AC 2010-2220: ENGINEERS AS TEACHERS: HELPING ENGINEERS BRING CUTTING EDGE SCIENCE TO UNDERSERVED COMMUNITIES

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K-12 Pre-Engineering Education

Engineers as Teachers: Helping Engineers Bring Cutting Edge Science to Underserved Communities

Abstract

There is growing concern among the scientific community that the United States is not preparing a diverse enough group of students, in the areas of science, technology, engineering, and mathematics (STEM). The percentage of bachelor's degrees in STEM awarded to women in 2008 was only 18% while the representation of African-American and Hispanic students combined accounted for only 11% of bachelor's degrees, far below their combined 28% share of the general population. Research shows a large part of this problem can be attributed to the access underrepresented students have to higher-level STEM curriculum, resources and social capital.

In order to decrease the STEM achievement gap, a science education nonprofit, Iridescent, works with engineers to implement real-world, inquiry-based Family Science Courses in these underrepresented communities. Iridescent's mission is to foster curiosity and inspire self-confidence in young people with limited access—unlocking doors to their future and preparing them to help solve the world's most pressing issues. In order to accomplish this, Iridescent uses *volunteer engineers* to teach cutting edge science to students and their families.

Through Iridescent's partnership with the University of Southern California (USC), engineering undergraduates enroll in "Engineers as Teachers" and receive 3 units of technical elective credit for participating in the training program. During the 16-week training undergraduate engineers partner with graduate students, faculty and professional engineers and learn to break down complex ideas into simple lessons, identify learning objectives, design aligned experiments and assess learning through a pedagogical theory-based approach.

Throughout the training, engineer volunteers develop a story that pervades the five lessons. Each of the lessons incorporates fundamental physics concepts contributing to the students' understanding of the overarching story. Story topics are based on the engineers' research fields and align with the California State Science Standards of Education for different grade levels. Examples of topics include: The Physics of Running, Structural Color, and Bird Flight Aerodynamics. Experiments for each lesson enable participants to design and build working models that not only help them develop a deeper understanding of the concepts but also experience two very important aspects of scientific research: failure and the rewards of persistence. Engineers also incorporate pedagogical theory into each lesson using graphic organizers to develop student's higher-level thinking and questioning as students connect the content to the experiment in the "Think About It" section of the graphic organizer.

Iridescent uses formal assessments to measure interest in STEM subjects, and the content taught in every course. Content-based assessments are based on pedagogical theory and are constantly being modified to test for higher learning. Informal assessment questions are also completed by students and parents to measure STEM interest and knowledge. When asked what they want to do when they grow up, a participating student replied, "Maybe I'll become a scientist". As a result of our impact thus far, we've reached approximately 4,000 students and parents and on average participants have demonstrated an 80% increase in STEM interest.

The following paper will review: a description of the Family Science model and its relationship

to universities, a framework for volunteer engineer training, an explanation of pedagogical-based curriculum, an illustration of the students, families, schools, and school staff we work with, our impact so far, and our goals for future impact on Los Angeles students and their families.

Introduction

In 2006-07 of the 1.5 million bachelor's degrees awarded that year, only 5% were awarded to the fields of engineering and engineering technologies[1]. Furthermore, the representation of female and minority students in the areas of science and engineering remained, and continues to remain disproportionate. Females and ethnic minority students in STEM careers have been underrepresented for the past 30 years[2]. In 2008, degrees in STEM awarded to women was only 18% while the representation of African-American and Hispanic students combined accounted for only 11% of bachelor's degrees, far below their combined 28% share of the general population[3]. Underrepresentation continues into the workforce in these areas as well [4]. Without the representation of minorities and women in science and engineering, the United States is endangering its competition in the global economy[4].

In order to encourage participation in a dedicated and difficult field, much must be done to change the perception of science and engineering by minorities and women. Improving attitudes toward and achievement in science require continued classroom experiences in STEM, extracurricular activities involving STEM and the encouragement of others significant in a student's life[5]. Much research has also been done in order to determine the factors that inhibit the participation and success of minority and female students in STEM education. "The barriers for females and minorities are similar and include:
(1) Negative attitudes regarding mathematics and science along with negative perceptions of themselves as science and mathematics learners.
(2) Lower performance levels and lower rates of participation in mathematics and science courses and on standardized tests.
(3) Limited exposure to extracurricular activities in STEM.
(4) Lack of information, limited role models, varied influence of significant adults, and little interest or aspirations for STEM careers.
(5) Competitive rather than cooperative learning environments.
(6) More limited, often inferior, resources to support engaged learning.
(7) Teaching and learning environments that fail to support different learning and interaction styles.
(8) Discrimination and harassment in the classroom, especially against girls. "[5]

The formal education system does not have the capacity to provide STEM curriculum intervention enabling minorities and women course and career opportunities in STEM[5]. BEST (Building Engineering and Science Talent) has determined a "framework of design principles as a first approximation of what it takes to succeed over time in demanding educational and social environments. Programs designed to increase diversity in STEM courses and careers should address several areas. (The associated BEST design principle is listed.). The areas include, but are not limited to:
(1) **Challenging content:** Academic enrichment in science and mathematics
(2) **Personalization:** Contextual learning that enhances personal meaning and motivation to

learn.
(3)**Defined Outcomes:** College readiness experiences through on-campus or other college-connection events.
(4) **Engaged Adults:** Substantive, ongoing professional development in science and mathematics for teachers, including ongoing contact with content experts.
(5) **Sustained Commitment:** Broad-based, collaborative partnerships that promote high expectations and a college-going culture."[6]

Through the utilization of undergraduate engineers at the University of Southern California, and the continued participation of parents and families, Iridescent addresses all areas listed by BEST in order to provide students of underserved and underrepresented communities the opportunity to participate in STEM courses and careers.

Iridescent trains engineers to develop and teach hands-on, Family Science Courses to underserved children and their parents. The program has been successfully implemented in Los Angeles, the Bay Area and Salinas and shown to improve participants' interest in science, content knowledge and self-efficacy. The Family Science Courses are designed and taught by engineering undergraduate and graduate students to families at schools in the evenings. Each Family Science Course consists of five evening sessions of two hours each. Families are invited (including younger siblings). Formative assessments such as Exit Slips (three questions checking for content understanding) are conducted at the end of every session. Pre and post tests are conducted in each Family Science Course. Food is provided at every session. Instruction is translated into Spanish if the majority of families are Hispanic and non-English speaking. Topics illustrate the real-world applications of Physics and range from Cardiovascular Mechanics to Bird-flight Aerodynamics. Since Iridescent's incorporation in January 2007, 200 engineers have undergone science communication training and conducted 132 workshops reaching ~4000 underserved children and parents. For the purpose of this paper, we will be focusing on the most established site, Los Angeles, California.

School Demographics and Location

The Los Angeles community consists of a large and incredibly diverse population. With over 9 million people, 29% declare themselves white (not Hispanic), 9% consider themselves Black, and 48% of Hispanic or Latino origin, while 54% of the households in Los Angeles speak a language other than English[7]. Los Angeles is also one of the nation's capitals of economic deprivation with ~40% of residents unable to meet their basic needs, 1/3 of full-time workers earning less than $25,000/year and more than 20% of children living in extreme poverty. In addition, Hispanics and African Americans are 2.5 times more likely to be extremely poor as compared to non-Hispanic whites [7].

We recruit 1st-7th grade low-income students from Los Angeles Unified School District (LAUSD), District 7 schools that serve 78% Hispanic and 21% African-American students with the goal to increase the representation of these communities in higher STEM education. These students frequently attend under-funded, low-ranked schools with high levels of teacher turnover and emergency-credentialed teachers[4, 8-10]. The scarcity of academic support, informal and formal mentorship and role models within friend and family networks exacerbate the educational challenges facing these students[11-13]. As a result, these students are underrepresented in higher education, most notably in STEM[14-19].

In order to reach out to the most underserved schools (degree of need is measured by parent income and education levels, school crime and Academic Performance Index), we have developed an Urban School Needs Map that helps us compare Los Angeles public schools based on publicly available data (figure 1). All data is taken from the CA department of education, Los Angeles School Police Department and Los Angeles Unified School District. Thus we can make more data-driven decisions, scale cost-efficiently and identify long-term school partners that need and want to co-invest in the Family Science Courses. Ability to support the Family Science Courses is measured by parent response and administration's efficiency (e.g. the time taken to repair computers). The map can be accessed from www.IridescentLearning.org, "About Us", "Impact" and "USN Map Project". We also use a poverty map from United Way to determine whether we were operating in the high poverty areas.

We work with partner schools in order to recruit families by showing videos from previous Family Science Courses at Back to School Nights and parent meetings and by sending invitation letters to the parents. An example of such a recruiting video can be seen on our nonprofit YouTube channel: http://www.youtube.com/watch?v=Wq545270FDA

SCHOOL TYPE (X AXIS) VS. API (Y AXIS)

Dimension of the dot = Teacher to Student ratio

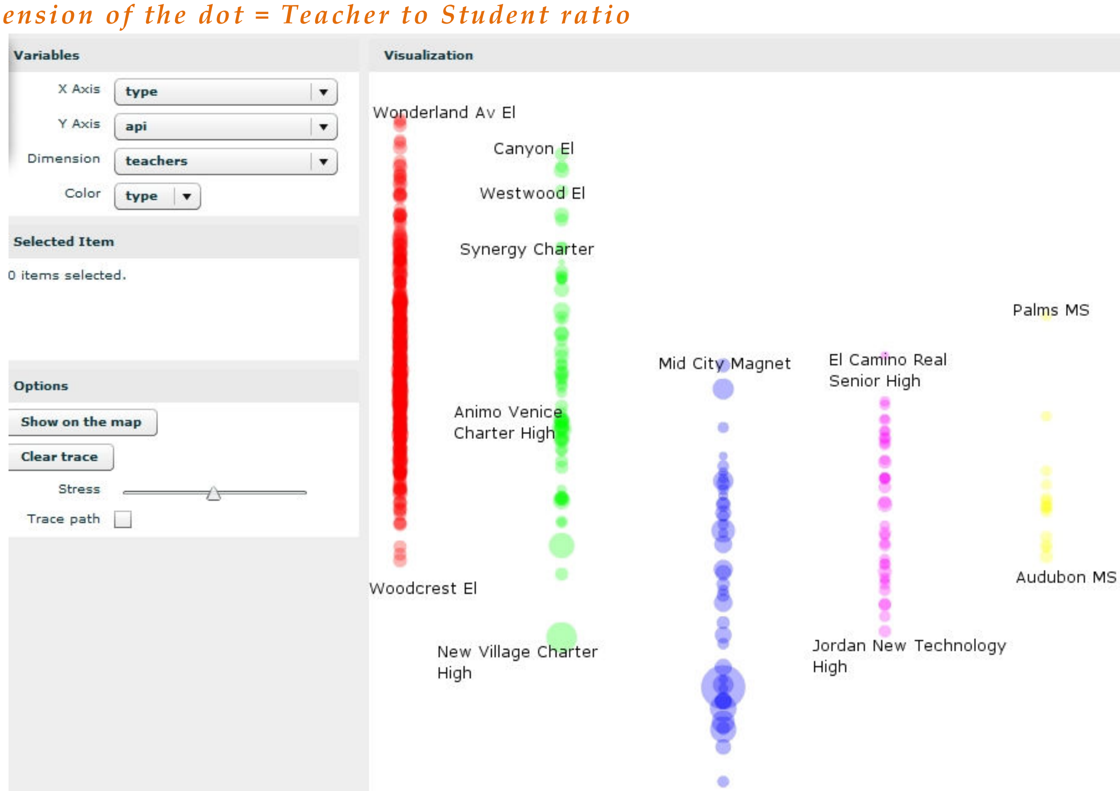

Figure 1 The scatter plot compares schools by type – elementary (red), charter (green), continuation (blue), high (magenta) and middle (yellow). The user can identify high and low performing schools by looking at the position of the schools on the y-axis (API).

Parent Involvement: Engaged Adults and Sustained Commitment

Numerous studies have established the link between parent involvement and improved student achievement, better school attendance, and reduced dropout rates.[20-38] Additionally, parental support has been identified as a predictor of the selection of a science or engineering major in college[39]. However, other studies and our experiences indicate that although parents care very much about their children's education they face significant obstacles to being involved.[32, 40-43] In order to increase parent-involvement, we must address: low education levels[26, 27, 33, 40, 42, 44, 45] language [32, 41, 46-50] logistical issues such as long working hours, multiple jobs or single parenthood, [33, 54] culture, [40, 55-58] and constrained communication between ethnic groups due to safety issues and mutual distrust.

We overcome parents' low education levels by designing materials that enable them to develop their own skills while facilitating their child's learning. Families attend 5-session courses allowing them sustained access to engineering and science content and to undergraduate and graduate engineers creating high expectations for learning, and a college-going culture[6]. The language barrier is addressed by providing bilingual materials, on-site translators and by communicating with adults via bilingual children. The direct instruction piece during which the engineers introduce and explain the concepts is limited to 15 minutes to ensure the translation process is not tedious for English-speaking adults. Logistical issues such as lack of time are mitigated by providing meals so that adults can free up the required time from preparing dinner, involving all the children to remove child care costs and by holding workshops at convenient times and in safe, familiar locations (e.g. school sites and community organizations). We support interracial communications by creating a space that allows interactions in pursuit of shared goals[59] (figure 2).

The emphasis on cooperative learning is culturally attuned to Hispanic and African-American communities whose "collectivist" cultures can clash with the individualistic nature of most formal education. Collectivism focuses on "interdependent relations, social responsibility and the well-being of the group"[40]. We build on the support of the family through an emphasis on cooperative learning and by inviting all (toddlers to grandparents) to participate in exploration.[45, 47, 54, 60]

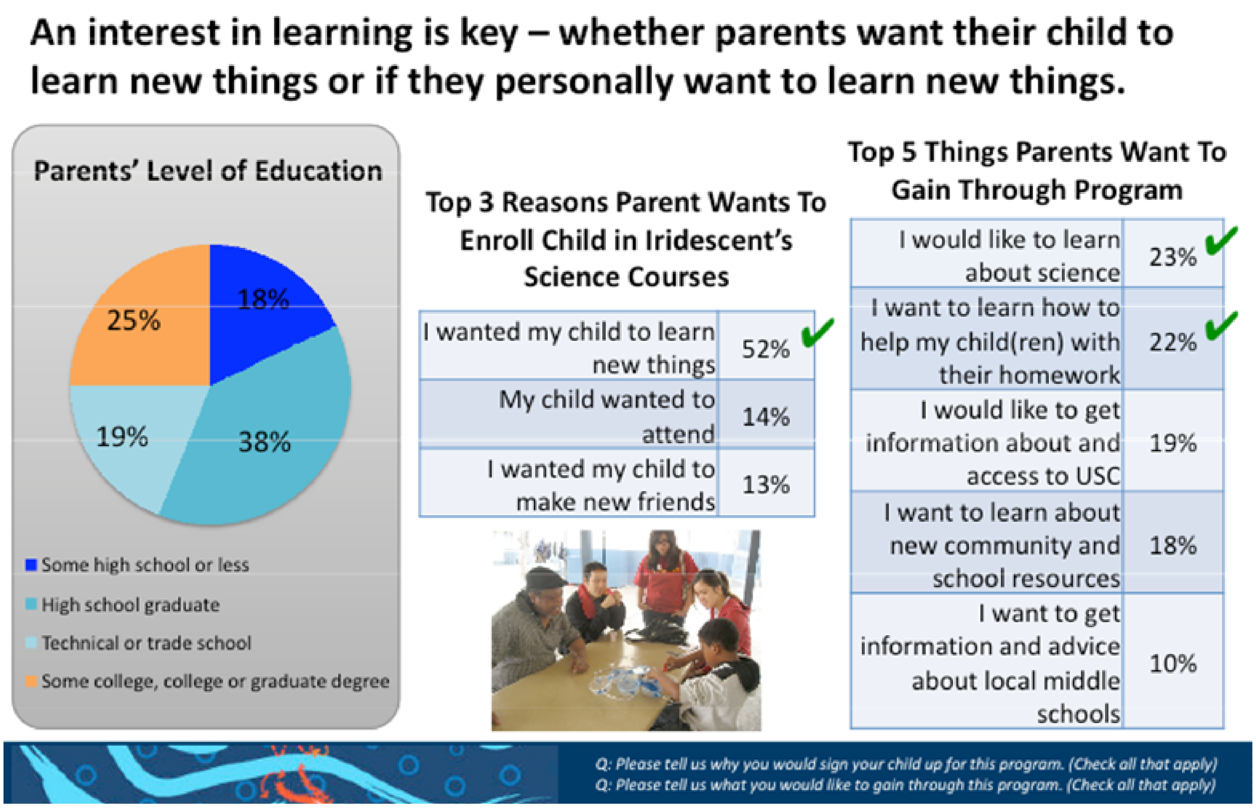

Figure 2: Top reasons for parents' interest in Iridescent

Engineers as Teachers: Personalization, Defined Outcomes, and Challenging Content

By working with engineers at the university level, Iridescent provides families with challenging content and college readiness experiences, key components to increasing the participation of minorities and women in STEM courses and careers[6]. University engineers also provide access to the field of engineering that would not normally be accessible to the students at school sites. None of our school partners offer courses or lessons that provide students with higher level science concepts found in engineering in accordance with the build, design, and re-design components of engineering analysis. Through a strong partnership with the University of Southern California, engineering undergraduates enroll in "Engineers as Teachers" and receive three units of technical elective credit for implementing the Family Science Courses. Every semester we recruit undergraduates by presenting in different classes, conducting social events and design competitions. We maintain a database of volunteers, alumni and potential candidates and send out a monthly newsletter. We encourage applications from women and minorities by advertising through campus diversity organizations. Undergraduates are paired with volunteering graduate students or professional engineers. We recruit the volunteers using Idealist.org and VolunteerMatch.org. We have recruited 20 undergraduates and 20 volunteers every year through these methods.

Interested candidates go through a *rigorous screening* process. They are required to: 1) provide a statement explaining why they are suited to this project. This stage tests applicants' interest, ability to self-analyze and write; 2) present a five-minute lesson on a topic of their choice. This tests their comfort with public speaking, preparation, time management, and initiative. Engineers go through 16 weeks of training during which they share their current research through two sets of four-session Family Science Courses. Their training addresses: how people learn, audience types and motivations, strategies for working with various age groups and designing engaging multi-media experiences[61]. The training also gives engineers a model for effective direct instruction, opportunities for them to practice their new skills and ways for them to self-evaluate their teaching.

Engineers are given a lesson plan template that helps them break down complex ideas into simple lessons, identify learning objectives, design learner-directed experiments and assess learning. Engineers limit direct instruction to 15 (consistent with what was said earlier) minutes so that the majority of the session time (1 to 1.5 hours) is spent experimenting and manipulating materials. Two well established lesson plan approaches are utilized: the Learning Cycles lesson approach[62] and Inquiry-based instruction[63]. Engineers practice teaching using few technical terms, real-world analogies and multi-media to ensure understanding for audiences with limited education. Engineers learn to use assessment practices such as graphic organizers to ensure families make significant knowledge gains[64]. Weekly preparation includes a reading assignment, instruction planning and reflective practice. Engineers are observed by Iridescent staff in each session and given feedback on how to improve their communication. The course syllabus with weekly training details and the lesson plan template can be accessed from our website (www.IridescentLearning.org), under "Programs" and "Engineer Training".

Evaluation

We use a multi-method research approach to evaluate program impact on families' and engineers' understanding and behaviors. We gather data using surveys, interviews, pre- and post-test scores, concept mapping, and fieldwork[65-71]. We administer pre and post assessments about families' STEM experience and knowledge, social capital and interest and engineers' public communication skills. We measure how multiple contextual factors such as socio-economic factors, quality and accessibility of experts and educational and technology resources affect participants' interaction with the curriculum and activities.

Outcomes for the families include developing the motivation to learn about science and to think of themselves as science learners. Participants are asked a variety of open-ended questions in order to demonstrate their understanding of engineering and science and their interest in the field (figure 3). Ongoing involvement leads to positive changes in communication at the individual, family and community levels.

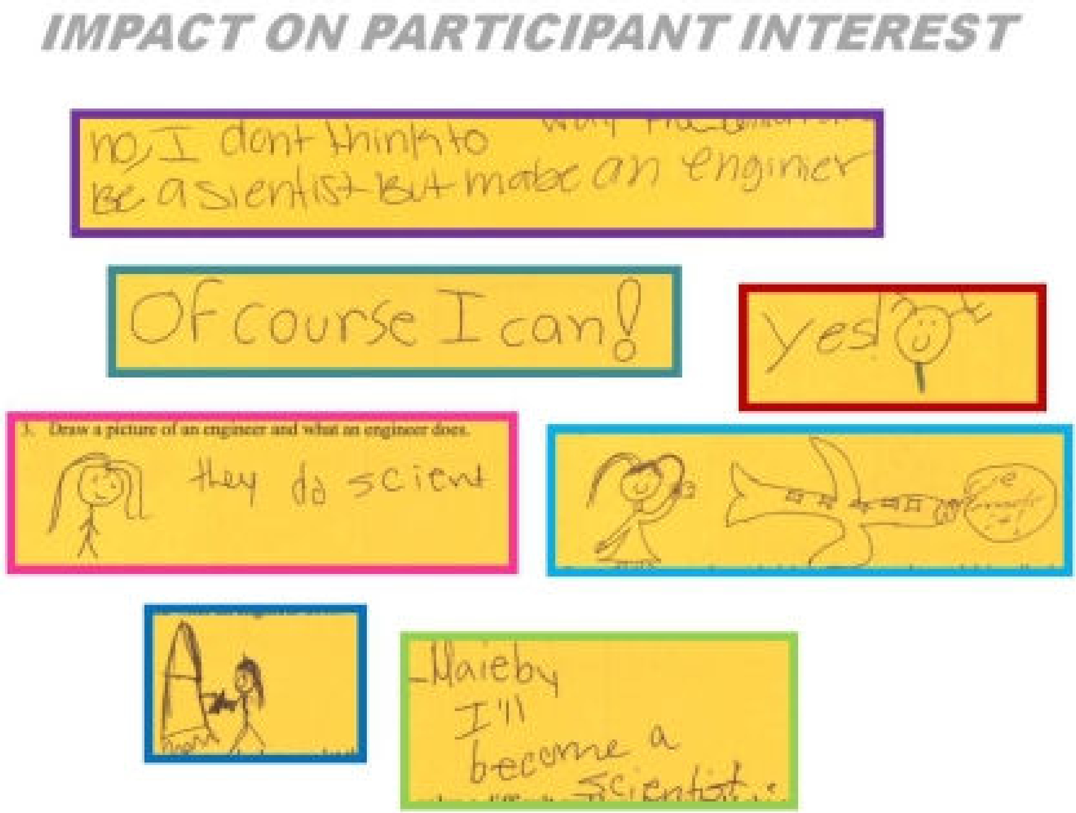

Figure 3: These examples were from the Girls and Mothers only Course that was led by two women aerospace engineers. After the Family Science Course, when asked to draw an engineer at work, the participants drew girls and women in their responses.

Measurable outcomes include a greater than 80% increase in families' STEM knowledge, interest and collective efficacy i.e. people’s confidence that they can unite to support their children’s science education.

Measurable outcomes for the engineers include a greater than 60% gain in: 1) awareness of their strengths and weaknesses while interacting with the public; 2) understanding motivations and learning styles of diverse audiences; 3) communication skills with the public.

Impact

Iridescent’s Family Science Courses impact the STEM community by:1) creating sustained learning experiences that help Los Angeles Schools broaden family participation in STEM; 2) fostering collaborations between universities and Los Angeles School that bring current research to the public; 3) impacting the STEM pipeline by bringing social capital to underserved communities; 4) developing and implementing technology-based, data-driven, evaluation and resource-allocation tools; 5) identifying factors that develop persistent participant interest in STEM

To date, we have developed a detailed 16-week training program that enables engineers to communicate complex ideas to the public. 160 engineers and 40 student-engineers have gone through our training and developed curricula on 14 topics (see figure 4) serving 4000 underprivileged children and parents at 80 sites in three cities.

We have provided 15,260 student contact hours and 1400 parent contact hours. We have had 20-30 families (40-70 participants) and >85% participant retention for every Family Science Course. We have conducted pre and post tests in each of the 132 workshops and have observed >80% gains in interest, motivation, knowledge of facts and terminology and >40% gains in understanding the processes of modeling and testing. We have developed ways of successfully recruiting and engaging non-English speaking parents. We have also conducted two large surveys (n = 361 and n = 943) and one in-depth interview study (n = 9) determining the needs of parents and the impact of the Family Science Courses. Results can be found on our website (www.IridescentLearning.org), under “About Us”, “Impact” and “Research”.

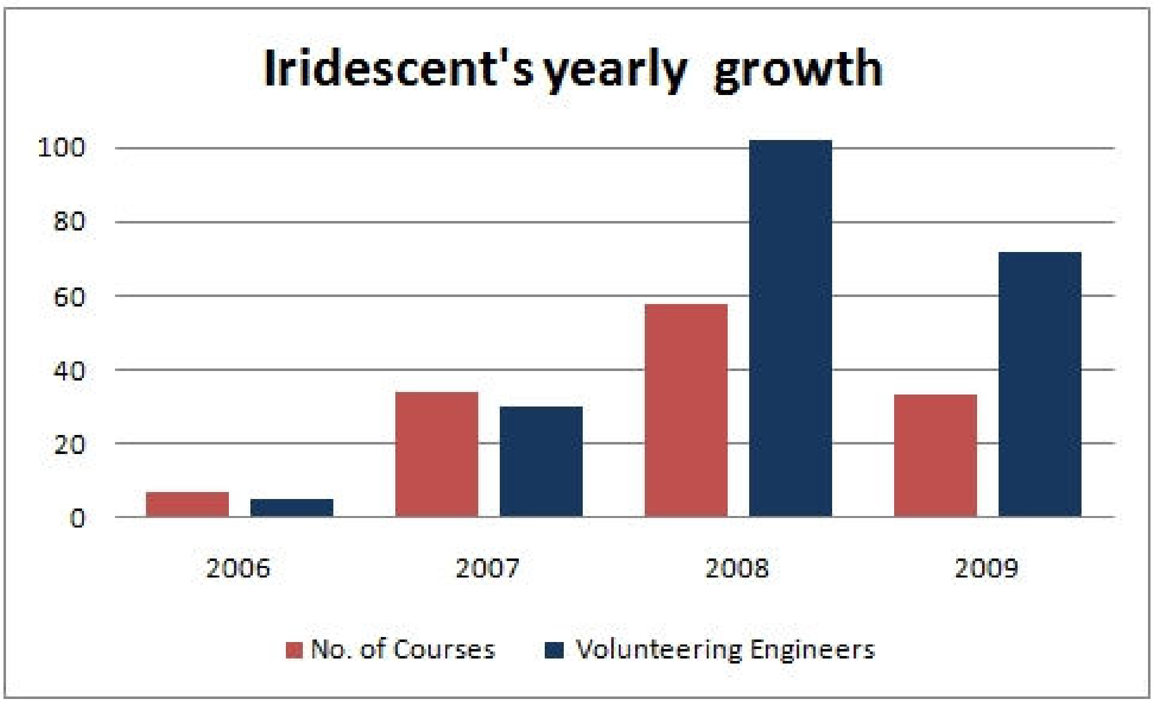

Figure 4: Iridescent’s yearly growth by the number of courses and volunteering engineers

Scalability and Growth

We have documented key aspects of the program for scaling. We have a detailed engineer training syllabus, lesson planning template, engineer observation forms, detailed guidelines and checklists for engineers, volunteers, translators, parents, teachers and school administrators and 70 existing lesson plans. We have developed a resource-allocation tool, the Urban School Needs (USN) Map that enables us to choose partner schools based on their need and interest in long-term partnerships. We have adapted the model for scalability by conducting seven courses in the

Bay area in 2007 and 2008 and one Family Science Course in Salinas with the Monterey Bay Aquarium in 2009. The primary lesson from these experiences was the importance of having a strong education partner at each site (Peninsula Bridge program for the Bay area and the Monterey Bay Aquarium for Salinas). With a strong partner, Iridescent's support role just entailed recruiting and training the engineers and providing comprehensive lesson plans. All other support activities were successfully conducted by the partner organizations.

Our vision is to have Iridescent sites in major metros within the United States and third world countries where there are high-need communities and strong resources (such as universities and technical industries). Scaling up will present challenges of magnitude, breadth and programmatic complexity[72]. The current Iridescent model has gone through three stages that will enable it to *scale successfully*: 1) We have shown it to be effective – i.e. we have credible evidence that the innovation has measurable and desirable effects; 2) We have shown that the initial successes can be replicated in settings similar to those in the scale-up site; 3) There is an established institutional mechanism (Iridescent partnering with universities and community organizations) to accomplish and sustain the scale-up.

Our three-year goal is to establish sites in the San Francisco Bay Area and in New York City. The Bay Area site is currently being established (Fall 2009) and we aim to start the New York City site in Fall 2010.

Our global vision is to adapt our curricula and develop teacher-support systems for implementation in third-world countries. We are currently partnering with a rural school system, Navodaya Vidyalayas, in India to test implementation of our curriculum at two sites. On successfully conducting the pilots in two Navodaya Vidyalayas, we will work with the administration to gradually deploy our curriculum within their system of 600 schools.

Conclusion

Iridescent's Family Science Courses incorporate all of BEST's recommendations of c**hallenging content, personalization, well-defined outcomes, engaged adults, and sustained commitment** in order to increase diversity in STEM courses and careers.

By utilizing University undergraduate and graduate students as instructors, Iridescent increases the exposure of challenging, STEM based curriculum to a diverse group of students. Engineers as Teachers also ensures that lessons are aligned with participating engineers' current research, and all lessons include a design-based experimental portion allowing instruction to be personalized. By working with student-engineers, families receive direct contact with college students and with college-ready curriculum. Families are also engaged in lessons as they learn alongside their children. Additionally, most families attend all 5-session courses allowing them sustained access to engineering and science content and to undergraduate and graduate engineers creating high expectations for learning, and a college-going culture.[5]

Iridescent's model using University graduates and undergraduates to deliver challenging content to the public can be replicated at different Universities with an engineering or higher sciences department. Iridescent is currently replicating this model in Monterey, Salinas, the Bay Area, and New York.

References

1. National Center for Education Statistics: U.S. Department of Education Institute of Education Sciences. The Condition of Education: Contexts of Postsecondary Education. http://nces.ed.gov/programs/coe/2009/section5/indicator40.asp

2. National Research Council - Board on Higher Education and Workforce. 2000. *Addressing the nation's needs for biomedical and behavioral scientists.* Washington, DC: National Academy Press.

3. Committee on Prospering in the Global Economy of the 21 Century. (2006). *Rising above the gathering storm: energizing and employing America for a brighter economic future*. Washington DC: National Academy of Science.

4. College Board. 1999. Reaching the top: a report from the national task force on minority high achievement. New York: The College Board.

5. *Fostering STEM Diversity, Davis-Butts, Oregon Pre-engineering and Applied Sciences Initiative, 2006,* (Clewell, Anderson, and Thorpe 1992; Rosser 1990; National Center for Education Statistics 2000b; Gatta and Trigg 2001).

6. Building Engineering and Science Talent (BEST). 2004. What it takes: pre-k-12 design principles to broaden participation in science, technology, engineering and mathematics. San Diego: BEST.

7. U.S. Census Bureau, State and County QuickFacts Los Angeles County, California 2000-2008 http://quickfacts.census.gov/qfd/states/06/06037.html.

8. *Condition of Education*. 2003, National Center on Education Statistics, U.S. Department of Education.

9. *Monitoring school quality: An indicators report*. 2000b, National Center for Education Statistics, US Department of Education: Washington DC.

10. Clark, K.B. and M.P. Clark, *Fifty Years Post-Brown: Desegregation to Diversity?* American Psychological Assocation, 2004. **35**(8).

11. Stanton-Salazar, R.D. and S.M. Dornbusch, *Social capital and the reproduction of equality.* Sociology of Education, 1995. **68**(2): p. 116-135.

12. Stanton-Salazar, R.D., *Manufacturing hope and despair: The school and kin support networks of U.S.-Mexican youth*. 2001, New York: Teachers College Press.

13. Clewell, B.C., B.T. Anderson, and M.E. Thorpe, *Breaking the Barriers: Helping Female and Minority Students Succeed in Mathematics and Science*. 1992, San Francisco: Jossey Bass.

333.

14. Gibson, M.A., *The new Latino diaspora and educational policy.* Education in the new Latino diaspora: Policy and the politics of identity., ed. S. Wortham, E.G. Murillo, and E.T. Hamann. 2002, Westport, CT: Ablex Publishing.

15. Bridgeland, J.M., J. John J. DiJulio, and K.B. Morison, *The Silent Epidemic: Perspectives of High School Dropouts*. 2006, Civic Enterprises and Peter D. Hart Research Associates for the Bill & Melinda Gates Foundation.

16. *Educational Attainment of High School Drop Outs Eight Years Later*, U.D.o.E.S.I.o.E. Sciences., Editor. 2004, National Center for Education Statistics.

17. Carger, C.L., *Attending to new voices.* Educational Leadership, 1997. **54**(7): p. 39-43.

18. McKissack, E.A., *chicano educational achievement: Comparing escuela tlatelolco, a chicanocentric school, and a public high school.* 1999, New York: Garland Publishing.

19. Scribner, A.P., *High performing Hispanic schools: An introduction.* Lessons from high-performing Hispanic schools: Creating learning communities., ed. P. Reyes, J.D. Scribner, and A.P. Scribner. 1999, New York: Teachers College Press.

20. Rumberger, R.W., *Dropping Out of Middle School: A Multilevel Analysis of Students and Schools.* American Educational Journal, 1995. **32**.

21. Lucas, T., R. Henze, and R. Donato, *Promoting the success of Latino language-minority students: An exploratory study of six high schools.* Harvard Educational Review, 1990. **60**(3): p. 315-340.

22. Baker, A.J. and L.M. Soden, *The challenges of parent involvement research.* 1998, ERIC Clearinghouse on Urban Education: New York.

23. Weisbaum, K.S., *"Families in FAMILY MATH".* 1990, Berkeley, CA: Lawrence Hall of Science, University of California, Berkeley.

24. Rogoff, B., C.G. Turkanis, and L. Bartlett, *Learning Together: Children and Adults in a School Community*. 2002: Oxford University Press.

25. Rogoff, B., *Developing Understanding of the Idea of Communities of Learners.* Mind, Culture and Activity, 1994. **1**(4): p. 209-229.

26. Epstein, J.L., *School/family/community partnerships: Caring for the children we share.* Phi Delta Kappan, 1995. **79**(9): p. 701-711.

27. EQUALS, *FAMILY MATH and Matematica para la familia.* 1992.

28. Gennaro, E., N. Hereid, and K. Ostlund, *A study of the latent effects of family learning courses in science discovery rooms and kidspaces: Museum exhibits for children.* Journal of Research in Science Teaching, 1986. **23**(9): p. 771-781.

29. *A report on the evaluation of the National Science Foundation's informal science education program.* 1998, COSMOS Corporation: Bethesda, MD.

30. Ascher, C., *Improving the school-home connection for poor and minority urban students.* Urban Review, 1988. **20**(2): p. 109-123.

31. Chavkin, N.F., *Families and schools in a pluralistic society.* 1993, New York: State University of New York Press.

32. Chavkin, N.F. and D.L. Gonzalez, *Forging partnerships between Mexican American parents and the schools.* 1995, ERIC Clearinghouse on Rural Education and Small Schools.: West Virginia.

33. Floyd, L., *Joining hands: A parental involvement program.* Urban Education, 1988. **33**(1): p. 123-135.

34. Peterson, D., *Parent involvement in the educational process.* 1989, ERIC Clearinghouse on Educational Management.: Eugene, OR.

35. Aspiazu, G.G., S.C. Bauer, and M.D. Spillett, *Improving the academic performance of Hispanic youth: A community education model.* Bilingual Research Journal, 1998. **22**(2): p. 1-20.

36. Jones, T.G. and W. Velez. *Effects of Latino parent involvement on academic achievement.* in *Annual Meeting of the American Educational Research Association*. 1997. Chicago, IL.

37. Astone, N.M. and S.S. McLanahan, *Family Structure, Parental Practices and High School Completion.* American Sociological Review, 1991. **56**(3): p. 309-320.

38. Rumberger, R.W., et al., *Family Influences on Dropout Behavior In One California High School.* Sociology of Education, 1990. **63**.

39. National Center for Education Statistics. 2000b. *Trends in educational equity for girls and women.* Washington, DC: US Department of Education.

40. Trumbull, E., et al., *Bridging cultures between home and schools: A guide for teachers.* 2001, Mahway, NJ: Lawrence Erlbaum Associates.

41. Shannon, S.M., *Minority parental involvement: A Mexican mother's experience and a teacher's interpretation.* Education and Urban Society, 1996. **29**(1): p. 71-84.

42. Lopez, G.R., *The value of hard work: Lessons on parent involvement from an (im)migrant household.* Harvard Educational Review, 2001. **71**(3): p. 416-437.

43. Melber, L., *Learning in Unexpected Places: Empowering Latino Parents.* Multicultural Education, 2006. **13**(4): p. 36-40.

44. Moles, O.C., *Collaboration between schools and disadvantaged parents: obstacles and openings.* Families and schools in a pluralistic society., ed. N.F. Chavkin. 1993, New York: State University of New York Press.

45. Sosa, A.S., *Involving Hispanic parents in educational activities through collaborative relationships.* Bilingual Research Journal, 1997. **21**(2): p. 1-8.

46. Hyslop, N., *Hispanic parental involvement in home literacy.* 2000, ERIC Clearinghouse on Reading, English and Communication.

47. Inger, M., *Increasing the school involvement of Hispanic parents.* 1992, ERIC Clearinghouse on Urban Education.

48. Lynch, S., *Science for all is not equal to one size fits all: Linguistic and cultural diversity and science education reform.* Journal of Research in Science Teaching, 2001. **38**(5): p. 622-627.

49. Moje, E.B., et al., *"Maestro, What is Quality?": Language, Literacy, and Discourse in Project-Based Science.* Journal of Research in Science Teaching, 2001. **38**: p. 469-498.

50. Warren, B., et al., *Re-thinking diversity in learning science: The logic of everyday language.* Journal of Research in Science Teaching, 2001. **38**: p. 529-552.

51. Fuentes, F., V.D. Cantu, and R. Stechuk, *Migrant head start: what does it mean to involve parents in program services?* Children Today, 1996. **24**(1): p. 16-18.

52. Delgado-Gaitan, C., *The power of community: Mobilizing for family and schooling.* 2001, Lanham, MD: Rowman and Littlefield Publishers.

53. Bright, J.A., *Partners: An urban black community's perspective on the school and home working together.* New Schools, New Communities, 1996. **12**(3): p. 32-37.

54. Scribner, A.P., *High performing Hispanic schools: An introduction.* Lessons from high-performing Hispanic schools: Creating learning communities., ed. P. Reyes, J.D. Scribner, and A.P. Scribner. 1999, New York: Teachers College Press.

55. Gibson, M.A., *The new Latino diaspora and educational policy.* Education in the new Latino diaspora: Policy and the politics of identity., ed. S. Wortham, E.G. Murillo, and E.T. Hamann. 2002, Westport, CT: Ablex Publishing.

56. Carger, C.L., *Of borders and dreams: A mexican-american experience of urban education.* 1996, New York: Teachers College Press.

57. Davidson, A.L., *Negotiating social differences: Youths' assessments of educators' strategies.* Urban Education, 1999. **34**: p. 338-369.
58. Lynch, S., *Equity and science education reform*. 2000, Mahwah, NJ: Lawrence Erlbaum Associates.

59. Kim, Y.C. and S.J. Ball-Rokeach, *Community storytelling network, neighborhood context, and civic engagement: A multilevel approach.* Human Communication Research, 2006b. **32**(4): p. 411-439.

60. Carger, C.L., *Attending to new voices.* Educational Leadership, 1997. **54**(7): p. 39-43.

61. Mayer, R.E., *Applying the Science of Learning: Evidence-Based Principles for the Design of Multimedia Instruction.* American Psychologist, 2008: p. 760-769.

62. Moyer, R.H., J.K. Hackett, and S.A. Everett, *Teaching Science as Investigations: Modeling Inquiry Through Learning Cycle Lessons*. 2006: Prentice Hall.

63. Polman, J.L., *Designing Project-Based Science: Connecting Learners Through Guided Inquiry (Ways of Knowing in Science Series)*. 2000: Teachers College Press.

64. Stull, A.T. and R.E. Mayer, *Learning by Doing Versus Learning by Viewing: Three Experimental Comparisons of Learner-Generated Versus Author-Provided Graphic Organizers.* Journal of Educational Psychology, 2007. **99**(4): p. 808–820.

65. Groves, R.M., et al., *Survey methodology*. 2004, New York: John Wiley & Sons, Inc.

66. Shadish, W.R., T.D. Cook, and D.T. Campbell, *Experimental and quasi-experimental designs for generalized causal inference.* 2002, New York: Houghton Mifflin Company.

67. Dillman, D.A., *Mail and Internet surveys--The tailored design method.* 2000, New York: John Wiley & Sons, Inc.

68. Merriam, S.B., *Qualitative research and case study applications in education.* 1998, San Francisco: Jossey-Bass.

69. Novak, J.D., *Learning, Creating, and Using Knowledge: Concept maps as facilitative tools in schools and corporations.* 1998, Mahwah, New Jersey: Lawrence Erlbaum Associates.

70. Weiss, C.H., *Evaluation: Methods for studying programs and policies.* 1998, Upper Saddle River, New Jersey: Prentice Hall, Inc.

71. Strauss, A.L. and J. Corbin, *Basics of qualitative research: Techniques and procedures for developing grounded theory.* 1990, Thousand Oaks, CA: Sage Publications.

72. *Scale-up in Education: Volume 1: Ideas in Principle*, ed. B. Schneider and S.-K. McDonald. 2006: Rowman & Littlefield Publishers, Inc. 328.