AC 2012-3539: OFFSETTING GENDER BIAS IN ENGINEERING: GENDER EQUITY INTERNET CONTROLLED FISH FARM CURRICULUM ACTIVITY

Mr. Presentacion Rivera-Reyes, Utah State University

Presentacion Rivera-Reyes is currently a graduate research assistant and a Ph.D. student in the Engineering Education Department at Utah State University. He formerly held a position as professor of telecommunication engineering at Technological University of Honduras. He received his B.S. in electrical engineering from the National Autonomous University of Honduras. He has experience in the telecommunication industry where he worked training engineers and technicians in high-speed transmission system for backbone networks.

Mr. Raymond Edward Boyles, Utah State University

Raymond Edward Boyles has an associate's in specialized, avionics, May 1992, from Pittsburgh Institute of Aeronautics, and a B.S., information technology, May 2008, and M.S., technology education, Aug. 2009, from California University of PA. Most Relevant Papers: Santoso, H., Boyles, R., Lawanto, O. & Goodridge, W. (2011). A Preliminary Study of Conducting Semi-Structured Interview as Metacognitive Assessment in Engineering Design: Issues and Challenges. American Society for Engineering Education. Presentations, five most relevant: TeleRobotics: The Internet, a Physical Sensor 73rd Annual Conference Program, ITEEA 2011. Dr. Kallis, J., Boyles, R. Implementation of Microgravity Experiments in the Classroom 73rd Annual Conference Program, ITEEA 2011 Teaching STEM Concepts with Agile Robotics. Dr. Kallis, J., Boyles, R. 73rd Annual Conference Program, ITEEA 2009. Tremaux's Algorithm with Recursion 73rd Annual Conference Program, ITEEA 2009. "Normalcy" 2008 Intercollegiate Art Show, Best of Show, California University of PA, April 3rd, 2008. "Die Verfeinerung von Sustainability" Create the Future Design Contest, NASA Tech Briefs and Solid Works, Oct. 14, 2008. "Teaching by strong interest through analogous Java Software," 56th Annual TEAP Conference. Harrisburg, Penn., Nov. 6-7, 2008. "G.S.Ohm: Electrical Innovation in Industry." Poster presentation at National Collegiate Honors Council Conference, Philadelphia, Penn., Nov. 17, 2006. "Societas crescit: Invention and Innovation through Team Teaching." Panel presentation at National Collegiate Honors Council Conference, Philadelphia, Penn., Nov. 16, 2006. Major Collaborators: Prof. John R. Kallis (California University of Pa.) Graduate Advisor: Prof. Gary Stewardson (Utah State University). Military: U.S. Army, Fort Carson, Colo. Unit Administrative Specialist (Dec. 1998-April 1999), duties: Created and maintained databases for 231 soldiers; responsible for processing all information on incoming and outgoing personnel databases implementation saved 18% manpower. Nuclear Chemical Biological Specialist (Jan. 1998-Dec. 1998), duties: Maintained, overhauled and calibrated all chemical equipment; trained soldiers in how to React in certain NBC situations. Fire Control Repairer, duties: Served as a shop foreman; supervised eight personnel which were responsible for repairing electronic fire control equipment; repaired all electronic equipment on the M!A! and Bradley tanks; and maintained records of cost and requisitioned funding from battalion. Saved 65% in cost by performing office computer repairs. Military Achievements: Two Army Achievement medals, Army Good Conduct Medal, National Defense Service Medal, Army Lapel Button, Army Service Ribbon, Expert Marksmanship Qualification Badge with Grenade Bar, and Marksman Marksmanship Qualification Badge with Rifle Bar. Work Experience: Utah State University, Jan. 2010 to present, instructor for ETE 1020 energy, power, transportation systems control technology exploration of the concepts and processes relating to the control and automation (both hard and programmable) of technical systems in the areas of energy and power, transportation, and agricultural and related biotechnologies. California University of PA, Jan. 2008 to May 2009, Teaching Assistant. Assisted the professor in class preparation, lesson plans, and distribution of materials Also gain teaching experience by lecturing the class section which deals with programming robots. Managed a laboratory, which allowed students to complete experiments. AT&T Broadband, Pittsburgh Penn., May 2000 to Dec. 2002, Head end Technician, responsible for all aspects of high speed data, telephony and cable operations, hybrid fiber to coax transmissions, programming in Visual Basic, C++, Java scripting, and M.S. Office. Experience with systems such as Cheetah, Path Tracks, and Cornerstone. Access Bandwidth Technician, responsible for implementing and maintaining telephony network systems for the Pittsburgh and surrounding areas. Data basing and systems programmer for repairs on nodal analysis and problem solving, Heilig-Meyers Furniture Company, Richmond, Va., Aug.1994-Nov. 1994, Network/Telephone/Alarm System Installer, traveled throughout the United States to install computer networks, telephone and alarm systems, which also

included maintenance and repair. Guardian Glass Corporation, Floreffe, Penn., Electrical Maintenance Technician, Nov. 1993-June 1994, installed PLC systems (Allen-Bradley); repaired and maintained laser systems, photo helix, pyrometers, and integrated control systems for network operations. WLTJ-WRRK radio station, installed and calibrated all transmission equipment for this radio station.

Dr. Oenardi Lawanto, Utah State University

Oenardi Lawanto is an Assistant Professor of the Department of Engineering Education at Utah State University. Lawanto holds B.S. and M.S. degrees in electrical engineering and a Ph.D. in human resource education. His research interests include areas in cognition, learning, instructions, engineering design, and e-learning. Currently, he is working on two research projects that investigate students' cognitive and metacognitive activities while learning engineering. Both projects are funded by the National Science Foundation (NSF).

Offsetting Gender Bias in Engineering: Gender Equity Internet-Controlled Fish Farm Curriculum Activity

Abstract

The purpose of this paper is to suggest ideas that may balance gender bias in engineering fields, and how to address a nationwide problem in the U.S. industrial competitiveness with regards to female participation. The Census Bureau estimates that 50.9 percent of the population in the U.S. is female, while only 11 percent of them are engaged in the engineering workforce [40]. The National Science Foundation (NSF) reports that, overall, women earn bachelor degrees in fields other than science, technology, engineering, and mathematics. Existing research suggests that the reason may be connected to the notion that engineering is a man's domain, while women are generally interested in environmental issues. In addition, research indicates a trend where women are more likely to occupy a larger percentage of the workforce in environmental issues such as bioengineering. This proposed activity implements an Internet-Controlled Integrated Fish Farm Environmental curriculum activity to encourage female participation and combine engineering core concepts. The study involves a project to raise fish indoors while maintaining a garden-type environment through integrated sustainable systems. Through this activity, female students can participate in water quality research, applying fundamental concepts of chemical engineering. In addition, the students manipulate the water recycling system and apply concepts of motion and flow stability related to mechanical engineering. Also, they become familiar with concepts of digital sensors related to electrical and computer engineering. Through the fish farm curriculum activity, students will have opportunity to: (1) work to implement the integrated sustainable systems to apply concepts and principles of networking; (2) be exposed to diverse concepts, principles, and fundamentals associated with different fields of engineering; (3) discover and expand their knowledge about the various fields including mechanical, computer, and chemical engineering; (4) connect their interest in environmental issues with different types of engineering concepts; and (5) identify that these integrated sustainable systems are crucial for the survival of the fishes of an Internet-Controlled Integrated Fish Farm Environmental curriculum activity. The intention of this project is to determine if female students will be likely to pursue an engineering career and thereby increase the percentage of female participation in the field of engineering in the U.S.

1. Introduction

According to the U.S. Labor Department, 15 of the 20 fastest-growing occupations projected for 2014 will require significant mathematics or science preparation. The workplace is projected to increasingly require a solid background in science, technology, and engineering [11]. If the U.S. educational system does not generate increased interest in students in the engineering fields, it is likely to be at a disadvantage in maintaining its status as an advanced industrialized nation. The U.S. could lose its scientific and technological competitive edge over other industrialized countries over the next few decades because of the lack of a labor force in technological fields. A study by the NSF in 1996 reported that during their last year of high school, male students were more than three times as likely to pursue an engineering career, as compared to female

students [30]. Some researchers believe that increasing the interest of female students in engineering fields should increase participation of women in engineering careers. Researchers are searching for solutions to eliminate the gender bias and thereby increase the participation of women in engineering in the U.S. The Society of Women Engineers (SWE) reported in 1996 that 55 percent of all U.S. undergraduates' students were women, but only 20 percent were enrolled in engineering [17]. In 2004, the SWE recognized that the percentage of women enrolled in engineering had decreased to 16 percent [18]. Evidence of this disparity presents itself where women represent 46 percent of the U.S. labor force, but hold only 22 percent of the jobs in math, science, and engineering [25].

In 1991, the Ryerson Polytechnic University of Canada initiated a summer camp for K-12 female students aimed at motivating them to choose an engineering-related career [45]. Moreover, in 2000's decade, Massachusetts Institute of Technology (MIT) has developed a program to motivate female high school students to pursue engineering [28]. However, these programs, although achieving relative success, involved students with a pre-existing interest in engineering-related careers. Also, these programs contained a very low part of female population of high school in the U.S. [28].

Similarly, the governments of other countries have recognized the importance of increasing interest in the field of engineering and have developed policies to motivate women to work in the field. For example, in March 2002, the Norwegian government passed legislation requiring that 40 percent of the executive board of director members should be women by the year 2005 [16]. Two years after the March 2002 legislation, in 2004, only 8 percent of women in Norway had involved themselves in a field related to engineering [16]. Richardsen and Mercer stated, "Considering the most recent statistics, one has to conclude that despite a number of political initiatives and social welfare policies that promote equality, Norway has failed in the implementation of these policies and therefore not achieved the desired results" [16]. In 2000, Gina Zabludovsky developed a study in Mexico which concluded that the participation of Mexican women as middle managers in governmental elected positions was 27 percent [16] (pp. 183). Also, Zabludovsky stated that participation of women in management positions in the same year had decreased to 14.3 percent [16] (pp. 183), and only 2 percent of which were in the field of engineering [16] (pp. 184). Jensen stated that the cultural perception of women, representation of gender beliefs, and the belief that "men hired men" are issues that suggest why women do not accept work in engineering disciplines [23].

The purpose of this paper is to propose thoughts that may balance gender bias in engineering disciplines based in the premise that women lead to a more nurture approach to animal wellbeing and consequently, showing interest in the areas of biology and bioengineering.

2. The attitude of women toward animals.

The results of a number of studies have suggested that women are engendered with a more positive attitude than men toward animals and their welfare. Studies have identified a gender bias insofar as attitudes towards the wellbeing of animals, with women characteristically displaying

more positive or "caring" attitudes with regards to this issue [36, 37]. Research by Knight, Vrij, Cherryman, and Nunkoosing [27] found that women, influenced by hormonal and genetic differences, are predisposed to spontaneously empathize and display a sympathetic reaction to animals, and are less tolerant of animal suffering [6]. Other researchers have maintained that the structural location of females in society better explains gender differences [1], meaning that females identify with animals and animal rights' issues because they perceive themselves and animals to have similar positions in society due to patriarchal oppression. Thus, females tend to express more egalitarian and non-hierarchical ideologies. Herzog, Betchart, and Pittman [20] proposed theoretical reasons for gender differences that included: (i) the sociocultural perspective, that women are socialized to care and nurture, at the same time as boys are encouraged to be less emotional and more utilitarian; and (ii) that femininity leads to a more nurturance-expressive dimension of personality that is more highly related to concern for animal welfare, even as masculinity relates to less sensitivity to the ethical treatment of other creatures.

Gender is known to have a major influence on an individual's views about animals [34]. In Pifer's study, females were more opposed to animal suffering than males in all of the 15 nations surveyed (including Great Britain, the U.S., Japan, France, and West Germany). A logical conclusion may be that women are more concerned about reverence for life compared to males. The recent increased public concern regarding the welfare of animals may be at least partially linked to greater recognition of women's rights and attitudes. Furthermore, Serpell [36] found that "the most important trends detected thus far are that women tend to show stronger affective and weaker utility orientation to animals than men" [7, 21, 26, 32, 33, 37, 43].

3. The attitude of women toward biology and bioengineering.

Baker and Leary (1995) conducted interviews with female students in K-2, K-5, K-8, and K-12 in an effort to determine what factors influenced them to pursue the field of biology [4]. During the interviews, students from middle to high school said that they rejected physical science because the area was not viewed as related to helping or caring, instead preferring biology that would allow them to help people, animals, or the earth [4]. Keeves and Kotte (1992) found that men were more likely to enroll in physics and chemistry courses in secondary school. Biology was the only female-dominated area; females exceeded the number of male students enrolled [25]. This saturation exists because biology has been traditionally viewed by women as a nurturing branch of science that focuses on living organisms and human health. Physics, however, is often viewed negatively by women as having a relationship to war and destruction [24]. The interest of females in biology and the objective to improve the environment and society may lead them to medicine or other health professions rather than science and engineering per se. In contrast, men who continue in science are drawn to applied science careers in engineering, computer science, and medicine, but not generally with the focus of helping people [29].

The percentages of women in engineering fields are increasing mostly in the field of bioengineering [12]. Two reasons are cited for the increase in female enrollment in bioengineering: a relatively large female population exists in this career and females feel confident and comfortable working with other women [39] and female role models [12]. According

to the American Society of Electrical Engineers (ASEE), biomedical engineering recruits the second largest percentage of female students following environmental engineering [12]. In addition, biomedical engineering has the highest percentage of women receiving a PhD in engineering (36 percent) [12]. Trower and Chait [38] stated that "the most accurate predictor of later success for female undergraduates is the percentage of women among faculty members at their college." Sandra Harding [12], suggested that "the presence of a significant number of women in a field often increases its legitimacy and the value of its work in the public perception."

4. Description of a fish farm project

Studies have suggested that biology projects such as fish farming encourage students to integrate the fundamentals of math and science. Wingenbach [44] has researched students enrolled in fish farming (aquaponics) programs at the secondary level, revealing the incorporation of math and science concepts and providing hands-on practical experiences [13]. Mooring and Hoyle (1994; quoted in Comoy & Peasley, 1997) reported that one aquaculture program in North Carolina used chemistry, biology, and math in an integrated manner with their closed recirculation system, pond, and caged pond production methods.

An Internet-controlled fish farm curriculum project raises fish in indoors in enclosure tanks that apply aquaculture and aquaponics to recycle the water [35]. Female students will develop the curriculum activity with the support of their teachers and assistants. With an Internet-Controlled Integrated Fish Farm Environmental (ICIFE) curriculum activity, students are expected to familiarize themselves with the basic fundamentals of engineering components of a fish farm such as aquaponics, hydroponics, biofiltration [35], and Internet Protocols (IP) [10]. The incorporation of technology, engineering, and mathematics related to the internet control provides innovative and hands-on activities through which women gain knowledge and skills using higher-order cognitive processes.

An ICIFE curriculum activity could be developed in-house with an indoor Recirculation Aquaculture System (RAS). A RAS is a series of rearing tanks and filters that constantly recycle water and monitor toxins to maintain optimum conditions needed to raise fish [18]. Female students will biologically treat the water through the process of particles' elimination and conversion of dangerous chemicals into non-hazardous forms. Also, they will keep the temperature [19] of the water in a safe range during operations. Female students are expected to apply concepts of denitrification [14], water exchange, nitrates, and hydroponics related to biochemistry engineering (See Figure 1[3]).

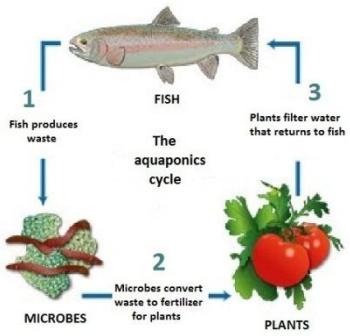

Figure 1

There are different types of fish that students could raise in an ICIFE curriculum activity. Although tilapia is the commonly used commercial fish in aquaponic systems, students could raise carp, goldfish, crappies, and rainbow trout [35]. Female students are more able than male students to adopt humane practices to care for the fish. Students also learn about fish behavior, characteristics, and provisions of feeding. An ICIFE curriculum activity estimates that students can apply their knowledge of biological principles in the process of fish treatment.

The systems of an ICIFE curriculum activity consist of a rearing tank, hydroponics, sump of particulate removal device, water circulation pump, an auxiliary, and a monitoring subsystem to integrate the farm's components.

A subsystem of hydroponics is where plants are grown by absorbing excess nutrients from the water of a rearing tank [8]. It consists of a tank with water and nutrients for growing healthy plants. The subsystem provides activities such as plant care, plant classification, management of chemical solutions and nutrients. Female students will work with:

- plants that grow in an aquaponics system such as leafy green vegetables, vines, fruit, and fruit trees, flowers, and fodder [8].
- process of efficiency but also of the chemical pathways involving raw materials such as nutrients for growing healthy plants [15].
- biofilters to remove fish excretory products, suspended solids, and excess of nitrogen and other dissolved gasses [17, 25].

During these activities, female students will also apply principles of biochemistry engineering along with the fundamentals of efficiency of chemical processes associated to different components of the subsystem. Also, they will analyze the behavior of water and plants involved in a hydroponic subsystem [15].

The subsystem sump of particulate removal device and water circulation pump consists of a clarifier tank used to prevent the excessive accumulation of fish residuals and waste. Female students will observe and analyze the amount of water circulating in the system [41] and level of toxicity with the scale of potential Hydrogen (pH) [35]. In this part of the ICIFE curriculum activity, students will gain an understanding of the fundamentals of mechanical engineering and

fluid mechanics to apply relationships between forces, motion, flow stability, and flow in enclosed bodies [5].

The auxiliary subsystem consists of the cooling, heating, and electrical equipment needed to develop the fish farm project. Female students will familiarize themselves with the electrical facilities installed and the schematics including a water pump, sunlight lamps, and other devices to monitor the rearing tank [8]. As a result, female students will be exposed to electrical components applying the basic concepts of electrical engineering [22].

The monitoring subsystem observes the water temperature, pH indicator of the water, rearing tank level of water, and surveillance of the fish farm facilities [42](See Figure 2). Female students will install and configure a Web-based device [42], host server to observe alarms, and surveillance cameras to observe ICIFE. They will be exposed to the principles of automation and computer engineering, apply concepts of an SNMP agent, SNMP server, routing, internet protocol (IP) addressing, and management information database (MIB) [10].

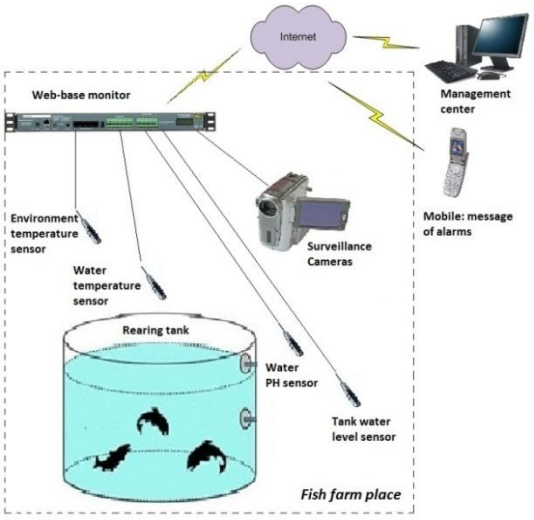

Figure 2

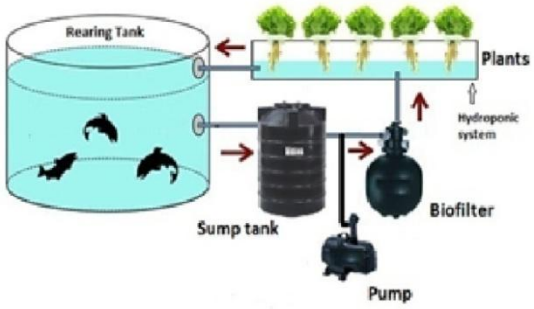

Figure 3

Figure 3[2] shows all of the subsystems together as part of the ICIFE curriculum activity.

An ICIFE curriculum activity exposes students in a comfortable environment. Also, an ICIFE will encourage female participation to utilize bioengineering as a base while exposing them to different areas of engineering. Because women are interested in the area of bioengineering, this curriculum activity will be oriented to motivate a large female population to enroll in engineering careers. Another important result of developing an ICIFE curriculum activity is the influence of a role for the female students. Bioengineering is comprised of a majority of female faculty members [38] and a higher fraction of women receiving PhDs in engineering [12]. Although government policies have largely failed to motivate women to work in engineering fields, private sector companies have demonstrated the importance of role models in recruiting women in their companies. Google [9] is partnered with dozens of organizations focused on attracting young women to tech fields. Diana Johnson, Manager of World Exploration in Search of Great Talent for the Texas Instruments Company [31], stated “Multicultural citizens are not entering the

engineering field in great enough numbers, so they are under-represented (as compared to the census population data). We need to encourage under-represented students to pursue math and science to strengthen our engineering pipelines for the future."

5. Conclusion

With an Internet-Controlled Integrated Fish Farm Environmental curriculum activity, female students will be involved in working with principles of bioengineering. Also, they will apply concepts and principles related to other engineering fields in an environment with other females and faculty as role models. This curriculum activity could be developed in every high school nationwide, increasing the interest, participation, and recruitment of female students in engineering-related careers, coinciding with their preference in nurturing living organisms. Increasing the interest of female students in engineering will likely increase their participation in engineering-related careers. The overriding objective of this curriculum activity is to encourage and prepare female students to pursue an engineering career in similar numbers as male students. The last intention of this curriculum activity is to increase the percentage of women in the field of engineering in the U.S. As Neal Lane, a former Assistant to the President for Science and Technology noted at the Summit on Women in Engineering [8] stated, ". . . we simply need people with the best minds and skills, and many of those are women."

References

1. Adams, C.J. (1994). Bringing peace home: A feminist philosophical perspective on the abuse of women, children, and pet animals. Hypatia, 9: 63-84.
2. Aquaponics Gardening Blog spot. Retrieved from http://aquaponic-gardening.blogspot.com/
3. Backyard aquaponics. Retrieved from: http://www.backyard-aquaponics.org/all-about-aquaponics-fish-diagram. Backyard Aquaponics Pty Ltd, Success, Western Australia 6964.
4. Bakery, D., & Leary, R. (1995). Letting girls speak out about science. *Journal of Research in Science Teaching, 32*, 3-27.
5. *Bar-Meir, G. (2002). Basic of Fluid Mechanics. Version 1.2.* Free Software Foundation, Inc. 51 Franklin St, Fifth Floor, Boston, MA, 02110-1301.
6. Baron-Cohen, S. (2003). *The essential difference: Men, women and the extreme male brain*. Penguin/Basic Books. Penguin Group Editorial. Penguin Books Ltd: 80 Strand, London, WC2R ORL, England.
7. Blackshaw, J. K., & Blackshaw, A.W. (1993). *Student perceptions of attitudes to the human-animal bond. Anthrozoos: A Multidisciplinary Journal of the Interactions of People & Animals, 6,* 3:pp. 190-198(9).
8. Booz, D., & Yohe, B. (n.d.). SCHS's aquaculture. Retrieved from http://www.angelfire.com/md2/schs/
9. Bradley, C. (2010, April 6). Financial edge. Top tech companies for women. Retrieved from http://financialedge.investopedia.com/financial-edge/0410/Top-Tech-Companies-Hiring-Women.aspx#axzz1ixZIP1XV. Blog by C. Bradley.
10. Bruey, D. (2005). *SNMP: Simple? Network management protocol.* Rane Note. Rane Corporation. Retrieved from: http://www.rane.com/pdf/ranenotes/SNMP_Simple_Network_Management_Protocol.pdf
11. Bureau of Labor and Statistics, Fastest growing occupations, 2004-14. Retrieved from http://www.bls.gov/emp/emptab21.htm
12. Chesler, N.C., Barabino, G., Bhatia, S. N., & Richards-Kortum, R. (2010). The pipeline still leaks and more than you think: A status report on gender diversity in biomedical engineering. *Annals of Biomedical*

Engineering. (Feb. 2010). Biomedical Engineering Society. Massachusetts Institute of Technology. *Journal of Biomedical Engineering*.
13. Conroy, C., & Peasley, D. (1997). *National aquaculture curriculum phase I evaluation report*. Submitted to the National Council for Agricultural Education/USDA.
14. Corpron, K.E., & Armstrong, D. A. (1983). Removal of nitrogen by an aquatic plant, Elodea densa, in recirculating Macro brachium culture systems. *Aquaculture*, *32*, pp. 347–360.
15. Darton, R. C., Prince, R.G.H., & Wood, D. G. (2003). *Chemical engineering: Visions of the world. 1st Ed.*, Netherlands: Elsevier Science B.V. Retrieved from http://www.scribd.com/doc/7011048/Chemical-Engineering-the-First-1-O0-Years
16. Davison, M.J., & Burke, R.J. (2004). *Women in management worldwide: Progress and prospects. Second Edition.* Surrey, GU9 7PT, England: Gowner Publishing Limited.
17. Hall, A. G. (1999). A comparative analysis of three biofilter types treating wastewater produced in recirculating aquaculture system. *Virginia Polytechnic Institute*.
18. Hanson, S. L., Schaub, M., & Baker, D. P. (1996). Gender stratification in the science pipeline: A comparative analysis of seven countries. Sage Publications, Inc., Thousand Oaks, CA. *Gender and Society, 10,* 3: pp. 271-290.
19. Helfrich, L., & Libey, G. (1991). Fish farming in recirculating aquaculture system (RAS). Department of fisheries and Wildlife Sciences. Virginia Tech.
20. Herzog, H. A., Betchart, N. S., & Pittman, R. B. (1991). Gender, sex role orientation, and attitudes towards animals. *Society and Animals*, *8*: 184-194.
21. Herzog, H. A., & Galvin, S. (1997). Common sense and the mental lives of animals: An empirical approach. In R. W. Mitchell (Ed.), *In anthropomorphism, anecdotes and animals* (pp. 237-253). Albany: State University of New York Press.
22. Holbert, D. (1998). Circuit analysis technique. Retrieved from: http://holbert.faculty.asu.edu/ece201/recipes.html
23. Jensen, K. (2002). Women working in science, engineering, and technology: Higher education and industry. Informatics Research Institute. UK.
24. Jones, M. G., Howe, A., & Rua, M. (1998). Gender differences in students' experiences, interest, and attitudes toward science and scientists. *Science Education, 84:* 180-192.
25. Keeves, J., & Kotte, D. (1992). Disparities between the sexes in science education: 1970-84. In J. Keeves (Ed.), *The IEA study of science III* (pp. 141-164). New York: Pergamon.
26. Kellert, S.R., & Berry, J.K. (1987). Attitudes, knowledge, and behaviors toward wildlife as affected by gender. *Wildlife Society Bulletin*, *15*: 363-371.
27. Knight, S., Vrij, A., Cherryman, J., & Nunkoosing, K. (2004). Attitudes towards animal use and belief in animal mind. *Anthrozoos: A Multidisciplinary Journal of the Interactions of People Animals*, *17*, 1: 43-62.
28. Massachusetts Institute of Technology. (n.d.). Women's Technology Program. Retrieved from http://wtp.mit.edu
29. Miller, P. H., Blessing, J. S., & Schwartz, S. (2006). Gender differences in high-school students' views of Science. *International Journal of Science Education, 28,* 4: 363-381.
30. National Research Council (U.S.). (1991). Women in science and engineering: Increasing their numbers in the 1990s: a statement on policy and strategy. Washington, DC: National Academy Press.
31. National Society for Hispanic Professionals. Interview with Diana Johnson of Texas Instruments "Manager of World Exploration in Search of Great Talent". Interview posted by NSHP Editor on March 6, 2006. Retrieved from: http://network.nshp.org/profiles/blogs/interview-with-diana-johnson
32. Paul, E. S., & Serpell, J. A. (1993). Childhood pet keeping and humane attitudes in young adulthood. *Animal Welfare, 2*: 321-337.
33. Phillips, C.J.C., & McCulloch, S. (2000). Students' attitudes on animal sentience and use of animals in society. *Journal of Biological Education*, *40,* 1: 17-24.
34. Pifer, L., Shimizu, K., & Pifer, R. (1994). Public attitudes toward animal research: Some international comparisons. *Society and Animals*, *2*: 95-113.
35. Rakocy, J. E.; Masser, M.P. & Losordo, T.M. (2006). Recirculating aquaculture tank production systems: Aquaponics — integrating fish and plant culture. Southern Region Aquaculture Center. Retrieved from http://www.aces.edu/dept/fisheries/aquaculture/documents/309884-SRAC454.pdf
36. Serpell, J. A. (2004). Factors influencing human attitudes to animals and their welfare. Universities Federation for Animal Welfare. The Old School, Brewhouse Hill, Wheathampstead, Herfordshire AL4 BAN, UK. Animal welfare 2004, I3: S145-151.

37. Serpell, J. A. (2005). Factors influencing veterinary students' career choices and attitudes to animals. *Journal of Veterinary Medical Education, 32,* 4:491-496.
38. Trower, C., & Chait, R. (2002). Faculty diversity. *Harvard Magazine, 98*: 33-37.
39. Tully, D., & Jacobs, B. (2010). Effects of single-gender mathematics classrooms on self-perception of mathematical ability and post secondary engineering paths: An Australian case study. *European Journal of Engineering Education*, *35,* 4: 455-467.
40. United States Census Bureau. (1993). *Statistical abstract of the United States*. Washington, DC*:* U.S. Dept. of Commerce, Economics and Statistics Administration, Bureau of the Census, Data User Services Division.
41. Waters, P. L. (n.d.). High school aquaculture/aquascience programs: A success story and model for future programs. Retrieved from http://www.masgc.org/pdf/bab/eoe/Waters.pdf
42. Web-based climate monitor / Relay Control. (2010). Relay Goose II. Datasheet. Rev. 1.06. ITwatchdogs.com. Remote sensors.
43. Wells, D.L., & Hepper, P. G. (1997). Pet ownership and adults' views on the use of animals. *Society and Animals, 5*: 45-63.
44. Wingenbach, G. J., Gartin, S. A., & Lawrence, K. D. (1999). Students' perceptions of aquaculture education in the northeast region. *Journal of Agricultural Education, 40,* 11999: 14-22.
45. Zywno, M.S., Gilbride, K.A., Hiscocks, P.D., Waalen, J.K., & Kennedy, D.C. (1999). Attracting women into engineering, a case study. Ryerson Polytechnical Institut*e,* Ontario, Canada. Retrieve from: http://www.ewh.ieee.org/soc/es/Nov1999/10/BEGIN.HTM