

The *INS* of imaging science and image processing IN education

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Abstract

IN is a small word with big implications. At the Center for Image Processing in Education we teach K-14 educators how to use image processing and analysis as an exciting way of engaging students in explorations of science and mathematics. Through a new collaboration with the Center for Imaging Science (CIS) at the Rochester Institute of Technology, we are finding ways to incorporate imaging science into K-14 education. Because of this collaboration, CIPE is becoming more involved in imaging science education and CIS is becoming more adept at using imaging science in education. During this talk, I will provide examples of CIPEs work, describe how teachers and students use image processing and analysis for educational purposes, and outline how CIPE and CIS will collaborate in their educational adventure. Feedback will be solicited about how imaging scientists from industry can participate in the collaboration.

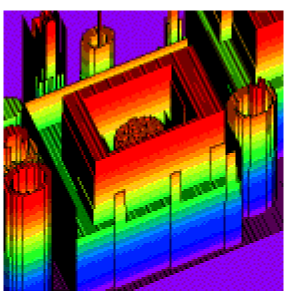

Figure 1. A student's castle

Digital Castles

Making castles in the air is a euphemism for dreaming unrealistically and failing to get down to business. But the Center for Image Processing in Education (CIPE) (http://www.cipe.com) prides itself on helping young people make castles that have practical benefits. Unlike the stone and mortar castles of the Old World, CIPE helps students build computerized versions that teach digital image literacy.

Digital castles are used in CIPE's *Camp IPX* workshops to teach elementary and middle school children about false color assignments in digital images. The students use *NIH Image*, a freeware image processing program available from NIH at http://rsb.info.nih.gov/nih-image/Default.html, to create colorful designs in an image window. Then they create a surface plot of their design. Numeric differences between the colors selected by the students and the background color of the image create illusory castle walls and moats.

This is more than a fun classroom exercise. It is a cogent example of CIPE's discovery-based approach to education. By engaging in the castle building activity, students discover important principles about how digital images are made. First, they learn that digital images are matrices of numbers to which colors or shades of gray have been assigned. Second, they learn that the colors represented in a digital image may be altered by changing the numbers in the image. Third, the students learn that numeric values in a digital image are changed by operations such as cutting and pasting, filling, and drawing lines, circles, and squares. Finally, the students learn that three-dimensional representations created from a digital image are expressions of the numbers contained within that image. Each of these principles are foundational to a rudimentary understanding of imaging science.

Image Processing *In* Education

CIPE has a successful history of developing materials that help teachers use professional analysis tools for instructional purposes. Since 1992, CIPE has introduced digital image processing into elementary school, secondary school, and college classrooms. For its NSF Advanced Technological Education project (NSF Grant No. DUE-975201), CIPE has produced four sets of instructional materials and has conducted hundreds of professional development workshops. The four sets of instructional materials are *Discovering Image Processing*, a collection of ten lessons that teach basic concepts of image processing; *A&P Technologist*, a set of twelve lessons that use image processing and analysis as a tool for learning anatomy and physiology in community college and high school Advanced Placement classrooms; *Biotechnologist*, which uses image analysis to teach concepts common in the practice of biotechnology; and *Environmental Technologist*, a set of lessons designed to help educators use remote sensing and other kinds of data from the Internet to conduct environmental investigations.

Summative examination of CIPE's ATE project underscores its success. CIPE has been featured in local and national television news programs, professional journals, magazines and newspapers. Calling image processing "…a tool for unlimited exploration," a recent edition of Curriculum/Technology Quarterly [10], dedicated an entire issue to descriptions of teachers using CIPE's materials in the classroom. Instructional products published by CIPE—HIP® (Hands-on Image Processing) for Educators, HIP® Mathematics, and HIP® Biology—have won prestigious awards. All three products have been awarded "Software of the Year" awards from Technology and Learning Magazine. HIP® Biology was a finalist for a CODIE award from the Software Publishers Association. A recent review of CIPE's *A&P Technologist* materials *by The American Biology Teacher* praised the instructional materials as "...one of the best accompanying guides [for the CD-ROM] that [the author has] seen" and that the material's premise, "'discovery through image analysis,' describes exactly what [CIPE's] program accomplishes.".[4] CIPE organizes an annual conference on educational applications of visualization technologies--NITEC. The 1999 conference held in Tucson, Arizona, was attended by more than 150 educators, educational administrators, researchers, and industry representatives. At the conference, a number of students from across the nation presented research conducted with image processing and analysis technology.

CIPE's dissemination efforts, which involve a combination of conference, workshop, Internet, and direct mail outreach channels, have also been highly successful. In step with the goal of the ATE program to foster self-supporting educational enterprises, CIPE supports approximately one-third of its annual budget with sales of instructional materials and workshops. This percentage is likely to grow as CIPE adds more offerings to its product line and develops connections with publishers.

Guided Discovery

CIPE uses image processing software and a guided discovery format to bring scientific research alive for students of all ages. This approach supports a reform-based pedagogy derived from the National Science Education Standards (NSES)[12]. In accordance with the NSES, CIPE emphasizes inquiry and active learning. Science, according to the NSES, is a process that learners do. Accordingly, educational materials developed for today's learners must be hands-on and minds-on.[12] Students should learn science by participating in and experiencing the scientific research process. They should be challenged to question the data before them, pose hypotheses, identify research strategies, plan approaches to studying those problems, make decisions based on their research, and work in a cooperative setting that emphasizes sharing and quality interaction with their peers.

An authentic research tool such as *NIH Image* (and its spin-offs—*Image/J* [http://rsb.info.nih.gov/ij/] and *Scion Image* [http://www.scioncorp.com]), employed for instructional purposes, fosters student empowerment. It differs considerably from multimedia tutorials. While using real analysis tools, students are actively involved in real research. Accordingly, such tools are superior to the inherently passive "point-and-click" applications common in multimedia- and Internet-based education. They better support the goals of the NSES by creating opportunities for students to engage in hands-on, inquiry-based learning.

Studies have shown that inquiry-based learning enhances students' skills of graphing and interpreting data [11], fosters scientific literacy and understanding of science processes,[8] increases vocabulary knowledge and conceptual understanding,[9] and improves achievement on tests of procedural knowledge.[5] CIPE's use of real data, a real research tool, and real scientific methods provides students with experience in performing an authentic task that bears a strong resemblance to tasks performed in a real work setting. Accordingly, learning processes are cultivated in addition to outcomes [1]. CIPE's approach can also foster the kinds of outcomes ascribed to discovery-based learning by Nissani:[13] facilitating conceptual change, exciting students' interest, overcoming negative attitudes towards science, and providing a meaningful, hands-on experience with the process of scientific discovery.

Counting Crows

Anecdotal data indicates that CIPE's work has empowered students in ways that are hardly imaginable with traditional modes of instruction. For example, Mike Ellison, a science teacher in Vancouver, Washington, relayed the following story to CIPE:

A...project involved an eighth grade student interested in dinosaurs. He contacted a researcher at the University of Oregon investigating whether dinosaurs were ecto- or endotherms. The researcher provided us with CAT scans of skulls which the student analyzed. In this case we were able to provide the image processing techniques to the researchers who were unfamiliar with their use, solving a measurement problem for them. My student made a couple of trips to the university to talk to the researcher and we also corresponded via email. The group we worked with published their results in Science.

At CIPE's 1999 National Imaging Technology in Education Conference (NITEC), a number of students from across the nation presented research conducted with image processing and analysis technology. One pair of students from Harrisburg, Pennsylvania, demonstrated how they had used digital image processing to examine changes in facial symmetry with aging.[14] Another pair of middle school students from the same school presented how they had used a digital camera and image analysis software to calculate the daily number of new American crow droppings covering a section of sidewalk in their city.[2] The analysis was extremely pertinent to Harrisburg because the crow population boom has been reeking havoc in the state capitol region.[7] Another recent anecdote related by an instructor in Portland, Oregon, regarded a female high school student who wrote an image analysis macro that is being used by medical researchers to automate their analyses of digital photomicrographs.[6]

Imaging Science *In* Education

CIPE has recently established collaboration with the Chester F. Carlson Center for Imaging Science (CFCCIS) at the Rochester Institute of Technology (RIT). For CIPE, this collaboration is a marriage made in heaven. CFCCIS has 36 research and teaching laboratories dedicated to specialized areas of imaging science, including electronic imaging, digital image processing, remote sensing, medical imaging, color science, optics, and chemical imaging. It also works closely with industrial partners such as Agfa-Gevaert N.V., Barco Graphics, Eastman Kodak Company, Fuji Xerox Company, Ltd., Hewlett Packard Laboratories, Imation Corporation, Matsushita Research Institute Tokyo, Munsell Color Foundation, Inc., Polaroid Corporation, Ricoh Company, Limited, Sony Corporation, Toyobo Company, Ltd. Asahi Optical Co., Ltd., Dainippon Ink & Chemicals, Inc., Fuji Photo Film Company, Fujitsu Laboratories, Inc., Hitachi Koki Co., Ltd., 3M Corporation, Mitsubishi Chemical Corporation, Nippon Paper Industries Company, Rexam Graphics, Samsung Electronics Company, Ltd., Toppan Printing Company, Ltd., and Xerox Corporation The resources available at CFCCIS will provide CIPE unparalleled access to imaging science research and industrial applications that can be developed into educational activities for K-16 consumption.

CIPE's collaboration with CFCCIS arose out of a talk given by Ian Gatley, Director of CFCCIS, at CIPE's 1999 National Imaging Technology in Education Conference (NITEC). Dr. Gatley's talk cataloged the impact of new imaging technologies in many scientific fields, including remote sensing, astronomy, medical imaging and industrial applications like cameras, copiers, printers, and scanners. He suggested that these sweeping changes demand a careful and ongoing revision of teaching curriculum in the age of "digital literacy." According to Gatley, not only is such literacy important in bolstering public understanding of imaging science as a discipline, it is critical to developing cadres of young people prepared to enter into imaging science careers. Dr. Gatley also described how CFCCIS, to address this need for weaving digital literacy into the teaching curricula, had developed a workshop to provide K-12 teachers with the skills necessary to capture images, to manipulate those images, and to extract information from them.

Gatley and CIPE quickly identified that each organization could help the other. CFCCIS could provide access to resources unavailable to CIPE in the past. CIPE could help CFCCIS integrate the science of imaging into K-16 education.

An outgrowth of this new collaboration has been an understanding that each organization attempts to achieve different ends. CFCCIS is primarily concerned with teaching the science of imaging. CIPE helps educators teach the imaging of science.

NITEC 2000

Both approaches are key to enhancing digital literacy among educators, young people, and the public. To truly understand the information being gained from an image, the science of imaging must be understood. To be a competent imaging-based scientist, core image processing and analysis skills must be mastered. In the past, CIPE's approach has been to focus on developing image processing and analysis skills rather than on teaching the science of imaging. This approach has been successful at creating learning scenarios that capture the interest of young people and introduce them to the power of digital imaging.

But educators and their students often want to go farther than manipulating images and measuring their characteristics. They wish to capture useful images, understand how imaging systems work, and even build their own imaging systems. Accordingly, this year's National Imaging Technology in Education Conference (NITEC) will be held at CFCCIS. This hosting of a K-16 educator's conference by a leading academic institution will promote a better appreciation of how the science of imaging and the imaging of science can be integrated to enhance education. At the conference, imaging scientists and educators will share their work and learn from each other. It is anticipated that the scientists will learn about the strategies educators use to help young people become digitally literate. The educators will come away with a better appreciation for the workings of imaging science.

Imaging Scientists in Education

The moral of this meandering includes three basic points. First, because educators and young people have demonstrated that they can master the imaging of science, it is likely that they can delve into the science of imaging as well. Often, we underestimate the brilliance of our young people and ascribe to them limitations that do not exist. Young minds can engage in very sophisticated science if they are provided with an appropriate learning environment and the proper tools.

Second, involving educators and young people in imaging science has tangible benefits. By engaging in imaging science, young people become digitally literate and more appreciative of the work of imaging scientists. And, by increasing their digital literacy, young people can be "hooked" by imaging science. Capturing the interest of young people will be an important task of imaging science as a discipline. To ensure that sufficient numbers of talented young people choose to pursue careers in the expanding field of imaging science, the discipline needs to overcome its relative anonymity at the pre-college levels. Overcoming the anonymity of imaging science among young people will require a dedicated effort by the discipline to integrate itself into K-12 teaching.

Thus, the final point: Imaging scientists can play a lead role in this integration. That is why CIPE and numerous educators and their students are present at this conference. They are here to observe and to demonstrate what they can do. They are also here to learn from the distinguished imaging scientists present at this meeting. I invite you to talk to the educators and young people, and learn how they can help make imaging science an accessible and interesting focus for learning at all levels. We can work together to improve the science of imaging and imaging of science *IN* education.

References

1. Batson, Trent, and Randy Bass. "Primacy of Process: Teaching and Learning in the Computer Age." *Change* 28, no. 2 (1996): 42-47.
2. Boyd, Gregory, and Bennett Carpenter. "Avian Invaders: A Digital Assessment of the Pennsylvania Capitol American Crow Roost Dispersal Project." Poster presented at the *National Imaging Technology in Education Conference.* Tucson, AZ: Center for Image Processing in Education, 1999.
3. CRA. "Telephone Survey of Participants in Professional Development Workshops Conducted by the Center for Image Processing in Education (CIPE): In Press.", 50 pp. 1999.
4. Ellis, Linda K. "A & P Technologist (Review)." *The American Biology Teacher* 61, no. 2 (1999): 149.
5. Glasson, G. E. "The Effects of Hands-on and Teacher Demonstration Laboratory Methods on Science Achievement in Relation to Reasoning Ability and Prior Knowledge." *Journal of Research in Science Teaching* 26, no. 2 (1989): 121-31.
6. Hadder, Bart. Letter to Steven Moore, 1998.
7. Lenton, Garry. "Study of Bird Droppings Wins Class Invitation to Conference." *The Patriot News,* 8 July 1999, sec. B, col. 3 p. 1.
8. Lindberg, D. H. "What Goes 'Round Comes 'Round Doing Science." *Childhood Education* 67, no. 2 (1990): 79-81.
9. Lloyd, C. V., and N. J. Contreras. "What Research Says: Science Inside-Out." *Science and Children* 25, no. 2 (1987): 30-31.
10. Mann, L. "Image Processing for Unlimited Exploration." Curriculum/Technology Quarterly 6, no. 2 (1997).
11. Mattheis, F. E., and G. Nakayama. "Effects of a Laboratory-Centered Inquiry Program on Laboratory Skills, Science Process Skills, and Understanding of Science Knowledge in Middle Grades Students." Educational Resources Information Center, ED 307 148, 1988. http://www.aspensys.com/eric/.
12. NAS/NRC. *National Science Education Standards*, National Academy Press, Washington, DC, 1996.
13. Nissani, M. "Dancing Flies: A Guided Discovery Illustration of the Nature of Science." *The American Biology Teacher* 58, no. 3 (1996): 166-71.
14. Smith, Nasstaljia, and Chelsie Houser. "Using NIH Image to Measure the Effect of Time on the Symmetry of Faces." Poster presented at the National Imaging Technology in Education Conference. Tucson, AZ: Center for Image Processing in Education, 1999.

Biography

Steven Moore holds a Ph.D. in Renewable Natural Resources Studies from the University of Arizona. He also holds a B.S. degree in biology from Southern Illinois University and an M.B.A. from the University of Illinois. Dr. Moore has taught environmental studies, human biology, environmental management, and sociology at the undergraduate level, and image processing and analysis to educators in numerous settings. Dr. Moore is the Executive Director of the Center for Image Processing in Education.