

PERSPECTIVE ON AN ENGINEER-TAUGHT, FAMILY SCIENCE PROGRAM IN URBAN, UNDERSERVED COMMUNITIES

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IRIDESCENT is a science education nonprofit that helps engineers communicate current science, technology, engineering, mathematics (STEM) research to the public. Engineers design and teach engaging hands-on *Family Science Courses* to underserved 3rd-7th grade students and their families. Topics range from the Physics of MRI to Bird Flight Aerodynamics, illustrating the real-world applications of science concepts and exploiting the power of narrative stories instead of discrete disconnected concepts.

In three years Iridescent has trained 209 volunteering professional engineers, undergraduate and graduate students. 54% of volunteers return to teach with us again. Engineering instructors have conducted 132 multi-session courses (36 Family Science Courses) providing 17,391 student hours and 1560 parent-hours of instruction. These courses have reached more than 4100 underserved K-12 students and their parents in Los Angeles, East Palo Alto and Salinas. We have a strong partnership with the University of Southern California through which engineering undergraduates receive three units of technical elective credit for going through our training and developing and teaching the Family Science Courses. We have been rigorously evaluating the program's impact on the families and on the engineers since we started.

Iridescent's model is based on the following four **THEORETICAL PRINCIPLES**:

Community of Learners: The concept of parents and children "learning together" is very powerful with both groups actively structuring shared endeavors. The adults (engineers and parents) are responsible for guiding the overall process and the children learn to participate in the management of their own learning and involvement. Some leadership is provided at times by children. This shift in roles appeals to the participants and results in high levels of engagement and learning. As one 6th grader excitedly said, "Your parents are learning too".

Cognitive Apprenticeship: Parents and children collaborate with one another and their engineering instructors toward a shared understanding. Learning tasks are designed within "zones of proximal development" just beyond what a participant can accomplish alone, but within their reach. The courses are designed to enable participants to learn through observation, modeling, discovery, analysis and reflection (Collins, 1988; Collins, Brown, & Newman, 1989; Lave, 1988; Scardamalia & Bereiter, 1985).

High-level skills: We focus on participants developing a deep understanding of the content and being able to transfer their learning to a new problem or generate causal explanations (*A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*, 2001; McComas & Abraham).

Inquiry based learning: The courses are structured around soliciting and building on participants' prior knowledge; engaging participants in learning content as well as learning how to organize and reason about the content; providing experiments in which participants control, reflect upon, and evaluate their learning; and scaffolding participants working together and with the

instructors to discuss evidence and connect their findings with scientific explanations. The experiments are carefully designed to allow participants to redesign, create and improve the original, thereby developing an understanding of the “engineering as redesign” process. Much research has been conducted that shows the beneficial effects of inquiry-based instructional practices particularly with disadvantaged students (*How People Learn*, 1999; Cuevas, Lee, Hart, & Deaktor, 2005; Lee, Buxton, Lewis, & LeRoy, 2006; Marx, et al., 2004; Minner, Levy, & Century, 2009; Samarapungavan, Mantzicopoulos, & Patrick, 2008; Wilson, Taylor, Kowalski, & Carlson, 2009).

The above theoretical framework is also employed to train the engineers and to help them develop their science communication and leadership skills.

PRIOR WORK: We draw from the following to develop a powerful program for our diverse stakeholders:

Family Science: Examples of Family Science programs include the EQUALS Family Science Program (Jones & Velez, 1997), the Australian Family Science Project (Rooney, 1993), 4-H (DeMerchant, Lytton, & Lytton, 1995) and the Hands-On Science Outreach program (Katz, 1996). Others such as the Open Classroom (Rogoff, 1994; Rogoff, Turkanis, & Bartlett, 2002) and NSF’s Out of School Science Experiences (Gennaro, Hereid, & Ostlund, 1986) have structured learning experiences that families undertake in formal and informal settings. These family-based programs have been shown to be particularly important in boosting the achievement of underserved students (Barton, Drake, Perez, Louis, & George, 2004; Barton, et al., 2001; Ingram, Wolfe, & Lieberman, 2007; Smith & Hausafus, 1998).

Public engagement and understanding of science: The NSF-funded, Portal to the Public Initiative, develops and tests program models that engage scientists and public audiences in face to-face interactions that promote appreciation and understanding of current science research (Schatz & Russell, 2008).

Professional development for scientists: BA Perspectives (coordinated by the British Association for the Advancement of Science) encourages scientists, engineers and social scientists to explore the social and ethical implications of their research and trains them to interact with the public at a poster session in a science festival.

RESEARCH QUESTIONS The program impacts both the underserved families as well as the engineers. To determine the impact of the program on both these groups we look at the following questions: 1) What is the change in participants’ interest in STEM over a 4 week intervention period? 2) What is the change in participants’ high-level understanding of course concepts over a 4 week period? 3) What is the change in engineers’ perception of their ability to communicate STEM research to the public over a 16-week period? 4) What is the change in engineers’ commitment to similar skill-based volunteering opportunities?

METHODOLOGICAL CONSIDERATIONS AND RESULTS We have conducted pre and post tests for each of our 132 multi-session courses. Initially Iridescent staff designed the instruments and the questions focused on *participants’ understanding* of science terminology, definitions, applications etc. Thus we measured content gains of 60-80%. We then made two

changes to the model. We shifted the instructional focus to high-level understanding and started training the engineering instructors to design the pre and post tests. The latter was to enable the program to scale efficiently and to provide the engineers with a comprehensive lesson planning experience. With these changes we have been measuring lower gains (40-60%) in participant learning. However, gain in participants' STEM interest has consistently been measured between 70-90%.

Our first attempts at evaluating the *program's impact on the engineers* consisted of a pre and post test that was adapted from a well-tested service-learning survey. The engineers rated themselves very highly on the pre-test and so the evaluation wasn't meaningful for our program. We are now in the process of testing and fine-tuning another evaluation.

INTERPRETATION The model of bringing trained engineers to share their expertise in engaging, hands-on ways with families is very effective in increasing the participants' interest in STEM. Enabling significant gains in factual understanding is relatively simple even when the pre and post tests are designed by instructors with less than eight weeks of lesson planning and teaching experience. However, enabling significant gains in high-level content understanding is much more challenging and is directly dependent on the effectiveness of our engineer training methods. Pre-tests conducted with the engineering instructors do not provide accurate data as the engineers lack the requisite prior knowledge to calibrate their self-assessments. A multi-method evaluation technique may be more useful to evaluate the program's impact on the engineers.

REFERENCES

- How People Learn*. (1999). Washington, DC: National Academy Press.
- A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. (2001). Longman Publishing Group.
- Barton, A. C., Drake, C., Perez, J. G., Louis, K. S., & George, M. (2004). Ecologies of Parental Engagement in Urban Education. *Educational Researcher*, 33(4), 3-12.
- Barton, A. C., Hindin, T. J., Contento, I. R., Trudeau, M., Yang, K., Hagiwara, S., et al. (2001). Underprivileged Urban Mothers' Perspectives on Science. *Journal of Research in Science Teaching*, 38(6), 688-711.
- Collins, A. (1988). Cognitive Apprenticeship and instructional technology *Technical Report*. Cambridge, MA: BBN Labs.
- Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive Apprenticeship: Teaching the crafts of reading, writing and mathematics. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: essays in honor of Robert Glaser*. Hillsdale, N.J: L. Erlbaum Associates.
- Cuevas, P., Lee, O., Hart, J., & Deaktor, R. (2005). Improving Science Inquiry with Elementary Students of Diverse Backgrounds. *Journal of Research in Science Teaching*, 42(3), 337-357.
- DeMerchant, E., Lytton, R., & Lytton, C. (1995). Science education for 4-H youth with family and consumer sciences applications. *Journal of Family and Consumer Sciences*, 87, 57-64.
- Gennaro, E., Hereid, N., & Ostlund, K. (1986). A study of the latent effects of family learning courses in science discovery rooms and kidspace: Museum exhibits for children. *Journal of Research in Science Teaching*, 23(9), 771-781.
- Ingram, M., Wolfe, R. B., & Lieberman, J. M. (2007). The Role of Parents in High-Achieving Schools Serving Low-Income, At-Risk Populations. *Education and Urban Society*, 39, 479.
- Jones, T. G., & Velez, W. (1997, March 24-28). *Effects of Latino parent involvement on academic achievement*. Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL.
- Katz, J. (1996). The rights of kids in the digital age. *Wired*, 166-171.
- Lave, J. (1988). *Cognition in practice: Mind, mathematics, and culture in everyday life*. Cambridge, UK: Cambridge University Press.
- Lee, O., Buxton, C., Lewis, S., & LeRoy, K. (2006). Science Inquiry and Student Diversity: Enhanced Abilities and Continuing Difficulties After an Instructional Intervention. *Journal of Research in Science Teaching*, 43(7), 607-636.
- Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., Fishman, B., Soloway, E., Geier, R., et al. (2004). Inquiry-Based Science in the Middle Grades: Assessment of Learning in Urban Systemic Reform. *Journal of Research in Science Teaching*, 41(10), 1063-1080.
- McComas, W. F., & Abraham, L. *Asking More Effective Questions*. Rossier School of Education, University of Southern California.
- Minner, D. D., Levy, A. J., & Century, J. (2009). Inquiry-Based Science Instruction What Is It and Does It Matter? Results from a Research Synthesis Years 1984 to 2002. *Journal of Research in Science Teaching*.
- Rogoff, B. (1994). Developing Understanding of the Idea of Communities of Learners. *Mind, Culture and Activity*, 1(4), 209-229.

- Rogoff, B., Turkanis, C. G., & Bartlett, L. (2002). *Learning Together: Children and Adults in a School Community*:Oxford University Press.
- Rooney, B. A. (1993). *A new approach to promote science in the community*. Paper presented at the National Conference for Primary School Teachers and Educators, Canberra, Australia.
- Samarapungavan, A., Mantzicopoulos, P., & Patrick, H. (2008). *Learning Science Through Inquiry in Kindergarten*. Wiley InterScience.
- Scardamalia, M., & Bereiter, C. (1985). Fostering the development of self-regulation in children's knowledge processing. In S. F. Chipman, J. W. Segal & R. Glaser (Eds.), *Thinking and learning skills: Research and open questions* (pp. 563-577). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Schatz, D., & Russell, L. (2008). *Portal to the Public. FACE-TO-FACE WITH SCIENTISTS Exploring the Features of Face-to-Face Interactions between Scientists and Public Audiences*. Paper presented at the Portal to the Public Synthesis Meeting, Pacific Science Center.
- Smith, F. M., & Hausafus, C. O. (1998). Relationship of family support and ethnic minority students' achievement in science and mathematics. *Science Education*, 82(1), 111-125.
- Wilson, C. D., Taylor, J. A., Kowalski, S. M., & Carlson, J. (2009). The Relative Effects and Equity of Inquiry-Based and Commonplace Science Teaching on Students' Knowledge, Reasoning, and Argumentation. *Journal of Research in Science Teaching*.