STEM Education, Girls, and the Challenges that Follow

Science, Technology, Engineering, and Math (STEM) Education Caucus

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Rayburn House Office Building, July 16, 2008

Success in STEM fields

- STEM participation
- Mathematics achievement
- Science achievement
- Family & Career Choices
- Conclusions

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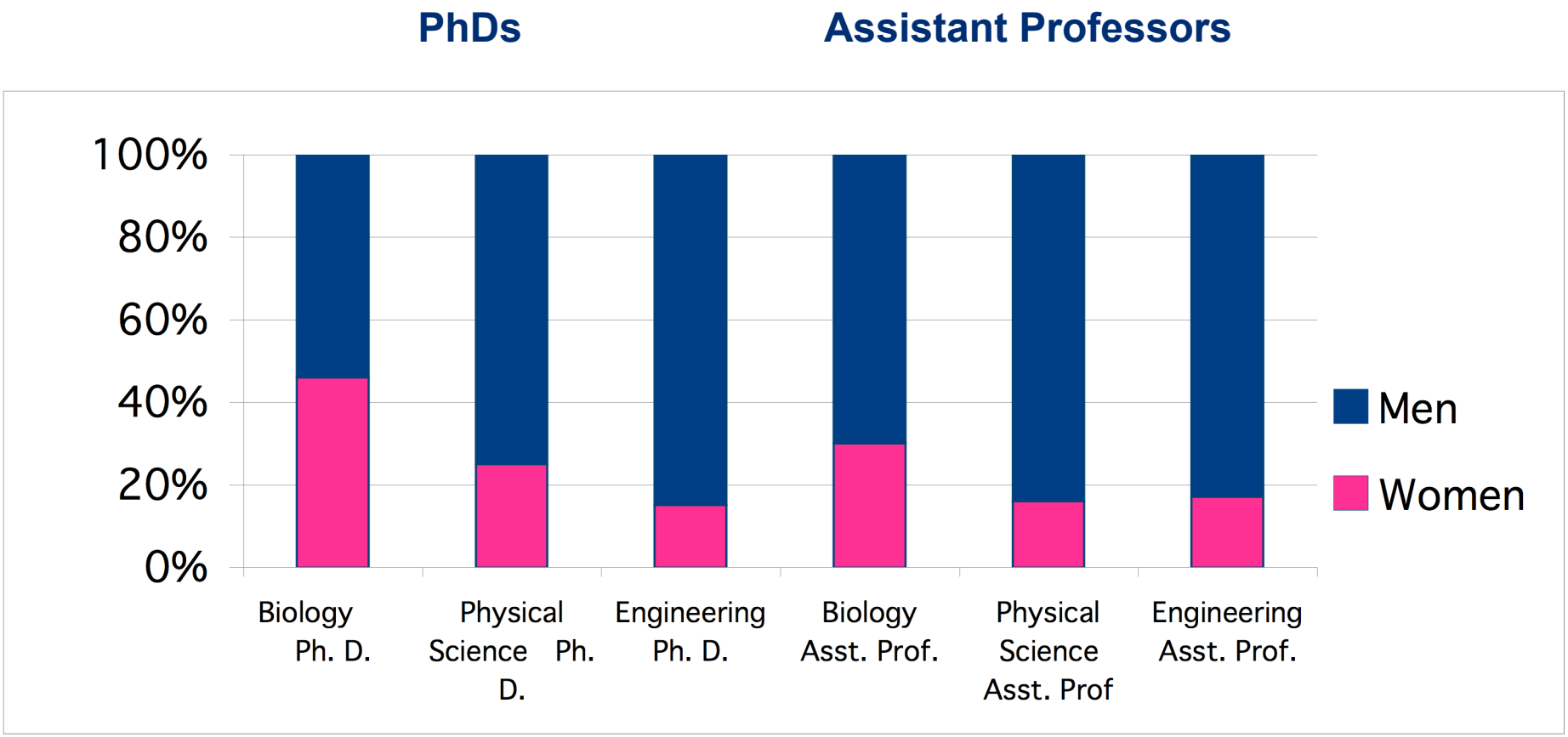
Percentages of PhD Recipients and Assistant Professors by Gender



Source: Handelsman, J., Cantor, N., Carnes, M, et al. (2005.) Enhanced: More Women in Science. *Science, 309*, 1190-1191.

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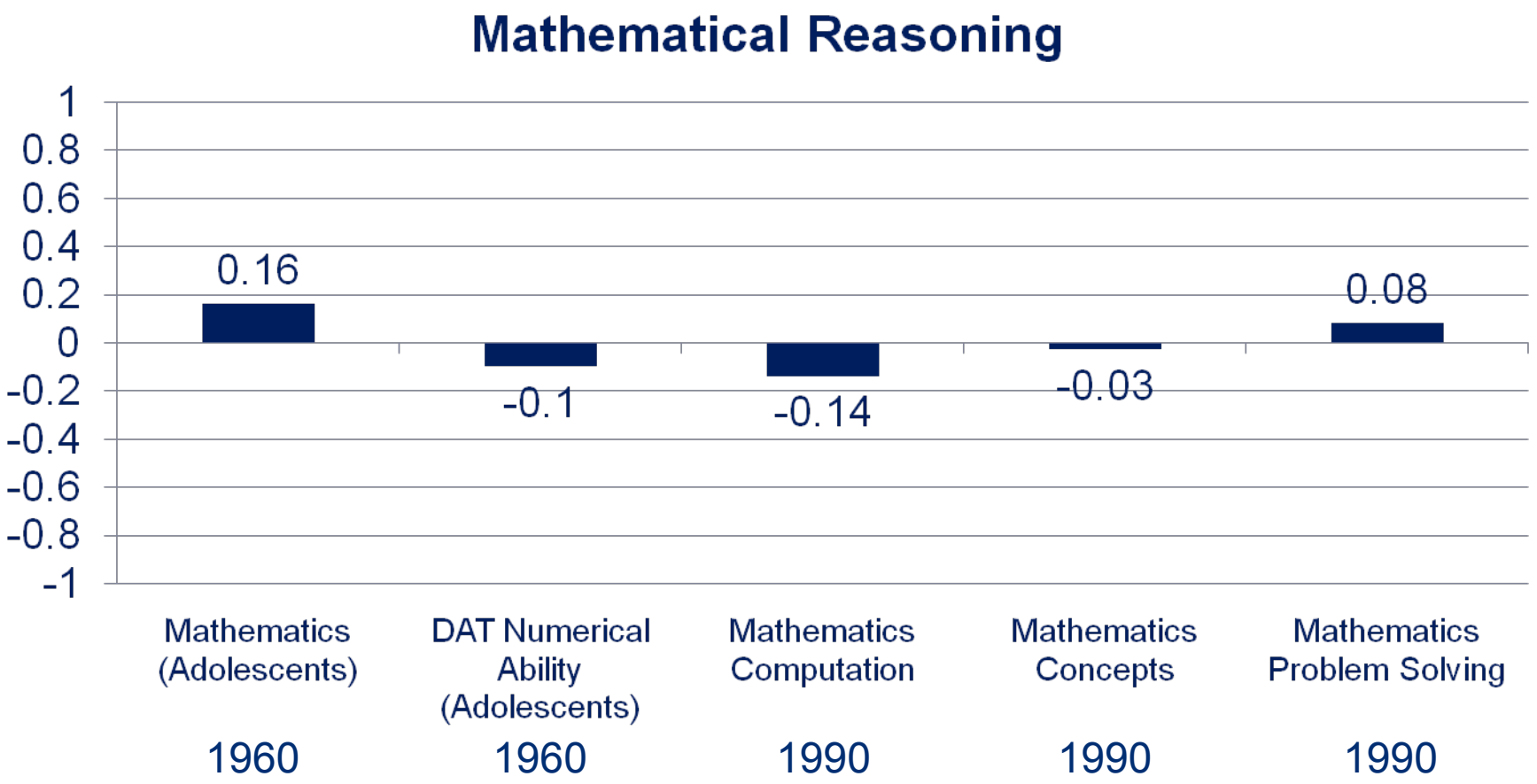
Gender trends in mathematical reasoning (effect sizes, + males, - females)



Sources: Hyde, J. S. (2005.) The Gender Similarities Hypothesis. *The American Psychologist,* 60(6), 581-592. Hyde, J. S. & Linn, M. C. (2006). Gender Similarities: Implications for Science and Mathematics Education. *Science, 314*, 599-600.

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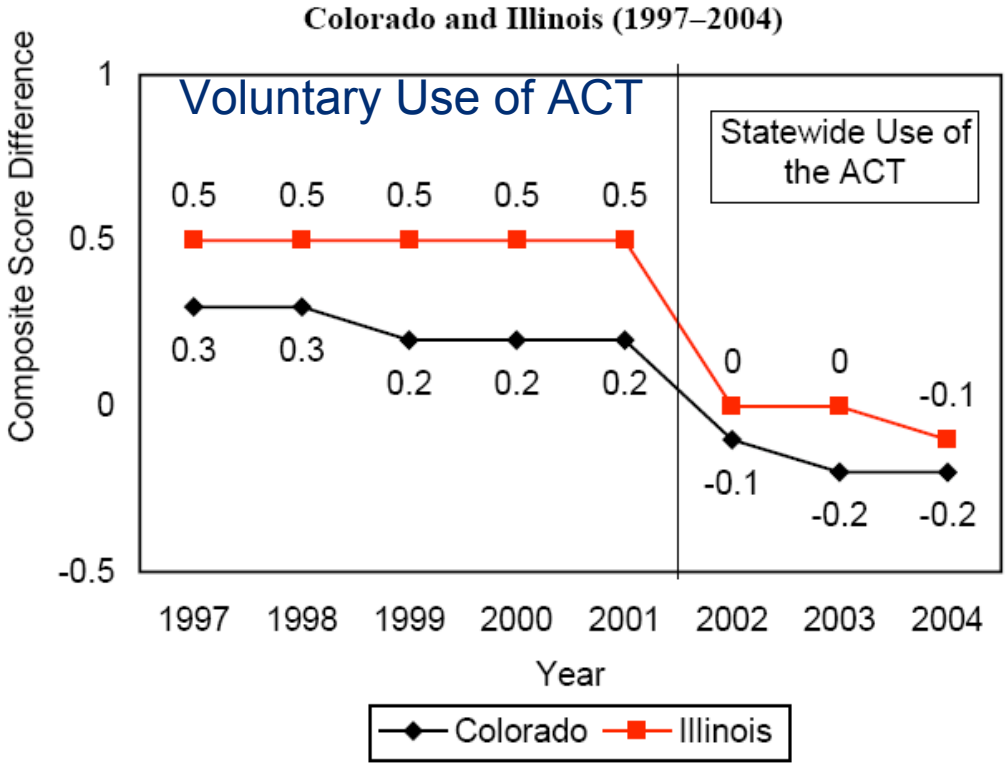
Voluntary and statewide performance on the ACT

Voluntary differences are uninterpretable. Statewide show no differences.



Source: Gender Fairness Using the ACT. *Issues in College Readiness 2005*. Available at: http://www.act.org/path/policy/pdf/gender.pdf.

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Gender similarities in mathematics

- Males and females take equal number of high school mathematics courses.
- More females than males graduate from high school.
- Females earn 48% of college degrees in mathematics.
- Performance differences are trivial.

Sources: TIMSS. Hyde, J. S. & Linn, M. C. (2006). Gender Similarities: Implications for Science and Mathematics Education. *Science, 314*, 599-600.

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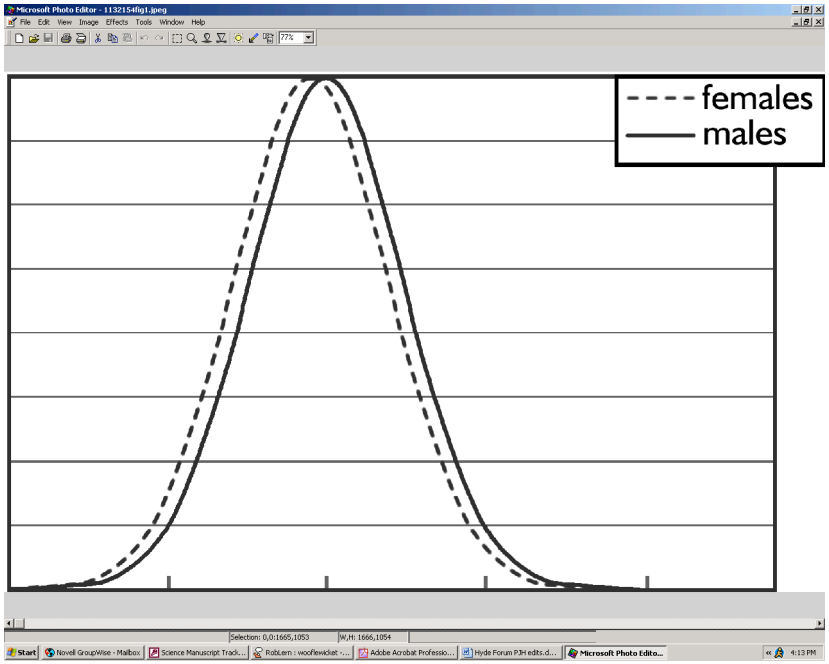
Graphic Representation of a 0.20 Effect Size for Difference between Males and Females

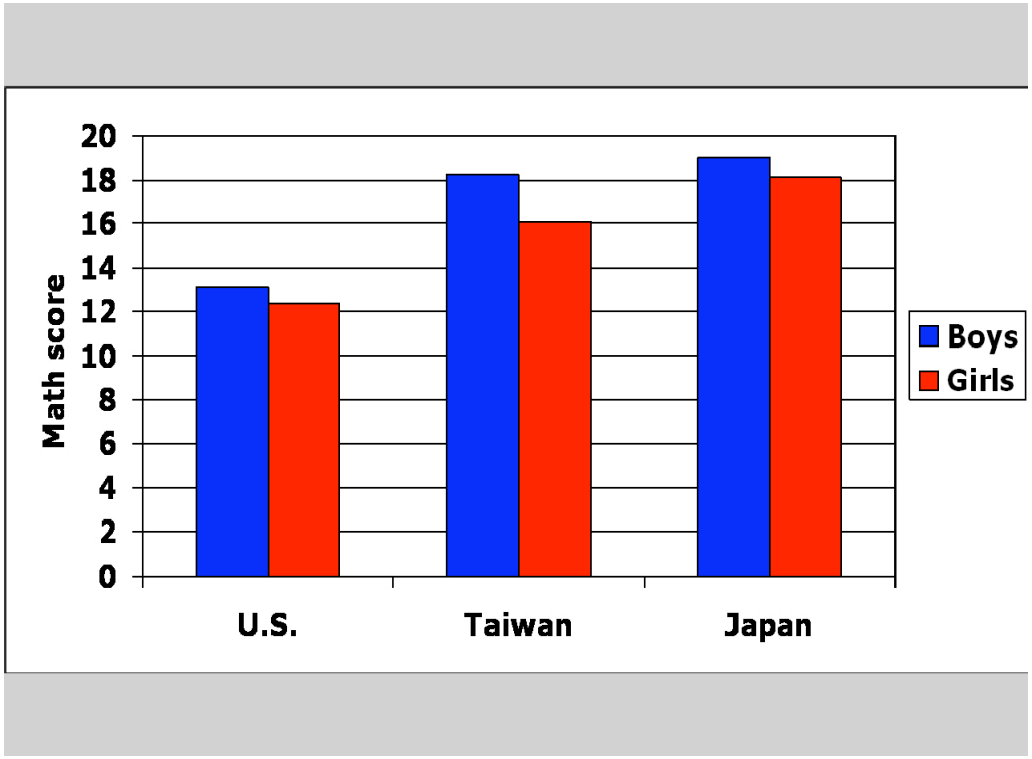


Mathematics distributions at the right tail of the distribution

- Prior to 1980, more males than females above 99th percentile.
- Today studies show very small differences at the 99th percentile, most favoring males but some favoring subgroups of females.
- These differences are too small to explain lopsided participation in Engineering programs.

Robinson et al. (1996) and LaChance & Mazzocco (2006). Stanley, *Johns Hopkins Magazine*, **49**, (1997); http://www.jhu.edu/~jhumag/0997web/letters.html
R. Monastersky, *Chronicle of Higher Ed.,* **51**(26), A1 (2005); http://chronicle.com/free/v51/i26/26a00102.htm

Cross-National and Gender Differences in 5th Graders' Performance on Word Problems



Sources: TIMSS. Hyde, J. S. & Linn, M. C. (2006). Gender Similarities: Implications for Science and Mathematics Education. *Science, 314*, 599-600.

Mathematics Achievement

- Gender differences in mathematics are trivial.
- For national sample taking ACT, scores equal or favor females.
- Differences by culture much larger than gender differences.

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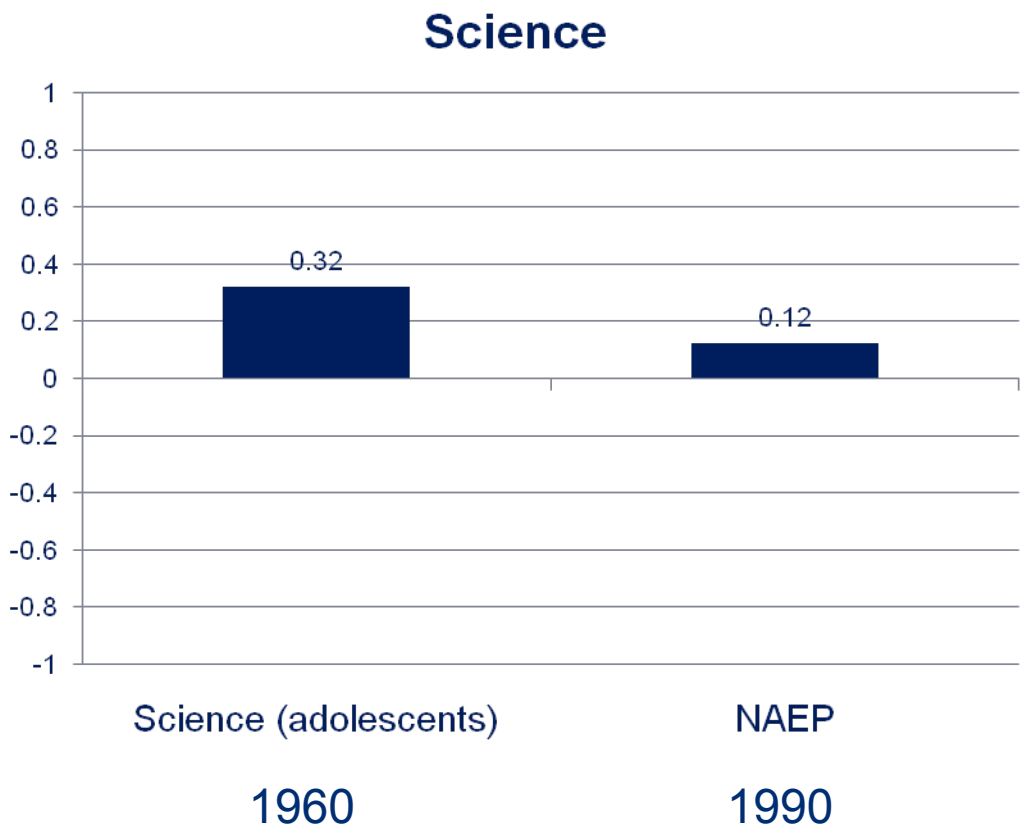
Gender trends in science



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Gender and science

- Gap between males and females is narrowing.
- Females lag males in taking high school physics.
- Only 15% of Engineering Ph. D. degrees go to females.
- Many students complain that middle school and high school science courses are boring and lack relevance to their lives.

Sources: TIMSS. Hyde, J. S. & Linn, M. C. (2006). Gender Similarities: Implications for Science and Mathematics Education. *Science, 314*, 599-600.

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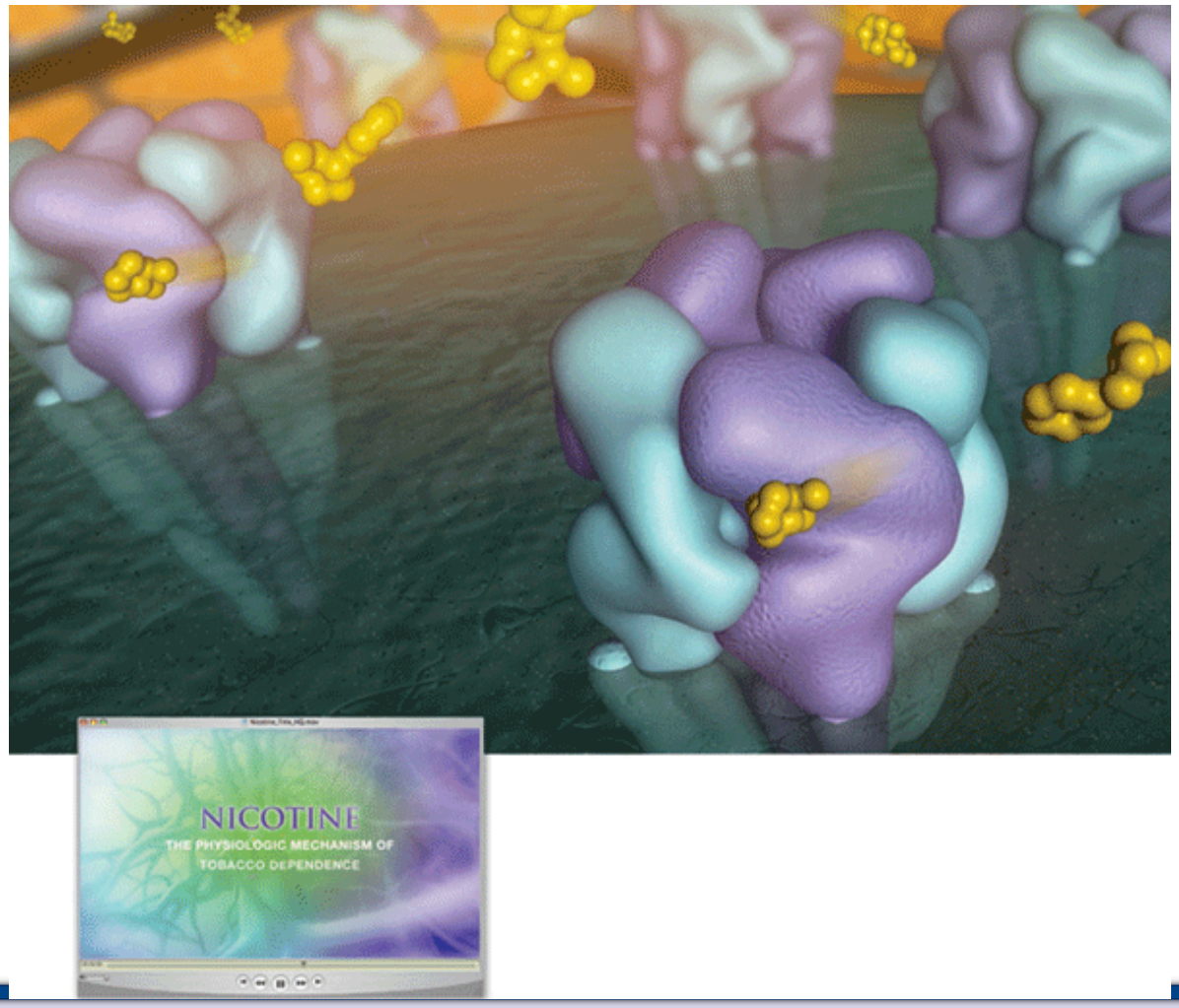
Scientists use Visualizations



From: *Science* 2007 Visualization Winners, "Nicotine: The Physiologic Mechanism of Tobacco Dependence "(Hurd, J., DeSmet, D., Guerrero, J., & Tolentino, D.), http://www.sciencemag.org/cgi/content/full/317/5846/1858/F8.

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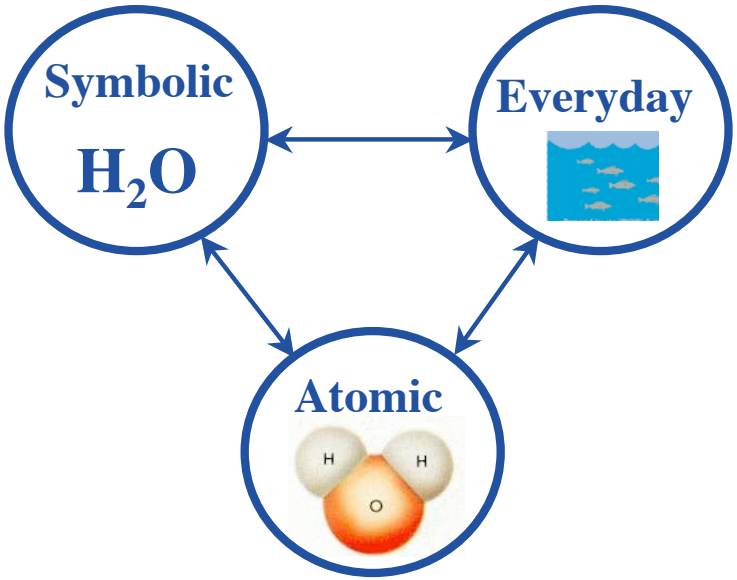
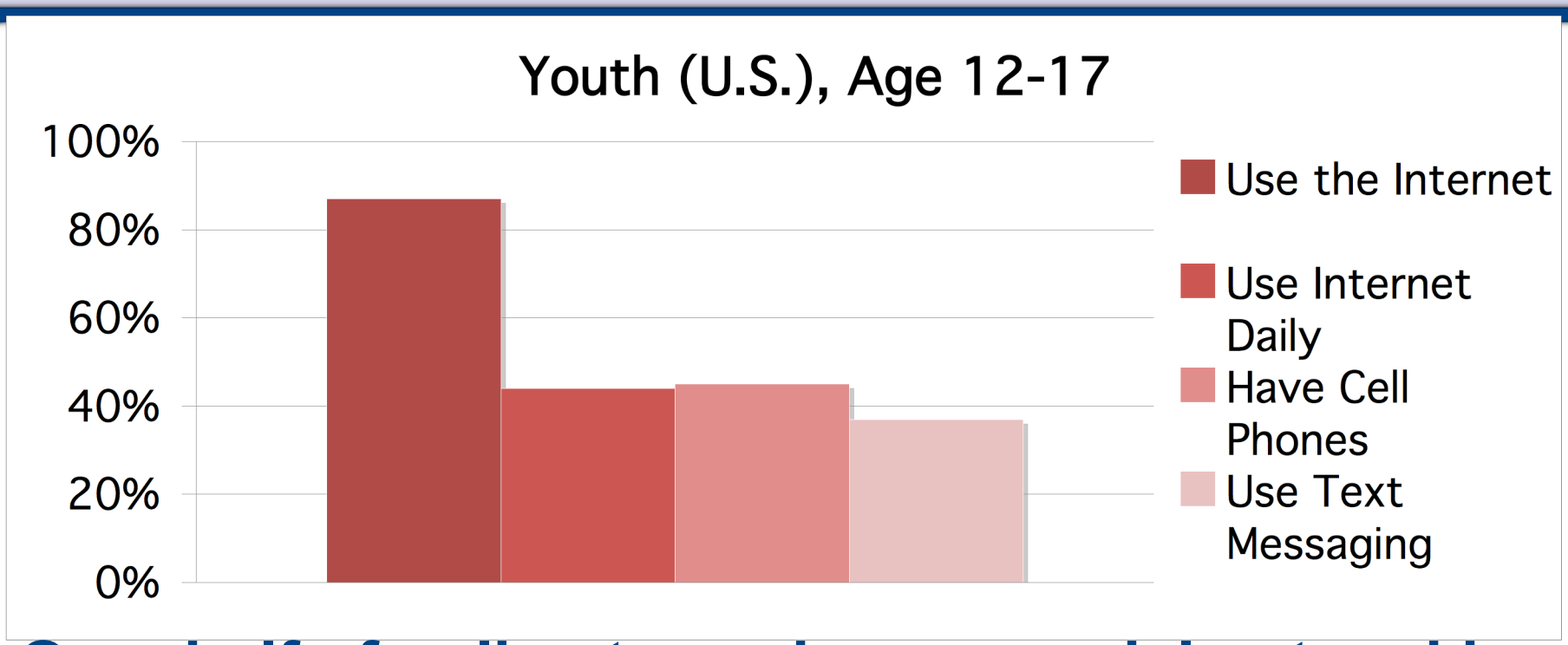
Can Visualizations of Complex Science Improve Learning Outcomes?

- Performance on spatial tasks is improving and gender effects are declining
  - video games and other spatial materials help.
- Students enjoy working with visualizations. Try one…



Sources: Feng, Spence, & Pratt, 2007; Flynn, 2007.

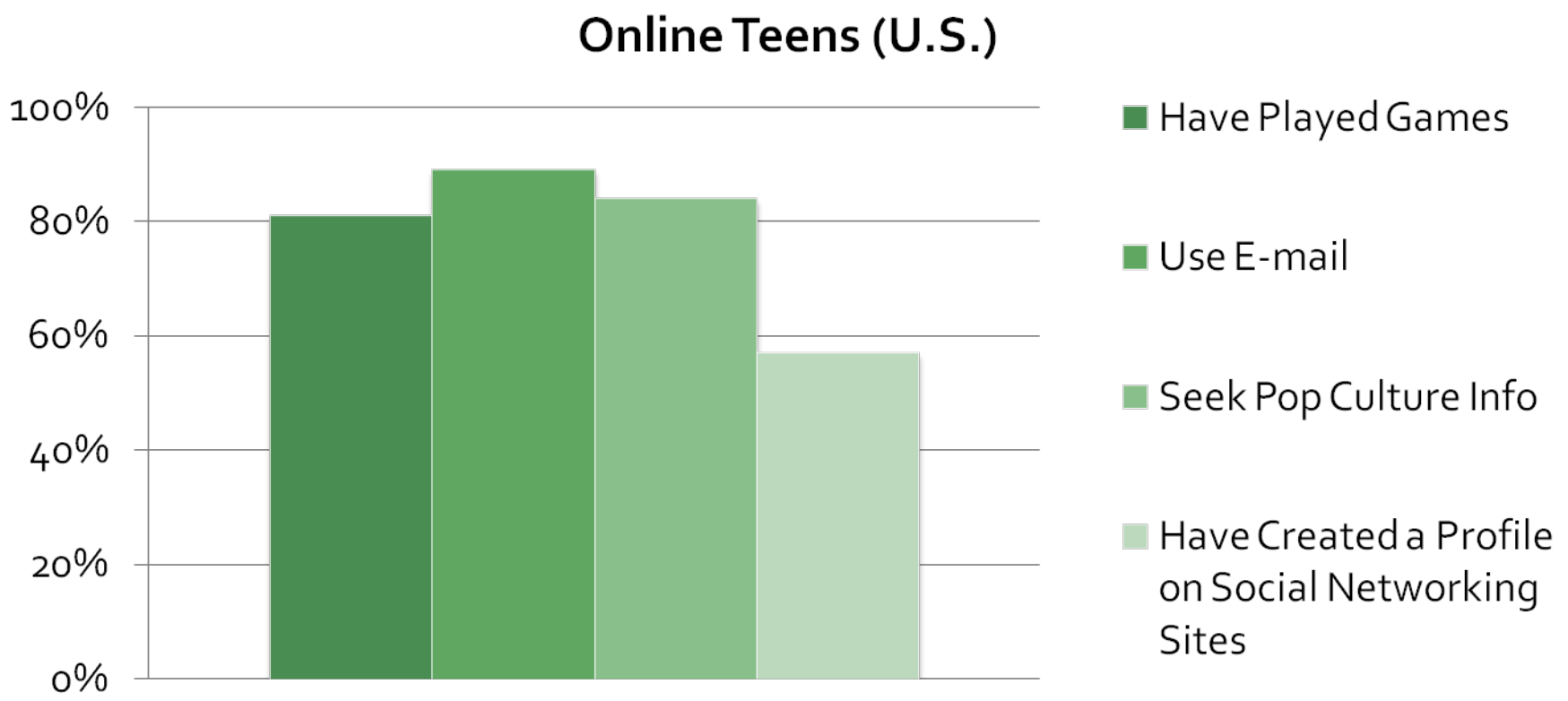
Teen Technology Use



Over half of online teens have a social networking site

Source: Lenhart, A., Madden, M., Hitlin, P. (2005, July 27). *Teens and Technology: Youth are leading the transition to a fully wired and mobile nation*. Washington, DC: Pew Internet & American Life Project. Available at: http://www.pewinternet.org/PPF/r/162/report_display.asp.

Online Teen Activities



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Enhancing Science with Authentic Dilemmas and Visualizations

- Technology Enhanced Learning in Science (TELS)
  - TELS explores how interactive software tools and visualizations embedded in high quality inquiry units can be used to increase pre-college student learning in science.
  - http://TELSCenter.org

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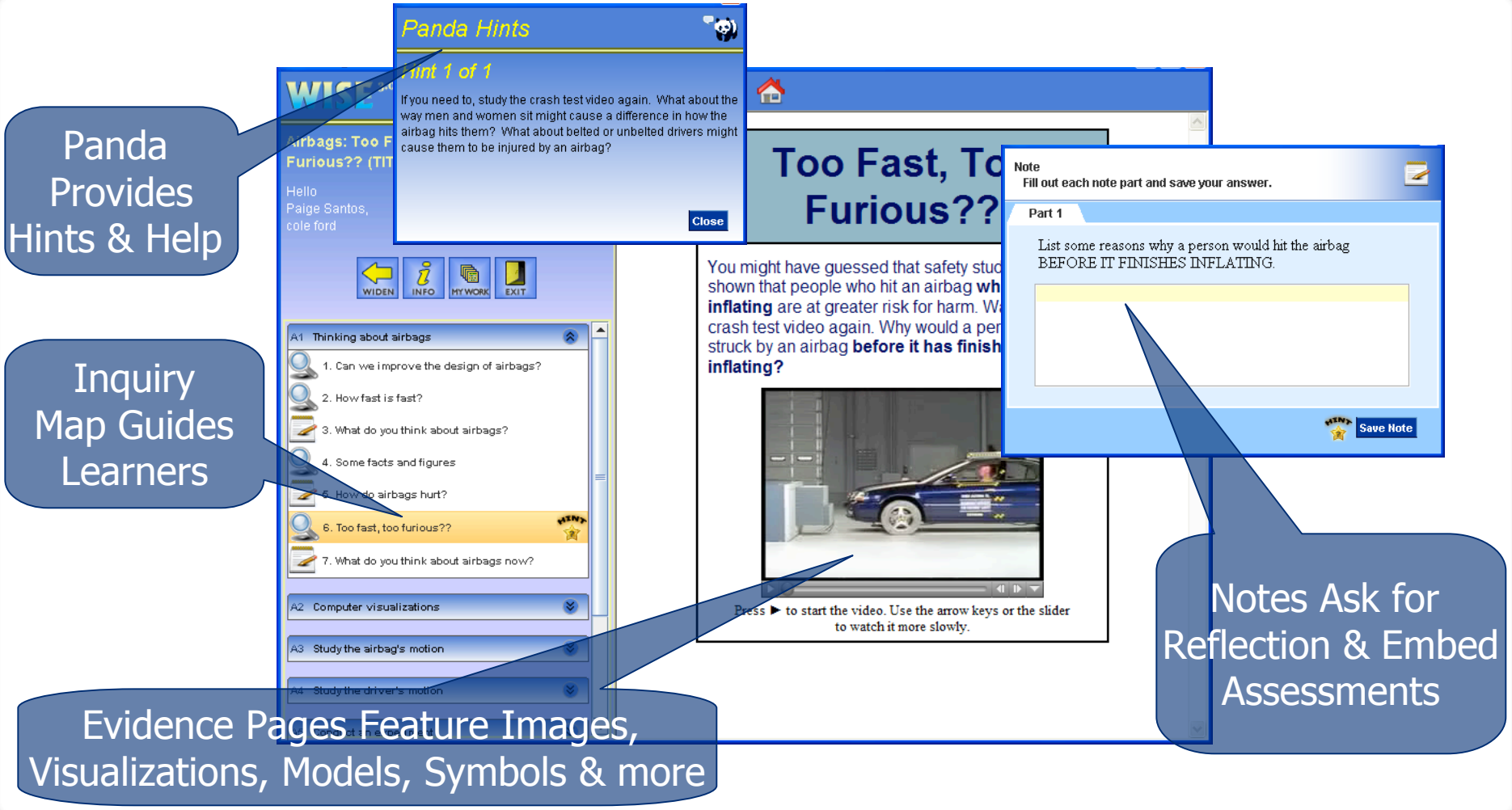
WISE Web-based Inquiry Science Environment



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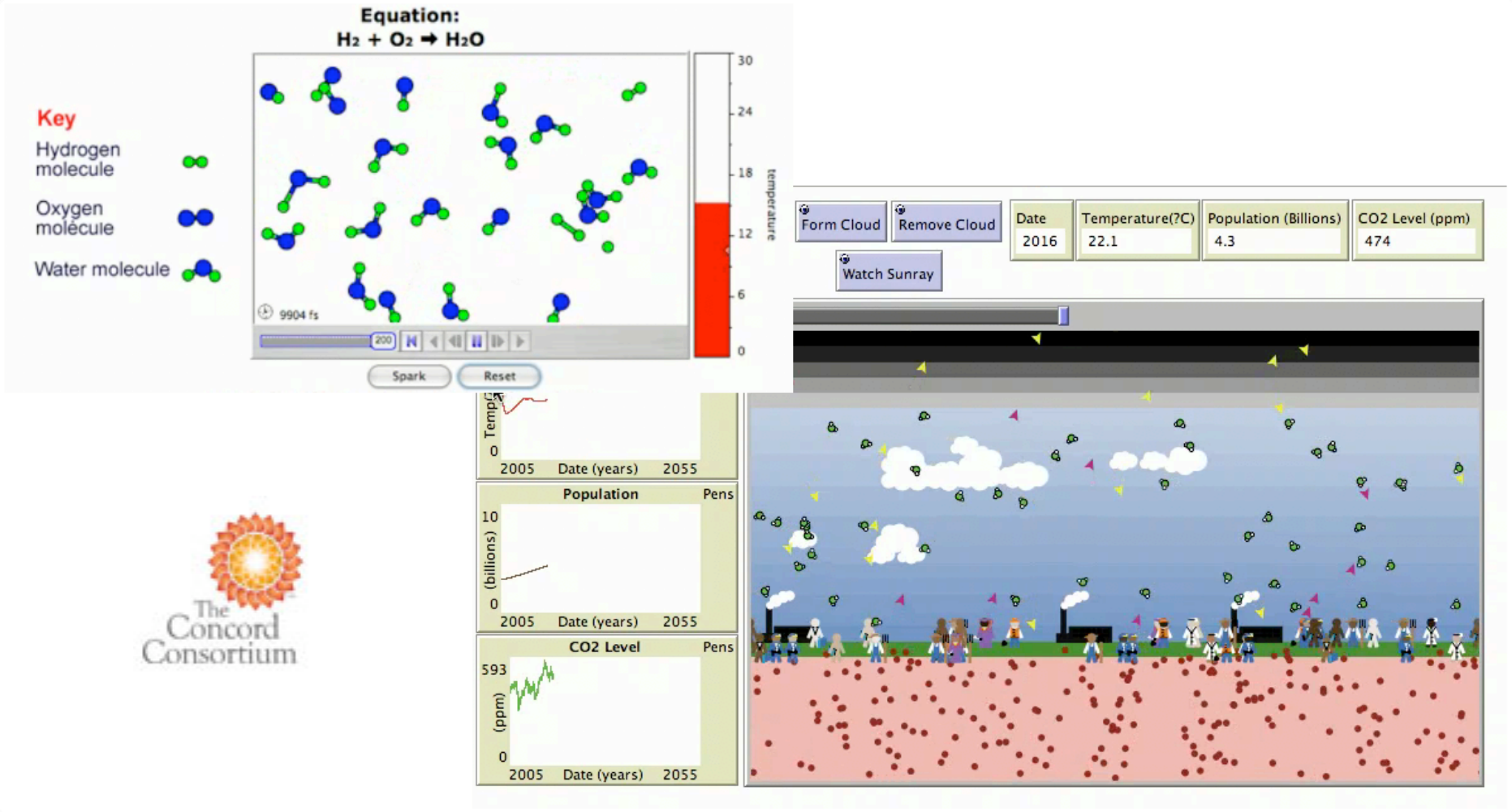
Scientific Visualizations



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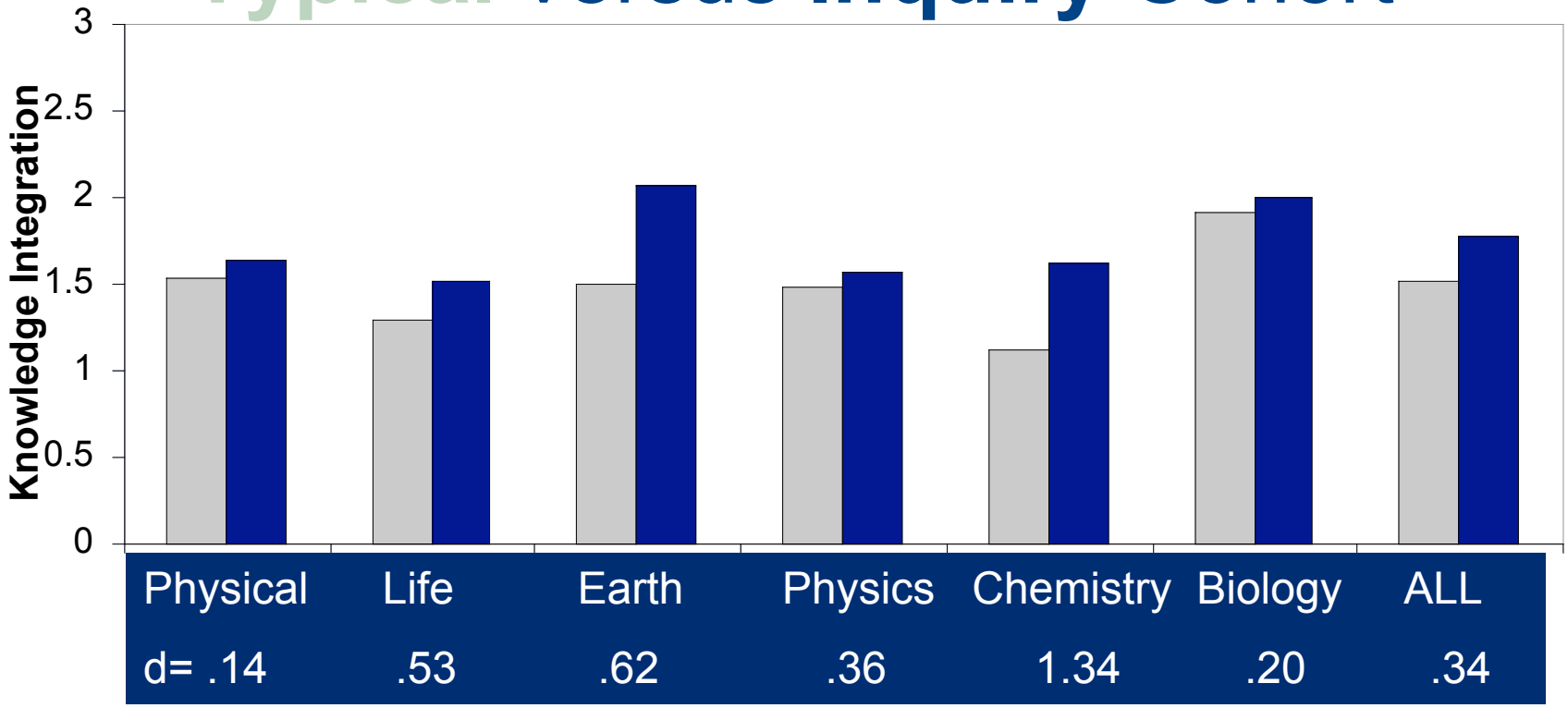
Cohort using visualizations in TELS modules outperformed the cohort using typical instruction

Typical versus **Inquiry** Cohort



Overall: Effect size = 0.34, *P < 0.001*

Linn, M. C., Lee, H.-S., Tinker, R., Husic, F., & Chiu, J. L. (2006). Teaching and Assessing Knowledge Integration in Science. *Science, 313*, 1049-1050.

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Visualization-based Science Instruction advantages all learners

Fixed Effects	Full Model Coefficient	Full Model *SE*	Final Model Coefficient	Final Model *SE*
Intercept (γ_{000})	.43	.05**	.45	.05**
Level 1 (student level)				
Gender (γ_{100})	.0006	.004		
Level 2 (classes within teachers)				
Cohort [Inquiry versus Typical]	.05	.01**	.06	.01**
School Level	.003	.002		

Science Cohort Comparison study. There is a large and significant effect for Visualization-based Inquiry instruction. There is no overall effect for student gender. There is a significant effect for teacher.

Lee, H.-S., Linn, M. C., Liu, L. & Varma, K. (2008). Impact of visualization-based inquiry science experience on classroom learning. TELS Report.

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Improving Science Achievement

- Better courses would benefit all learners
- Visualizations prepare students for authentic career activities
- Students and teachers like science better when visualizations are involved.

Corliss, S. ICLS, 2008

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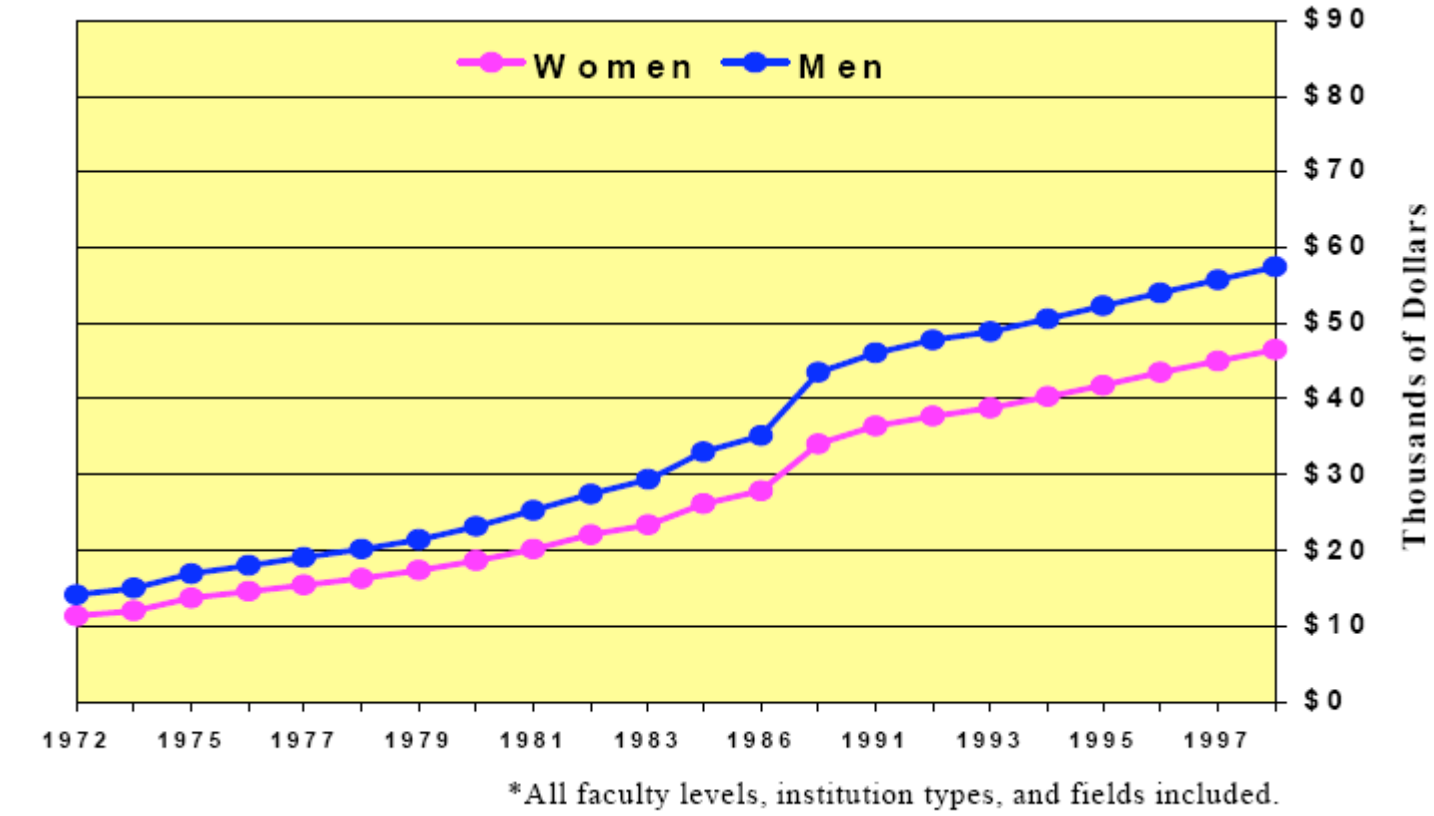
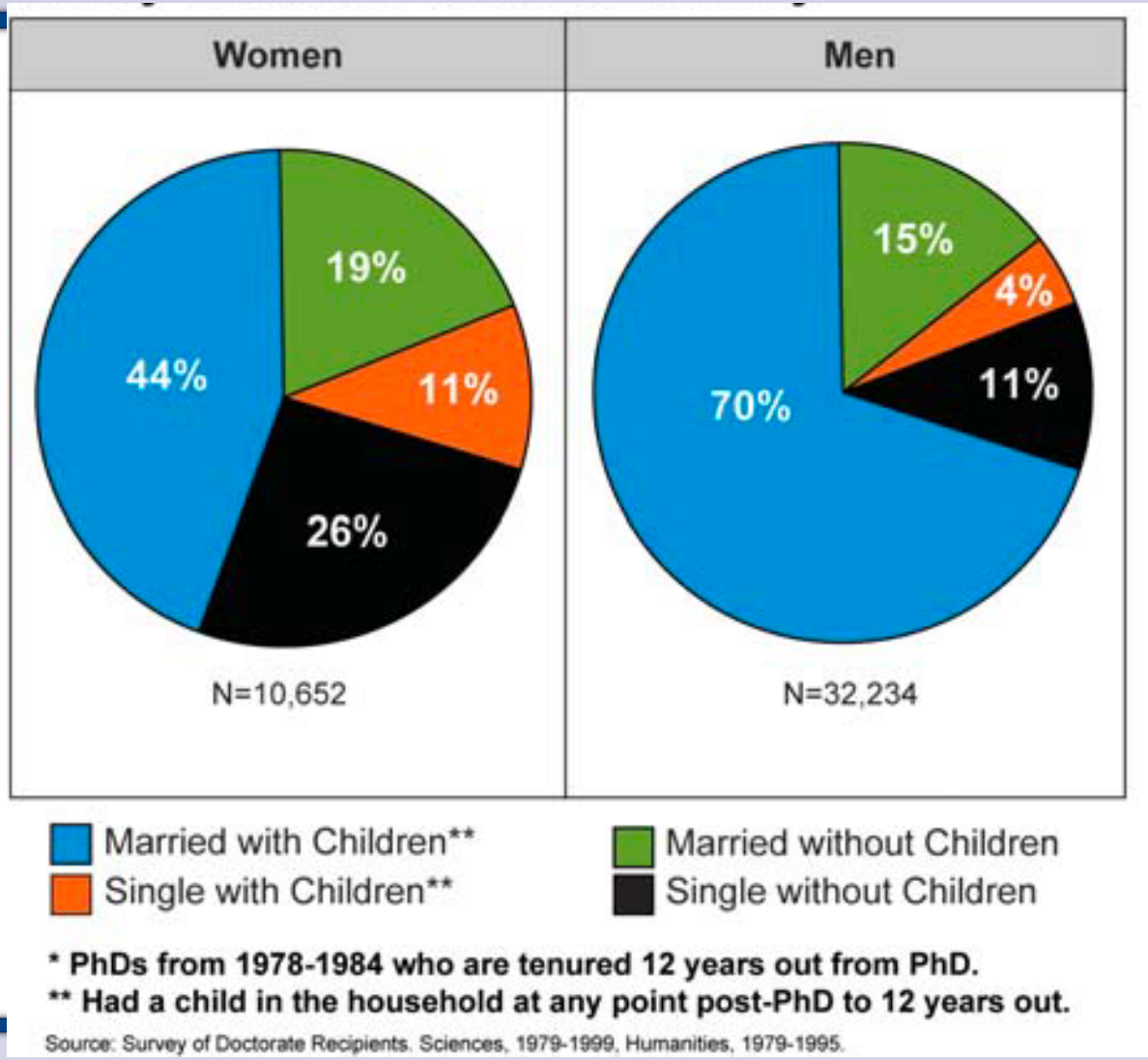
Average Full-Time Faculty Salary by Gender in the US



NCES. IPEDS Salaries. Tenure and Fringe Benefits of Full Time Instructional Faculty Survey [Created by Mason & Ekman, 2007]

Family Status of Tenured Faculty



*** PhDs from 1978-1984 who are tenured 12 years out from PhD.**
**** Had a child in the household at any point post-PhD to 12 years out.**

Source: Survey of Doctorate Recipients. Sciences, 1979-1999, Humanities, 1979-1995.

Do Babies Matter?

- In the doctoral survey, 55% of women with early babies (babies born any time up to 5 years post-Ph.D.) became tenured professors.
- By comparison, 78% of men with early babies got tenure.
- Women drop out of the tenure trajectory because they choose to have a family.

Doctoral survey, 1973-1999; Mason, M. A. & Ekman, E. M. (2007). *Mothers on the Fast Track: How a New Generation Can Balance Family and Careers*. New York: Oxford University Press.

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Conclusions

- Mathematics achievement is equal for males and females.
- Science achievement differences consistent with course enrollment differences.
- Scientific visualizations embedded in inquiry instruction improve science learning for males and females.

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Improving science instruction

- Spatial reasoning important and neglected in the curriculum.
- All students benefit from visualization-based inquiry instruction.
- No gender differences in outcomes.

Remedies

- Increase effectiveness and relevance of science courses.
  - Mathematics achievement differences eliminated when course enrollment equalized for males and females.
- Increase support for technology-enhanced learning and use of spatial reasoning.
  - Spatial visualization is important in science and neglected in the curriculum.
  - Cyberlearning offers powerful opportunity tied to student interest in technology.
- Increase options for women who wish to balance family and career in academia.
  - Career participation in STEM is increasing but many obstacles in graduate school and early career.

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