Using the Arts and Computer Animation to Make Chemistry Accessible to All in the Twenty-First Century

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Abstract The twenty-first century is truly the century of science and technology. If we will not make science and technology accessible to all, we will form a two-class society, divided not by royalty or economic status, but by knowledge of science and technology. It is our tenet in life that science education is a human right that belongs to all. Therefore, it is essential that we employ every method possible to make chemistry accessible to all in the twenty-first century [1, 2]. A Chinese proverb states: "I hear and I forget; I see and I remember; I do and I understand." At the Science Institute, Columbia College Chicago, we believe strongly in this proverb, and we incorporate visualization and art in the teaching of chemistry. Students remember and understand abstract chemistry concepts best by creating their own artistic projects. Through this process, students take an active role in the learning process, instead of only being passive observers. The students can produce visualization projects using the media of their choice, from computer animation (High Tech) to dance and drama (No Tech). These projects are used as an alternative assessment method where the evaluation is done in a constructive way by the whole class and not just by the instructor. This method has been proven successful with undergraduate students, with science teachers, and with middle and high school students. Many institutions in the USA and around the world have adopted this method.

1 Narrative

A key element of the innovative science curriculum used at Columbia College in teaching, learning, and assessing science to its non-science major student body requires all students to prepare projects to express their knowledge of science in an original and creative way [3], making use of the skills and talents in each individual's

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M. Gupta-Bhowon et al. (eds.), *Chemistry Education in the ICT Age*,
DOI 10.1007/978-1-4020-9732-4_5, © Springer Science+Business Media B.V. 2009

particular major field of study, personal interest, or cultural background. These projects have taken the form of videotapes, paintings [4], sculptures, audiotapes, dances, "rap" songs, and scripts for theater. Students present their research and investigation results using the medium in which they feel most competent, comfortable, and talented [5]. It has been observed that students better understand and retain longer the scientific information they present in their projects. The entire class benefits from the scientific content of the project presentations: each presentation inspires in the other students new ideas and new ways of looking at scientific material. This form of assessment allows the teacher, the entire class, and the student presenter to engage in a cooperative assessment. Furthermore, the projects often result in a permanent record, similar to portfolio assessment, which is both useful for its scientific and educational content, and valuable from a dissemination standpoint. This approach works outstandingly well with undergraduate non-science majors, with teachers and students of grades K-12, and with people who have developed hostility or anxiety toward science and standardized tests. This method, if properly utilized, can yield enormous benefits to many generations of students. Not only can it help students become citizens who are well-informed about science, it can also encourage more of them to choose science and science-related fields as possible career choices.

2 Examples of Student Projects

Abstract scientific concepts have been made concrete through paintings, sculptures, dances, and plays. A group of high school students from a very low-income neighborhood who participated in our program were invited to perform in a Gordon Research Conference on science visualization [6]. The Gordon Research Conferences are very prestigious scientific conferences; the students showed the conference participants how they visualize scientific concepts through dance, and how they are able to grasp the abstract concepts after visualizing them though dance. They performed dances on the Periodic Table, the Ionic Bond, and the Effect of Water on the Ionic Bond as part of the visualization process (Figs. 1 and 2). A group of middle school children performed a dance on the depletion of the Ozone Layer by CFCs. This dance was aired globally by CNN, and in the USA by NBC, ABC and WGN television stations (Fig. 3).

A group of college students in the course "From Ozone to Oil Spills: Chemistry, the Environment and You" produced a video on the formation of NH_3 (Fig. 4), in which they named nitrogen as "Agent 007," and the three hydrogens as "The Hydrogen Triplets." The video describes the covalent bond and the ionic bond of table salt in a satiric, but scientifically accurate, way. An art student [7] presented his understanding of the fission reaction and a nuclear explosion through an art book (Fig. 5), while another art student expressed in a painting her concern for the environment and the adverse effects of air pollution on our cities and on the human body (Fig. 6). An animation student created a DVD showing glacial melting as a

Fig. 1 Periodic Table dance performance in a Gordon Research Conference on science visualization

Fig. 2 Periodic Table dance performance in a Gordon Research Conference on science visualization

result of climate change (Fig. 7), and the destruction of the Ozone Layer by CFCs was presented using computer animation (Fig. 8). The "Science Classroom of the Future" was visualized by a group of students (Fig. 9) who presented abstract scientific concepts through computer animation. A movie depicting the discovery of Ra and

Fig. 3 Depletion of the Ozone Layer dance performance by Middle School children

Fig. 4 Student-produced video on the formation of NH_3

Po by Madame Curie, as well as her presentations in front of the French Science Academy, was produced by a team of students (Figs. 10 and 11).

An art student truly represented the danger we face by forming a two-class society. He presented a drawing of two groups of students resembling the two-class society divided by knowledge of science and technology. One group is busy working on their computers, while the other group is sad and deprived (Fig. 12).

Fig. 5 Images from an art book produced by a Columbia College Chicago student on the fission reaction and a nuclear explosion

Fig. 6 An art student's painting on the adverse effects of air pollution on our cities and on the human body

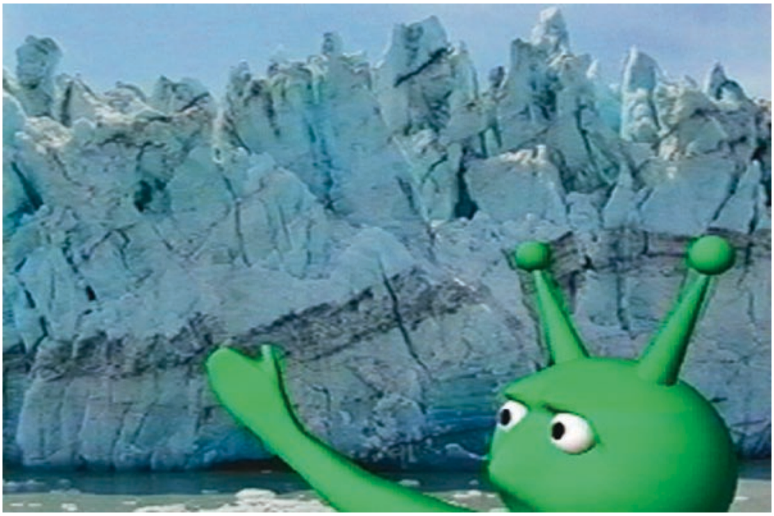

Fig. 7 Image from an animation student's DVD showing glacial melting as a result of global warming

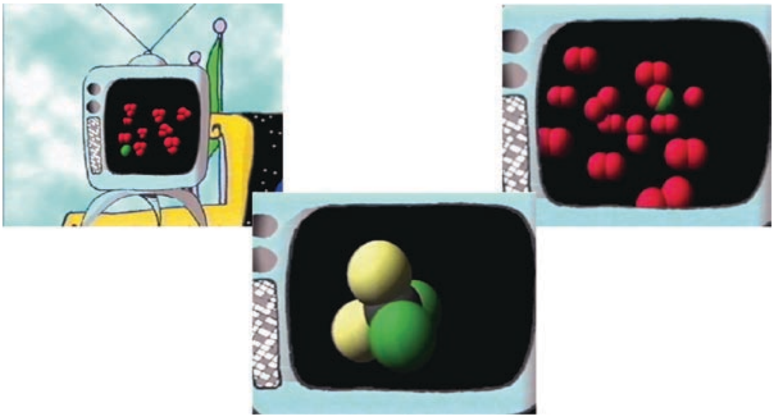

Fig. 8 Computer animation on the destruction of the Ozone Layer by CFCs, produced by a Columbia College Chicago student and presented on a television screen

3 Summary

This method of teaching chemistry at all levels has been proven successful in many institutions in the USA and around the world. Much of the funding for this curriculum was received from the National Science Foundation (NSF) and required an independent evaluator. The results of the evaluation showed that in

Fig. 9 A scene from the project "The Science Classroom of the Future" as visualized by a group of students

Fig. 10 A scene from a student-produced movie, showing Madame Curie in her lab

grades 5 through 10, students who studied using these methods achieved on standardized tests an average of 20% higher scores than their peers. An NSF site visitor to Columbia College Chicago, after attending one of our classes that was funded by NSF and developed in collaboration with Princeton University, wrote:

Fig. 11 A scene from a student-produced movie, showing Madame Curie with her equations

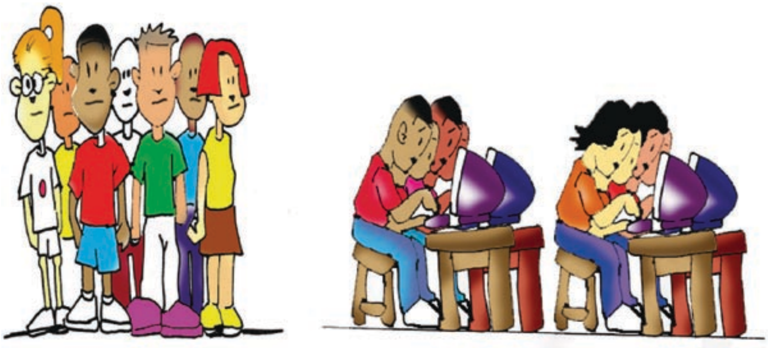

Fig. 12 A two-class society for children

"The class meeting I sat in on was scintillating. I have rarely been in a classroom where students had such energy and enthusiasm. It is quite important that the results of this project be shared with faculty at as many institutions as possible; this will certainly help faculty at other institutions to adopt/adapt this successful approach."

Acknowledgement Acknowledgement is given to the National Science Foundation for financial support of this work.

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