APPENDIX 1-E

Available Resources for Infusing Engineering Design into K-12 Engineering and Technology Curriculum

Available STEM (science, technology, engineering, and math) instructional materials from the Internet (Grade K-12)

Many well developed instructional materials for STEM are available online.

Websites:

- Boston Museum of Science (http://www.mos.org/EIE).
- Ford Partnership for Advanced Studies (http://www.FordPAS.org).
- ITEA Engineering byDesign (http://www.iteaconnect.org/EbD/ebd.htm): The International Technology Education Association offers great instructional materials for STEM.
- Materials World Modules (http://www.materialsworldmodules.org).
- NASA science curriculum Science, Engineering, Mathematics and Aerospace Academy (SEMAA) for Grades K-12: (http://www.nasa.gov/centers/glenn/education/SEMAA_GRC.html).
- Play School (http://www.abc.net.au/children/play/): An award-winning educational television show for children produced by the Australian Broadcasting Corporation and others.
- Teach Engineering Resources for K-12 (http://www.TeachEngineering.org).
- TechXcite (http://techxcite.pratt.duke.edu/).
- The Tech Know™ Project (http://www.ncsu.edu/techknow/).
- TryEngineering.org (http://www.TryEngineering.org. Multi-language site: http://www.tryengineering.org/home.php).

Entertaining science learning and engineering activities (Grade K-5):

As listed and mentioned by many educators in articles published in *Technology and* Children journal (Grant & Marciano, 2008; and Arango, 2008), resources are available for teaching K-5 students essential principles and concepts of science, engineering and technology, as well as the essentials of conceptual and imaginative deign and invention, in ways appropriate to the students' interests, development levels and cognitive maturity. They include online videos, interactive games, engineering and technology design simulation software (in many cases freeware). There are toys and devices ('gizmos") that can be used to teach science, technology and engineering concepts and age-appropriate analytic skills, using simple and well-structured problems. For example, Gear Action 20 Model Building Set, under $20.00, made by K'NEX (*Figure 1*) can be used to teach kindergarten and elementary students how gear system works, incorporating age-appropriate analytic principles of gear design such as gear ration and speed change, etc.. "Getting the students involved by identifying and learning about gizmos in their own homes makes clear some of the concepts that they already know, and allows them to combine that knowledge with the information that was presented to them by the instructor" (Grant & Marciano, 2008, p. 7). Toys, mechanical devices, TV series, video games, which can be used to teach science, technology and engineering concepts (McLaughlin, 2008, p. 2):

Figure 1. K'NEX gear design toy.

1. Online or classroom science learning and engineering design activities:

- Gizmos: Explore Learning at http://www.explorelearning.com is an easy-to-use, revolutionary pedagogic tool that transforms abstract concepts into vivid, animated pictures, wit interactive online activities to support regular classroom teaching of math and science topics, ranging from learning, visualizing to grading.

- Rube Goldberg: This design activity can be used to teach the essentials of mechanical design (such as the use of six simple machines). One of the best

website featuring past design activities is http://video.google.com/videosearch?hl=en&client=firefox-a&channel=s&rls=com.google:en-US:official&q=Rube+Goldberg&um=1&ie=UTF-8&sa=X&oi=video_result_group&resnum=8&ct=title#).

Other Rube Goldberg Project Reference:

Websites:

- Rube Goldberg (http://www.rubegoldberg.com).
- Rube Goldberg (http://www.rube-goldberg.com/).
- Rube Goldberg Machine (http://en.wikipedia.org/wiki/Rube_Goldberg_machine).
- Rube Goldberg Machines (http://www.youtube.com/results?search_query=o%09Rube+Goldberg+Machines+).
- Rube Goldberg Officeplace Contraption (http://www.youtube.com/watch?v=0J16dyV4Du8).
- Rube Goldberg (http://en.wikipedia.org/wiki/Rube_Goldberg)
- YouTube Rube Goldberg videos (http://www.youtube.com/watch?v=1kvdq8cRNBM).

Books:

- Benenson, G., James L., & Neujahr, J. L. (2002). *Mechanism and other systems*. Portsmouth, NH: Heinemann. ISBN: 0-325-00468-4

- Constable, G., & Somerville, B. (2003). *A century of innovation: twenty engineering achievements that transformed our lives*. Washington, D.C.: Joseph Henry Press. ISBN-10: 0309089085

- Hauser, J. F., & Kline, M. (1999). *Gizmos and gadgets: Creating science contraptions that work & knowing why kids can! Series.* Charlotte VT: Williamson Publishing Company. ISBN-10: 1885593260

- Kinnaird, C. (1968). *Rube Goldberg vs. the machine age*. Hastings House. ISBN 8038-6305-5.

- Macaulay, D. (2008). *The way things work*. Boston: Houghton Mifflin Company. ISBN-10: 0618233784

- Mazio, P. C. (1973). *Rube Goldberg, his life and work*. New York, NY: Harper & Row. ISBN 0-06-012830-5.

- Orsak, G. C., Wood, S. L., Douglas, S. C., Treichler, J. R., Munson, D. C., Athale, R. A., & Yoder, M. A. (2003). *Engineering our digital future:*

The infinity project. Upper Saddle River, NJ: Pearson Prentice Hall. ISBN 0-13-184828-3

- Wolfe, M. F. (2000). *Rube Goldberg: Inventions!* New York, NY: Simon & Schuster. ISBN-10: 0684867249

Video games:

- Viva Media. (2005) *Crazy Machines: The Wacky Contraptions Game Win/Mac*. ASIN: B000B642OI

2. Instructional toys and laboratory devices:

- Kelvin (http://www.kelvin.com/): The company markets a great variety of instructional toys and lab tools, devices and components, for teaching and learning principles of science, engineering and technology, from electronics to robotics.

- K'NEX: (http://www.knex.com/): Science, engineering and technology toys designed and marketed by K'NEX are well targeted to different age/grade groups, for teaching various principles of science, engineering and technology, ranging from simple machines to bridge, from amusement park to solar energy, from math to DNA. They are valuable tools for demonstrating and experiencing with essentials of science and engineering throughout K-12.

- Lego (http://shop.lego.com/Default.aspx): This Denmark-based toy company offers a variety of educational toys, which consist of colorful interlocking plastic bricks and an accompanying array of gears, which can be assembled and connected in many ways, to construct such objects as vehicles, buildings and even working robots, and then taken apart, so that the pieces can used to make other objects. This could be a valuable tool for teaching mechanical system to K-5 students.

- Lincoln Logs (http://lincolnlogs.knex.com/): Using notched miniature logs, about ¾ inches (1-2 cm) in diameter, Lincoln Logs have notches in their ends so that small model log buildings can be built. The toy could be a valuable tool for teaching construction system to K-5 students.

Online resources for K-12 engineering and technology teachers:

Many educational websites dedicated to K-12 curriculum features pedagogic tools as technology lesson plan and learning materials, as well as online or downloadable simulation software.

1. Teaching and simulating STEM (science, technology engineering and mathematics):

- About.com: Inventors (http://inventors.about.com/od/kidinventions/Inventions_Made_By_Kids.htm): This site provides a lot of information on invention and related issues (such as copyrights, patent and others), serves as a repository for children's innovative dreams, and is suitable to technology teacher to use as a reference source for development design curriculum in K-5 settings.

- Exploratorium (http://www.exploratorium.edu/afterschool/activities/): This site provides online demonstration videos on how concepts of science and technology work, including materials and step-by-step procedures, using simple after-school activities.

- ExploreLearning (http://www.explorelearning.com): This site contains great interactive 3D online games for teaching all branches of math and science covered in K-12 settings.

- Mom Inventors (www.mominventors.com/catalog/index.php?cPath=22):This site sells products designed for children's use, including those related to technology education.

- NASA (http://www.nasa.gov/): National Aeronautic and Space Administration website offers a great variety of science and engineering related instructional materials, including design simulation software; and the topics include solar system (http://solarsystem.nasa.gov/planets/index.cfm), space exploration (Mars at http://mars.jpl.nasa.gov/ and Space Mission at http://www.nasa.gov/mission_pages/exploration/mmb/index.html), and others.

- Rocky Mountain Learning Systems (http://www.rmlearning.com/index.htm): This site features age-appropriate instructional materials (mostly software or educational games) for children to learn on their own pace.

- Popular Science (http://www.popsci.com/environment/article/2008-06/future-environment): This great website features interactive and animated projects for learning science, engineering and technology, including futuristic city design based on alternative energy usage and ecologically conscious but yet sophisticated lifestyle (*Figure 2*).

2. Online ecology education: These websites features a great wealth of knowledge about environmental protection, alternative and sustainable energy sources, Everyday Environmentalist Carbon Footprint Calculator, and other analytic tools.

- Alliant Energy Kids (http://www.alliantenergykids.com/).

- Amazing Moms (http://www.amazingmoms.com/htm/earthday2.htm).
- A Project of Climate Change Education (http://globalwarmingkids.net).
- EcoKids (Canada) (http://www.ecokidsonline.com/pub/index.cfm).
- The Nature Conservancy (http://www.nature.org/activities/everydayenv.html).
- The Forest History Society (http://www.foresthistory.org/Education/Curriculum).
- The Green School Initiative (http://www.greenschools.net/7StepstoaGreenSchool.htm).
- Kids for Change (India) (http://infochangeindia.org/kids/kidsindex.php).
- U.S. Environmental Protection Agency Environmental Kids Club (http://www.epa.gov/kids/).

3. Online videos that could be used to broaden the technological and social perspectives of K-12 engineering and technology teachers.

- Inspector Gadget videos (http://www.tv.com/inspector-gadget/show/2412/videos.html).
- MacGyver TV series (http://www.tv.com/macgyver/show/706/summary.html).

4. For K-12 engineering and technology teachers' investigation on how engineering and product design firms work.

- Yanko Design (http://www.yankodesign.com/): This design firm features a great website with the motto "form beyond function" in contrast to the conventional idea of "form follows function."

Science instruction and Engineering design simulation software (Grade K-12):

Many freeware or low-cost software are available for students at elementary through high school levels to learn the fundamentals of mechanical systems, construction systems, architectural design, and other branches of science, engineering and technology.

1. For teaching and learning mechanical systems:

- FoilSim (http://www.grc.nasa.gov/WWW/K-12/FoilSim/index.html): The free software could be used in teaching and learning aerodynamic principles.

- RocketModeler (http://www.grc.nasa.gov/WWW/K-12/rocket/rktsim.html): This NASA site provides engineering design simulation software for space science and related field, including rocket design for teaching scientific principles of weight, thrust, aerodynamic forces, lift and drag, etc..

- The West Point Bridge Designer: (http://www.softpedia.com/get/Others/Home-Education/West-Point-Bridge-Designer-2011.shtml): This popular website, featured by The U. S. Military Academy at West Point, offers free bridge design simulation software (download site: http://bridgecontest.usma.edu/download.htm).

- Yenka (http://www.yenka.com/en/Yenka_Gears/): From electronics PCB (Printed Circuit Board) simulation, to gears set (in full 3D mode) design, to statistics modeling, this website offers digital simulation software for teaching and learning a variety of engineering analysis and design topics. A possible tool for infusing engineering analysis and design into K-12 curriculum.

Figure 2. Futuristic Mega City on Popular Science website (source: http://www.popsci.com/environment/article/2008-06/future-environment).

2. For teaching and learning construction and architectural design:

- Building Homes of Our Own (http://building-homes-of-our-own.software.informer.com/): This design and simulation software is intended for the middle and high school classrooms. It presents a macro view of the entire home building process from site selection to final sale, and allows students collect information, solve problems and make choices as they build a 3D home against a budget, then review credit applications and sell to the buyer of their choice." It could be used to teach the scientific and technological principles related to building construction.

- DesignWorkshop Lite (http://www.artifice.com/free/dw_lite.html): This freeware allows students to build your own 3D models for home design and visualization of architecture, landscapes, exhibits, or any kind of spatial design, and to view and walk-through ready-made models of any size. It could be used to teach the aesthetic and ergonomic principles related to architectural and landscape design.

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Jones, K. (2008). Ideas for integrating technology education into everyday learning. *Technology & Children*. Vol. 13 No. 1, 2008

Jones, K. (2008). Ideas for integrating technology education into everyday learning. *Technology & Children*. Vol. 13 No. 2, 2008

McLaughlin, C. (2008). The Future: Gizmos. *Technology & Children*. Vol. 13 No. 2, 2008

McLaughlin, C (2008). Energy and other scenarios. *Technology & Children*. Vol. 13 No. 1, 2008