Presentation to San Dieguito Teachers

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General Atomics

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Background information

- High school – no science fair; no science AP courses
- PhD UCSD 1980 Physics
- Education activities
  - American Physical Society
  - American Chemical Society
  - Optical Society of America
  - Lawrence Hall of Science
  - Biological Sciences Curriculum Study (BSCS)
  - National Science Foundation
  - Physics (phys-L), chemistry (chem-L) list serves
  - Actively campaigned for improved state science standards and framework

Differences Between School and Work

TOPIC	SCHOOL	WORK
Learning	Curriculum-based learning	Needs-based learning
Memorization	Often	Never
Importance of solving timed problems	Very	Not
Learning resources	Mainly textbook	Co-workers, books, suppliers, technical papers, web, trade magazines, etc.
Nature of problems	Well-defined Single subject area Work alone	Often ill-defined, e.g. What is the best way to … ? Multidisciplinary Work as part of team

Students should learn to work in teams- simplistic view of how industry works

- Wrong model: 4 horses pulling a cart work as a team
  - 4 students all working together in a science project, all responsible for everything
- Right model: a baseball team, all working together, but each with unique talents to achieve a goal –these are known as cross-functional teams
  - Science fair project: a science student developing the experimental plan, an engineering student building the apparatus, an art/design student developing the poster, an English student writing the text
- See next slides for teamwork/work details

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1. Be responsive – return phone calls and emails promptly. When asked to do something, do it on time – be sure to ask when it should be done. Document requests and responses in writing.
2. Become the world expert in your particular area.
3. Continually expand the depth and breadth of your knowledge and skills.
4. Utilize all information resources available - books, science magazines, web sites, search engines, search services, colleagues, patents, trade magazines, catalogs, sales reps, conferences.
5. Get involved with projects that have high value and are feasible.

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6. Understand and be aware of project constraints such as your personnel and company capabilities, competitor's strengths, and customer needs.
7. Innovate continuously. Always push your envelope as well as the science and technology envelope. Stay uncomfortable with what your skills and knowledge are.
8. Document your work in manner that can be easily understood by a co-worker a year from now. Use spreadsheets, tables and charts to convey your results in a concise, visual, and easy-to-understand manner.
9. Make sure that you learn something useful from any tests or experiments that you perform. These results should form the basis for future tests.
10. Learn from your mistakes. Don't repeat them.

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11. Don't believe everything you are told, even if it is company lore or told to you by an expert. Be skeptical. Ask for data to back up claims – still be skeptical. Ask for experimental details. Still stay skeptical. Reproduce the data yourself to truly convince yourself.
12. Enjoy your work.
13. Treat everyone you work with (above and below you) with respect. Thank them for their work. Acknowledge their contributions whenever possible. Keep them informed as to what you are doing and why you are doing it.
14. Have a sense of humor.
15. Develop a unique and necessary skill and knowledge set at your work that complements those of your co-workers and greatly increases the value of your project/team.

I have learned a lot from reading excellent popular science books

They show scientific ways of thinking and analyzing situations that do not occur using standard textbooks. Consider collaborating with your language arts teachers.

- **Physics**
  - Clouds in a Glass of Beer by Craig Bohren
  - What Light Through Yonder Window Breaks by Craig Bohren
  - Surely You're Joking Mr. Feynman by Richard Feynman
  - What Do You Care What Other People Think by Richard Feynman
  - The Meaning of it All by Richard Feynman
- **Chemistry**
  - Uncle Tungsten by Oliver Sacks
  - Life's Matrix by Philip Ball
- **Biology**
  - Bully for Brontosaurus by Stephen Jay Gould
  - Full House by Stephen Jay Gould
  - Any other book by Stephen Jay Gould

See also: http://scilib.ucsd.edu/spotlight/amsci100.htm

Skills that I use almost every day

- Importance of units, scientific notation, unit conversions. Units should be part of every equation. Numbers without their unit are meaningless. They should not be put in at the end. They provide a check on the correctness of your solution.
  - See http://www.sci-ed-ga.org/modules/driving/ Investigation #1 Problems and Solutions
- Importance of calculating and creating tables and graphs using Excel or other spreadsheet programs.

Results from Physics Education Research about Science Education

- Traditional methods that rely primarily on passive-student lectures, recipe labs, and algorithmic problem exams fail to promote conceptual understanding
- Interactive engagement methods involving heads-on (always) and hands-on (usually) activities which yield immediate feedback through discussion with peers and/or instructors promotes significant conceptual understanding
  - Often involve a learning cycle approach:

    Focus, Explore, Reflect, Apply; for example:

    http://cpucips.sdsu.edu/web/cips/default.html
- See http://www.physics.indiana.edu/~hake/
  - Particularly references 8 and 24

Great sites

- Science misconceptions
  http://www.ems.psu.edu/~fraser/BadScience.html
- Chemistry
  http://web.umr.edu/~gbert/links.html
  http://www.chemtopics.com/wwwchemf.htm
- Physics
  http://hyperphysics.phy-astr.gsu.edu/hbase/hph.html
  http://www.emmynoether.com/
  http://micro.magnet.fsu.edu/
- Biology
  http://www.stephenjaygould.org/library.html