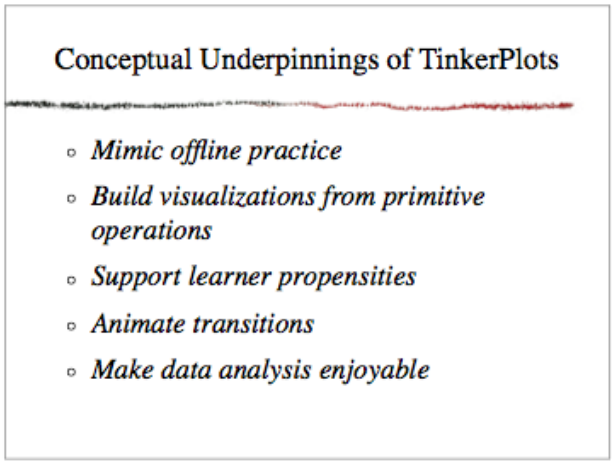


slide 8



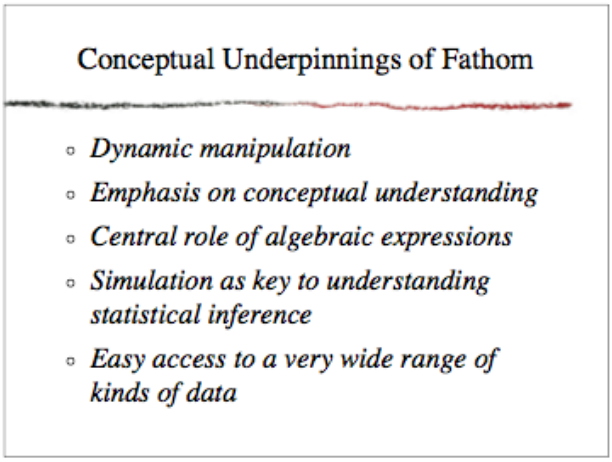
slide 9

TinkerPlots is designed for students in grades 5 through 8, aiming to build fluency with data representation and exploration. The use of animation, color, and dynamic manipulation support the learner in moving from simple representations to increasingly complex and analytic graphs.



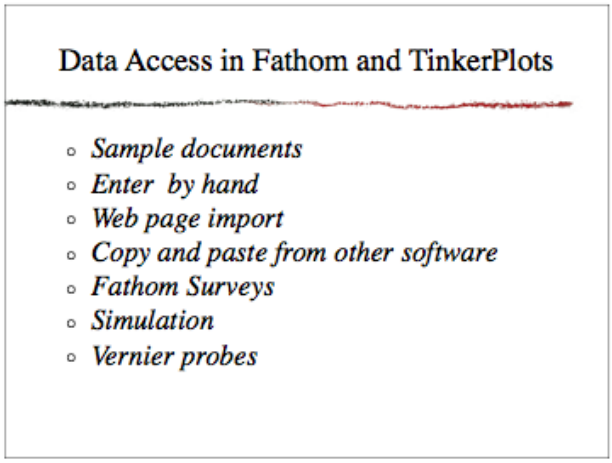
slide 10

Fathom is designed for students in grades 8 through 14. It provides a data exploration and analysis environment that facilitates use of data across the mathematics curriculum (especially statistics). Sampling and collecting measures are simulation capabilities that make it possible to build sophisticated simulations.



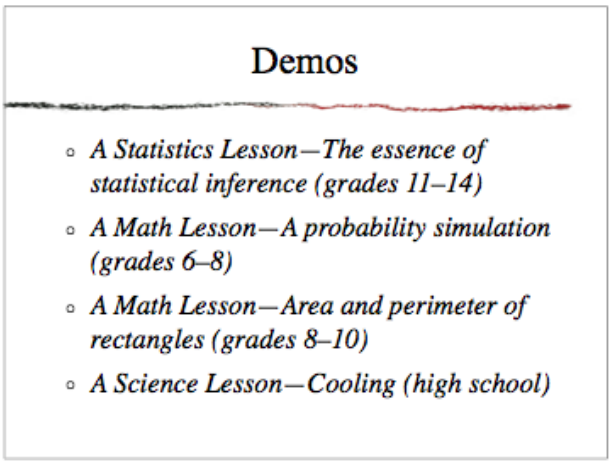
slide 11

There are many ways to get data into the two applications with a minimum of need for time consuming data cleaning. For example, Fathom Surveys allows creation of an online survey from within Fathom. Pushing a button brings the latest results into Fathom, adding new responses to whatever analysis the user has begun.



slide 12

At this point in the workshop we had time for one of the demos listed on the slide 13. Here we briefly explain the probability simulation.



slide 13

Suppose we want to simulate throwing two dice repeatedly and building up a frequency distribution of the sums.
With a collection of the six possible outcomes of rolling a die, we sample two with replacement.

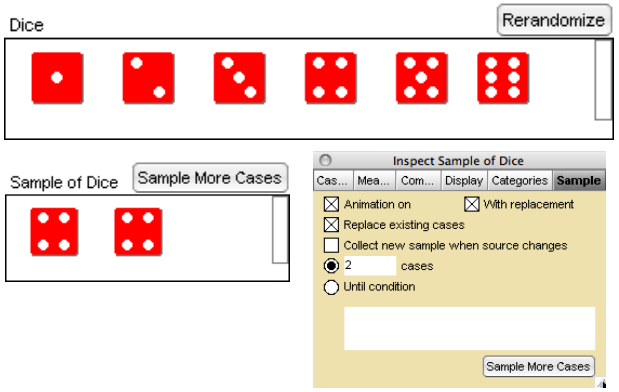


figure 1

In the sample collection we define a measure with a formula that computes the sum of the dice. Then we tell Fathom to collect these measures repeatedly, say 100 times. The result is a new collection consisting of these collected measures. A dot plot shows their frequency distribution as you see in slide 2.

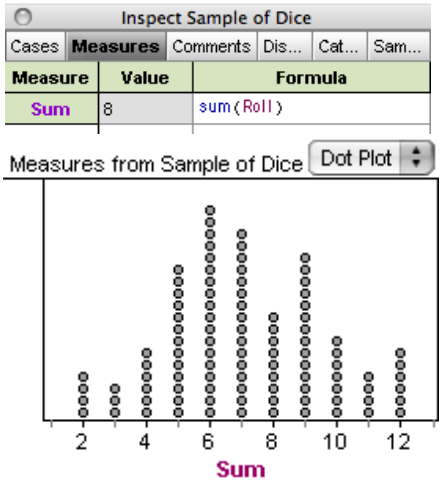


figure 2

The remainder of the workshop was devoted to discussion about statistics education in Japan, the present situation and the future.
High school teachers argued, “Without changes in the entrance exam to university we will not have any motivation to teach hands-on data analysis in mathematics class. Instead, we will continue to focus on preparing students for the exam, even though we and our students acknowledge

the importance of data analysis." Another teacher pointed out, "Mathematics teachers are not necessarily good at teaching statistics because, compared with traditional mathematics, there is frequently no right or wrong answer. Even the definitions of some statistics terms are not clear. We would like to learn how to teach statistics by attending seminars set up by statistics researchers."

Thoughts from William Finzer included the following: Though the mathematics classroom is a good place to start integration of data analysis into learning, in the longer term, data analysis will become a tool used by teachers and students of science and social science as well.

Mathematics teachers involved in teaching statistics would do well to form a community to support each other and new teachers coming into this area. The online community of U.S. statistics teachers teaching AP Statistics could be a model of this kind of community.

Data analysis and statistics are so dependent on technology for their real-world practice that it doesn't make sense to attempt their teaching and learning without appropriate technology. The years of research and development invested in Fathom and TinkerPlots make them worthy of consideration for adoption in Japanese education.

Bringing about increased emphasis on data analysis and statistics in pre-college classrooms is especially challenging because it must be approached on such broad and diverse fronts. Preparing teachers to teach with data, introducing ways of teaching with technology that involve students deeply with data, changing the national exam to include data analysis, and integrating data analysis into the curriculum materials are just a few of the tasks that lie ahead of educators and policy makers. It is heartening to encounter dedicated and talented people such as those attending this workshop who can take form a nucleus of people working for change in this vitally important area.