**Windows to the World: Perspectives on Case-based Multimedia Web Projects in Science**


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## Abstract


*Open-ended computer simulations enable students to solve scientific problems through case studies in areas such as human genetics. Use of the Internet allows students to communicate and discuss their scientific findings with others through Web-based posters and electronic conferencing. The aims of this study were to (1) examine high school students' learning during this case-based multimedia project; (2) analyze the interaction that occurred during electronic conferencing based on the high school and college students' Web posters in the United States, England, and Australia, and (3) compare the perspectives of high school students, and high school teacher on this project.*


"Before this I didn't even think about genetic testing and stuff like that. Now it's just like 'WOW!'" Quote from a high school biology student

> Without the human aspect any technology amounts to no more than a machine taking up space and time in the classroom. In the hands of a true educator, however, it provides a variety of windows to the world, windows that brighten the future of all who look through them. Preservice teacher and research assistant

During the past decade, a number of reports have called for changes in science instruction (American Association for the Advancement of Science, 1993; National Academy of Sciences, 1995; National Science Teachers Association, 1991). One change suggested has been for students to engage collaboratively in inquiry, studying authentic problems that connect science and technology with society (Hurd, 1997; Kumar, 1997; Marx, Blumenfeld, Krajcik, & Soloway, 1997; Oliver, Slotta, & Hannafin, 1999). Given the increasing social and ethical implications of DNA research in biotechnology and medicine, it is important for students to develop some understanding in this area and connect this knowledge later on to future situations in their lives (Bergland, 1997).

Even at an introductory level, it is important that biology students understand the science of genetic testing. The media reports genetic findings almost daily but, in an attempt to simplify the information, fails to make distinctions between things such as genetic probability and genetic certainty (Trumbo, 2000). Students need the information necessary to critically analyze what the media reports and use scientific facts to determine whether a discovery reported by the media is fact or has been affected by over simplification or sensationalism (Anderson, 1998). For example, the latest sensation in the media is the Human Genome Project. As it nears completion and more is understood about the underlying genetics of various conditions, more advances in the science of genetic testing are being made (Jegalian, 2000). With an understanding of the science behind genetic testing, students will have the tools necessary to make informed decisions about the ethics of genetic testing.

The issue of ethics is an extremely important component of high school and science curriculums. Both the American Association for the Advancement of Science and the National Research Council recommend that ethics be included in the science curriculum (American Association for the Advancement of Science, 1993). As we enter into the new millennium, there are an increasing number of scientific advances, each with many ethical issues that must be considered. With these advancements, students will need to understand the possible ethical considerations so they can make informed decisions about new regulations concerning the use of scientific advances. Evidence shows that the earlier students are exposed to ethical debates, the better. If students are introduced to the topic of genetics as they explore scientific topics, instead of during a separate course in college or graduate school, they will be more prepared to handle ethical issues later (Barden, Frase, & Kovac, 1997). By teaching students ethics, we can hope to instill critical thinking and responsible decision making into our students.

## Case-based Learning

One goal of problem-based case pedagogy is to foster problem solving skills in students through exposure to real-life dilemmas (Barrows, 1998; Lundeberg, Levin, & Harrington, 1999). Case-based learning is a valuable teaching method that is used to help students develop reasoning skills in many types of classes, and benefits students by giving them an opportunity to solve a problem and feel a sense of accomplishment. In science, teachers are increasingly using case-based learning to engage students in applying what they have learned to genuine biological problems (Smith & Murphy 1998; Wilcox 1999). The types of case studies vary, but all contain a reality-based problem and require the student to become the problem solver. A case-based orientation to computer simulations involves students in problem posing, problem solving, and peer persuasion (Lundeberg, Bergland, Klyczek, Mogen, Johnson, & Harmes 1999; Peterson & Jungck, 1988; Stewart, Hafner, Johnson, & Finkel, 1992).

Problem-based learning emphasizes the importance of social interactions in learning (Torp & Sage, 1998; Lundeberg, Levin, & Harrington, 1999), and advances in collaborative learning tools offer much promise for computer-supported collaborative learning environments (Koschmann, Meyers, Feltovich, & Barrows, 1994; Bonk & Cunningham, 1998; Brown, Ellery & Campione, 1998; Collins, 1998; Reil, 1998). Researchers comparing electronic discussions with live discussions have found that electronic discussions provide more opportunities for students to participate than do live discussions (Linn & Hsi, 2000), and students prefer Internet discussions to live discussions of their science posters (Lundeberg, Bergland, Mogen, Meirhofer, Sage, & Moore, 2000). Participating in role playing over the Internet allowed students to assume higher levels of perspective-taking than is typical of adolescents; however, when asking experts questions these same high school students focused primarily on lower-level questions (Sugar & Bonk, 1998). How might audience affect discussions over the Internet? Cooperative learning theory suggests that heterogeneous groups enhance learning to a greater degree than homogeneous ones (Johnson & Johnson, 1990). Given the skepticism of some regarding the value of technology in science education (e.g., Kimmel & Deek, 1995), and some of the difficulties students have with the Internet (Oliver, Slotta, & Hannafin, 1999), it is critical to understand more about this environment. Indeed, in their review of the research on K-12 telecommunication exchange projects, Fabos and Young (1999) argued that many such exchange projects have little educational value.

In this exploratory research, we used both qualitative and quantitative research over a 2-year period to examine the learning that occurred in a high school context when students were engaged in a case-based multimedia project. To better assess this learning, we used both pre and posttests, as well as artifacts students created, such as Web posters, and records of Internet conferences. We also collected interviews from both the students and the teacher involved in this project.

## Overview of the Case It! Project

Case It! is a National Science Foundation-sponsored project initiated by participants in the BioQUEST Curriculum Consortium. The goal of Case It! is to enhance case-based learning in high school and university biology courses worldwide via molecular biology computer simulations and Internet “poster sessions”. Students first play the roles of laboratory technicians as they analyze DNA sequences associated with particular cases and construct Web page posters giving results of genetic testing. They then play the roles of genetics counselors and family members as they ask and answer questions concerning these tests. To accomplish this, students use three software tools: Case It Investigator to gather background information, the *Case It simulation* to analyze DNA, and the Case It Launch Pad to access a Web page editor and Internet conferencing system. Although the Case It simulation works with any DNA sequence, we have concentrated on human genetic disease cases because of the high degree of student interest in these cases and ethical ramifications which make them particularly well suited for spirited discussion and debate.

## Use of Case It! software

Students begin in Case It! Investigator by reading the case of choice and a synopsis of the disease. Cases developed and class-tested to date include Alzheimer’s disease, breast cancer, sickle-cell anemia, Duchenne’s muscular dystrophy, cystic fibrosis, phenylketonuria, Huntington’s disease, and fragile-X syndrome. We originally downloaded the appropriate DNA sequences for the various disease conditions from Genbank, a government repository of genetic information, then modified the sequences to create multiple scenarios involving hypothetical “family members” being tested for the presence or absence of disease mutations. Thus, cases included with the simulation are reasonably realistic and give results similar to what would be obtained analyzing actual DNA samples. For example, the case on Alzheimer’s disease is presented in Figure 1.

**Background**: Alzheimer disease is by far the most common cause of dementia in aging persons. The disease symptoms are identical to other forms of senile dementia, and diagnosis had been possible only at autopsy by the detection of protein clusters called amyloid plaques in the cerebrum. The disease is multifactorial and inheritance patterns are complex. Some forms of familial Alzheimer disease appear to be inherited as autosomal dominant traits, while others are recessive. Spontaneous Alzheimer disease also can occur in the absence of inherited factors.

Mutations in at least four genes have been linked to Alzheimer disease. One of these is the amyloid precursor protein (APP) gene, which encodes the β-amyloid peptide found in the cerebral plaques of Alzheimer patients. The function of APP is not yet known, but certain APP point mutations are associated with inheritance of late-onset Alzheimer disease in some families. Two examples, which can be detected by RFLP analysis, are the codon 693 Glu to Gly mutation and the codon 717 Val to Ile mutation. The 693 mutation results in the loss of a MboII site, while the 717 mutation results in the gain of a BclI site.

**The case**: Martha, age 71, has been exhibiting increasingly severe symptoms of senile dementia and has been hospitalized for testing. She is in good health otherwise. Her three children—Sam (age 43), Joan (age 41) and Robert (age 38) —want to find out the cause of the dementia and determine the prognosis for Martha's future condition. They are also concerned that Martha may have a form of familial Alzheimer disease and want to know if they are at risk. The physician decides initially to test Martha for two mutations, 693 Gly and 717 Ile, in the amyloid precursor protein (APP) gene which are associated with inherited Alzheimer disease.

DNA samples: Martha (mother)
Sam (son)
Joan (daughter)
Robert (son)
Control wild type APP
Control 693 mutation
Control 717 mutation

To test for the 693 Gly mutation, digest the DNA with MboII and perform a Southern blot using the APP probe. To test for the 717 Ile mutation, digest the DNA with BclI and then use the APP probe. Compare the test samples to the control samples, and use the results to determine the genotype of each individual. (Note: Small fragments are generated with the MboII digestion; use 1.2% agarose and short run times.)

- Does Martha have either of these two APP mutations?
- Did any of Martha's children inherit an APP mutation?
- What conclusions can you draw regarding Martha's diagnosis?
- What can you tell Martha's children about their risk for Alzheimer disease?
- What issues are raised by this type of testing?

***Figure 1*: Case 4. Alzheimer disease.**

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Researching the genetics of a disease enables students to better understand the results of the electrophoresis simulation. Students also research symptoms, treatments and resources for the hypothetical "family members" in the case they have chosen. When students click links or use the button bar to access pull-down menus of links (see Fig. 2), Investigator will automatically open their Web browser to those Internet sites, and keep track of them for future reference.

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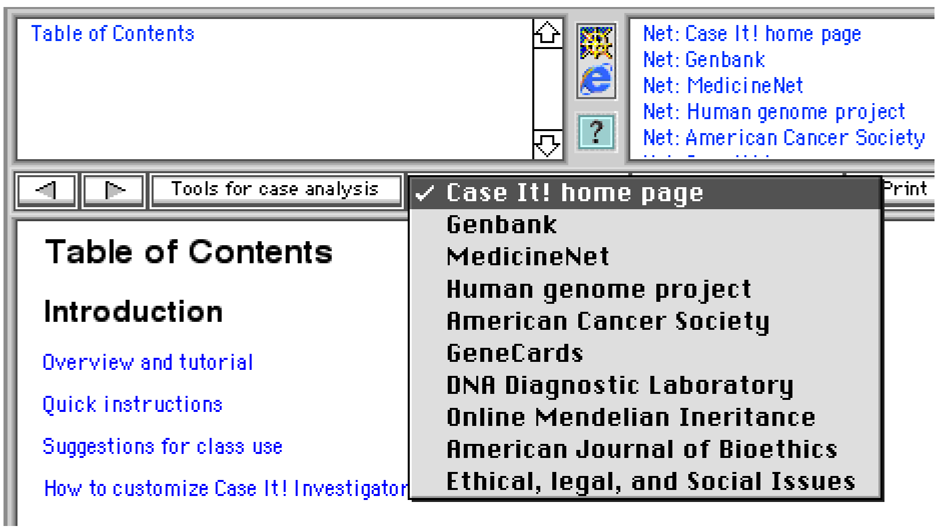


***Figure 2*: A portion of a sample screen from Case It Investigator showing customizable menu of Web sites.**

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Next, students play the role of genetics counselors as they use the Case it! simulation to analyze DNA sequences (see Fig. 3). After gathering background information, students use the Case It simulation to run analyses for DNA sequences associated their particular case. Current capabilities of the simulation include restriction enzyme digestion, DNA gel electrophoresis, Southern blotting, dot blotting, and PCR. After running analyses, students use the simulation to take "photos" of the resulting gels and blots and save them for later incorporation into Web pages via the Web page editor.

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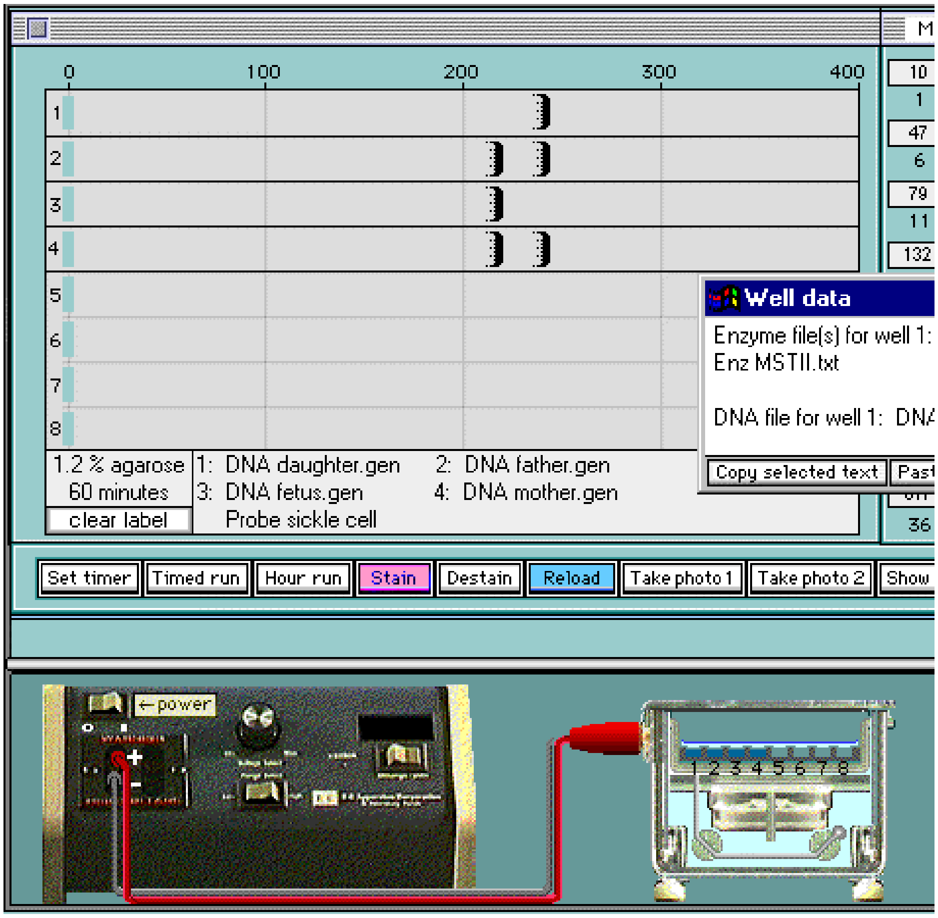


***Figure 3*: Lab Bench screen of the Case It simulation showing results of one scenario from the sickle-cell case.**

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Figure 3 shows an example scenario from the sickle-cell disease case, run from the “Lab Bench” screen of the simulation. The sickle-cell mutation eliminates a restriction enzyme, the recognition site for the enzyme MSTII; therefore with sickle cell disease the mutated fragment is larger. To detect the sickle-cell mutation, a patient’s DNA is digested with MSTII and a Southern blot is performed using a probe corresponding to this region of the hemoglobin gene. The presence or absence of the sickle-cell mutation can be determined based on the size of the fragment identified by the probe. Abnormally large fragments (the ones to the left) move more slowly through the gel than normal fragments (the ones to the right). In this example, the father and mother are both heterozygous for the sickle-cell mutation, since they carry both an abnormal (fragment to the left) and a normal gene (fragment to the right). The daughter carries only the normal gene, but the unborn fetus carries only the sickle-cell gene.

**Case It! Launch Pad**

After using the Case It! computer simulation to analyze DNA, students create "posters" via a custom Web page editor accessible from the Case It Launch Pad. This editor enables students to easily add and edit the various sections of their Web pages and to incorporate gel/blot photos and other images. The integrated Web page editor/conferencing system is designed for ease of use, even if students have had no prior experience building Web pages or conferencing. Students play the role of genetics counselors when responding to questions sent to their own group's forum regarding their Web poster; they play the role of family members when sending messages to other groups' forums. Numerous ethical issues can be discussed at these "counseling sessions," including questions regarding the molecular biology of the disease, symptoms, treatment, and ethical issues that might arise. The Launch Pad also organizes links to each group's discussion forum and published Web page, and provides a feature for compiling messages sent by individual students, which is handy in grading student participation in conferencing.

## Evaluation Results

We examined the effectiveness of this case-based multimedia Internet project within the context of two high school biology courses over a 2-year period. The majority of the high school students were seniors in year 1; in year 2, the majority of the students were juniors. In the first year of the project the high school teacher implemented this project as an "extra credit" project; in the second year, he included it as part of the curriculum. To evaluate the effectiveness of this project we collected 45 pre and posttests of student learning and interviews with 29 students, as well as the teacher and student teacher implementing the project. We also rated the Web posters students constructed and examined their Internet conferencing in depth.

We triangulated data to look for themes across the tests of learning, interviews, posters and Internet conferencing (Strauss & Corbin, 1990). We found the following themes: (a) Case It! fit with some science standards, (b) students developed awareness of genetic diseases, genetic testing, and underlying genetics, (c) students developed an awareness of ethical issues associated genetic testing, (d) this project developed student interest through connecting science to real-life situations, and (e) this project promoted positive use of technology in schools. We conclude by discussing both the value of the project and some of the challenges faced during implementation.

## Standards

During his interview after the project was completed, the teacher reported that Case It!  addressed numerous standards in the science currriculum: "career concerns because students had to put on their genetic counselor hat. It certainly hits home the concept of how people deal with ethical and societal issues. It also hits home the state standards on genetics and on the passing of traits and that kind of thing. It probably, realistically, hit at least 10 points of the state standards and probably addressed 3 or 4 of the components of the state standards. That's pretty good if you can get one activity or part of your curriculum to do that."

## Genetic Diseases, Genetic Testing and Underlying Genetics

According to the teacher, he reported that Case It! fit well with his goals to teach genetics: "One of the major goals was for students to learn about the genetics involved with a particular trait. Obviously with over 4,500 genetic traits, I can't cover all of that in a 9-week class. So being exposed to some of the common ones like Case It! does have incorporated within it, is beneficial. That was one of my goals and that was certainly accomplished."

The most common reason why students felt the Case It! project was valuable was in furthering their knowledge of genetic diseases. Seventy-six percent of the students in 2000 and 2001 who were interviewed reported that the project was useful in helping them learn more about genetic diseases. As one student commented, "I had no idea what this disease was before.…it's amazing how much you can learn from just genetic testing." Research assistants' journals and observation notes corroborated this interview data showing that most students understood the genetics involved in their case disease, as well as the process and interpretation of electrophoresis. "I felt this group gained an excellent understanding of genetics and genetic testing, including PCR, RFLP, electrophoresis, as well as the individual characteristics of their disease that dealt with all of the above. They put together an excellent poster, which was very complete. I was not the only one who noticed this, as shown by a few compliments during conferencing."

This interview and observational data is corroborated by our analysis of student conferencing and Web poster scores. The greatest percentage of Internet conferencing was devoted to asking for explanations related to the disease (44%) or asking for explanations related to the genetic testing (10% of time). In responding to questions, students gave 78 explanations or 36% of their total responses. Slightly less time was spent asking questions about facts related to genetics (12%), or answering factual questions (20% of replies).

In the Appendix we present the rubric we used to score students' posters. The mean scores on accuracy of gel blots was 3.5 (out of 4) for the first year and 4.0 for the second year. Mean scores on interpretation of their gel blots was 2.6 out of 5 for the first year and 4.2 for the second year.

Prior to the beginning of this project, high school students completed a case analysis test designed to measure students' understanding of scientific concepts and ethical issues before and after the simulation. The case analysis test included a case about a fictitious disease similar to the cases presented in Case It! Students answered open-ended questions requiring them to interpret the results, explain the biology and advise the family regarding ethical issues.

In the first year, on the posttest, high school students in the experimental (volunteer for extra credit) group scored significantly higher than those in the control group, $t\ (26) = 3.77, p > .001$; mean scores of the experimental group ($M = 12.4$, $SD = 4.1$) were twice as high as the mean score of the control group ($M = 6.0$, $SD = 4.8$). There were no differences on the pretest between the students who chose to do the project for extra credit (experimental group) and those who chose not to participate (control group), $t\ (26) = .986, p = .986$; both groups scored a mean on the pretest of 7.3 out of a possible 18 points.

In the second year, when the project was a regular part of the curriculum, we also found significant differences between pretest and posttest scores, $t$ (16) = 6.38, $p$ <.001. Students' scores on the posttest ($M$ = 15.06, $SD$ = 2.48) were almost twice as high as their scores on the pretest ($M$ = 8.9, $SD$ = 3.57). The teacher reported that he thought the project was more beneficial to students' learning as a regular part of the class, rather than as an extra credit project, and students' higher scores on the posttest (15.04 in the first year versus 12.4 in the second year) corroborate his perspective.

**Ethical issues**

One of the questions on the case test required students to give advice to the family in the case about ethical issues raised by the results of the genetic tests. Students in the control group did not improve their score on posttest; both pretest and posttest scores averaged a mean of 1.5 or less (out of a possible score of 5). In contrast, students in the experimental group changed from a mean of 1.4 on the pretest to 3.53 on the posttest, which was significant, $t$ (14) = 9.91, $p$ <.001. Likewise, in the second year, students significantly increased their pretest scores from 2.70 ($SD$ = 1.04) to 4.05 ($SD$ =.89) on the posttest, $t$ (16) = 4.57, $p$ <.001.

During interviews, the majority (91%) of students reported that the project encouraged them to think about ethical decisions they might face in the future. As one said, "It caused me to think about when I have a family what I want to do in that situation.".

This interview data is corroborated with the student conferencing data. Aside from explanations, the second largest percent of conferencing time was spent discussing ethical questions (16% of time; 43 questions) and answering ethical questions (26 replies; 12% of time). For example, one group had a lengthy discussion (20 interactions during one thread) about whether to keep visiting an advanced Alzheimer's patient and whether or not to bring grandchildren to visit. In another group, they discussed ethical considerations centered on the idea of assisted suicide. In response to a university student's comments that the plug should be pulled so as to save money (a bit flippant at best), the poster creators respond:

> "To answer your question about ending the life of another because they have Alz., we won't say whether it is the right thing to do or not, but it is something people need to think about. A couple should discuss their wishes with their partner before their disease progresses, that way the partner will know he/she is making the right decision for that person."

This shows some depth of thought and no biases on the part of the responders. In another question a hypothetical Martha played by a university student poses the idea that she should commit suicide (as she lives in Oregon and it can be physician-assisted) rather than let her kids watch her "lose my mind." To this they respond that they realize that "choosing to end your life is a very big decision." This responder then goes on to say that:

> "I personally can't change your mind or tell you what is right, but don't do anything without talking to your family first."

If these responders have any biases about suicide it is not evident in the professional way they handle this issue as counselors.

Another HS group also conferencing on Alzheimer's, engaged in much talk about the ethical issue of putting a family member with Alzheimer's either in hospice/nursing home care or taking care of them at home:

> ------------------------------------------------------------
> Article No. 2619: [Branch from no. 838]
> posted by university student on Thu, May. 11, 2000, 10:35
> Subject: re: Dear Doctor
> …Also, my grandpa has Alzheimers and I was wondering if he should go in a nursing home. Can an untrained person take care of a person with this disease. Sincerely,
>
> Jeff
> ------------------------------------------------------------
> Article No. 2820: [Branch from no. 2619]
> posted by high school student on Thu, May. 11, 2000, 11:38
> Subject: re: Dear Doctor
> Jeff I would only suggest a nursing home if your grandfather is desperately in need of one or if you feel that your family cannot possibly take care of him anymore. This is more of a personal opinion because I do not feel it's in the best interest of anyone to just be thrown into a nursing home. As a professional opinion I would do what is in the best interest for your grandfather. If you need to take him to the doctor to get a second opinion that would be an option too. Also you can consider keeping your grandfather in his home, but getting a live-in nurse. There are many options to consider. I would think a great deal about this before you make any big decisions. Tina
> ------------------------------------------------------------
> Article No. 3631: [Branch from no. 2820]
> posted by university student on Tue, May. 16, 2000, 18:59
> Subject: re: Dear Doctor
> Thank you for your response. I was specifically wondering what the visible side effects of the disease are so that I can make an "educated decision." I know that it could possibly be an inhumane thing to put a man in a nursing home, but would it be more inhumane to leave him out of one and without proper treatment. Do you really think that I could handle watching this person that I love degenerate so much?

Sincerely, A concerned grandson

One question on the case test asked students to provide advice regarding the ethical issues involved in this case situation. Results showed that on the pretest students scored an average of 1.89; whereas on the post-test their mean scores were 3.73.

### Student interest

All of the students reported that the case-based project was valuable, but cited different reasons for this opinion. Fifty percent of the students chose the disease because it was in their family, such as breast cancer, Alzheimer's, sickle cell, and cystic fibrosis. The majority of students in both years, 59%, also liked the project because it was genuine; they felt it related to real life. Approximately half of the students, 47%, liked that the project provided a fun and novel way to learn about genetic diseases and testing. "…it doesn't bore you. You're doing something different and it's with real people instead of just one teacher talking at you."

Students' interview responses showed they became very involved in the role playing during Internet conferencing: "I think it's cool how people are really getting into it. Once in awhile I forgot that the people asking the questions were other students. It's pretty believable. It puts you in a pretty realistic situation." "I liked playing the role of the counselor. I don't feel like I know that much, but I think it's neat to just think about all these things that go on. Several others also commented on the reality of the role-play situation. For example:

> Helping people out is really like, I mean they, they're the patients and they ask you what to do. It puts you in like a doctor's sort of position. It makes you really think about some people out there really need help. They need answers, and it's nice there's these people that try to help them.

About a third of the students (34%) reported that interacting with peers regarding their Web posters provided them with a different perspective, one that is grounded in the real world: "It [the role of the genetics counselor] introduces you to what people actually do and if you are in that situation, what happens." Thirty-one percent of the students also reported having to think more about what they put on their Web posters through interactions with their peers and 28% reported enjoying this kind of interaction with their peers: "I think it is an interesting way to look at it (genetics), because they usually say, 'hey, learn this stuff and take a test'. This way you are learning about it and interacting with a real situation."

> The teacher in his interview spoke about the importance of interaction with peers: The third thing I think they could use is interacting, being with a partner. I think that that is always useful, being able to cooperatively work with a partner. For the most part, our kids did a nice job working with one another. There were some that didn't work as well with others, as we had hoped, but that had to do with some of the kids being absent when they needed to be there. Those are things beyond our control. I think that's beneficial because some of these people are going to go off,

> get a job, have to work with a team, and when the team is supposed to be doing something in a meeting, somebody's going to be sick or gone or whatever and I think it's a real good life lesson.

## Technology

The teacher thought that the technology skills students gained though this project were valuable: "The second thing is the power of the technology and the technology that they used was really, I think, beneficial in how they were able to use it." During the Internet conferencing, students asked clarifying questions (from the family's perspective) and corrected inaccuracies. The majority of students (71%) reported being asked at least one question they did not know the answer to, which inspired them to do additional research and to revise their poster including this new information. Some of the students "got sick of being asked the same questions over and over" so they "added information about the…10 questions that were asked about the same topic."

Most high school students liked the interaction with university students; as one high school student said, "People are asking you questions that you don't know how to answer then you have to research it and answer them. So then you find out a lot more that if you just researched it and did a project."

In the first year, all of the high school students changed their posters based on interactions from university peers, adding explanations and some ethical issues for families to consider (e.g., whether to have children if the parents are carriers of a disease). In the second year of the project, students were better prepared; however, the majority of high school students still revised their Web posters.

Students reported enjoying this kind of interaction. As one student said,

> It was cool to use the Internet for chatting back and forth. I never really used it like that before. I just normally look up stuff of interest. I think it's great to incorporate technology into class; it's a lot of fun.

During interviews students reported liking the opportunity to build Web sites and sharing their data with an audience. This student said,

> I think the most positive thing for me was learning how to make a Web site. It's like doing a report but you can put it on the Internet for anyone to look at. I'm so used to just writing papers and turning them in. I thought this was a really unique way to do a report.

## Value of the Project and Challenges Faced

While the reasons the students liked the Case It! project remained constant for the students in the years 2000 and 2001, the students' reasons for disliking aspects of the project differed by year. The interview data showed that all students felt that doing the project was valuable, although a few difficulties came up, such as plagiarism and preparation of the Web posters. In the first year when the project was extra credit, the biggest complaint (71%) was that students felt that they needed more time to complete the project. In the second year, with so many additional schools involved, not all classes were ready with their Web posters in time for conferencing. In the group of 2001 students, the biggest complaint (41%) was that not all of the groups finished their posters on time. This was discouraging to some of the high school students. In fact, those students who reported negative reactions to communicating with peers over the Internet were frustrated because not all schools had their posters up by the proposed date: "It was fun to talk to people, like in London and different universities, but it would have been better if everybody had their Web pages up when we were looking at the different ones." One group thought that some of the questions they got were not very good because the answer could have been located on their Web page. Finally, one group also felt "stupid" because they made a mistake in running their gel results and the college students they interacted with corrected them.

In contrast to Fabos and Young (1999), we found that students' Internet conferencing fostered extended explanations and discussions of ethics in science. According to both the students and the teacher Case It! is a good way to incorporate real-life situations and explore careers in molecular biology and genetics. Case-based learning may be an effective way to engage students in learning science, since it encourages problem-motivated investigations of biological phenomena (Stepien & Gallagher, 1993), especially, if students first grapple with problem-based cases and then build on the ideas presented in the cases (Cognition and Technology Group at Vanderbilt, 1997), which they did in this investigation through the role-playing during their Internet conferencing. For those not particularly interested in the biological sciences, this simulation allowed students to expand their knowledge of multimedia, improve skills on building Web pages and Web conferencing. Internet conferencing seemed to work more smoothly the first year, when the conferencing had fewer groups scheduled to participate at the same time. However, students reported liking an international audience and a chance to gain the perspectives of others not in their immediate high school class.

Our goal is to expand the Case It! project to include high schools and universities worldwide, and we cordially invite interested educators to participate. To download the latest versions of Case It Investigator and the Case It simulation, at no cost, contact the second author.

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**Appendix**
**Rubric for rating Web posters: Poster #: Total score =**

**Quantity of Information 1 2 3 4**

| | | | |
|---|---|---|---|
| Just gel blot | gel blot & background info | Blot, info & small statement to family | Blot, info, statement to family & explanation |

**Quality of Information related to disease 1 2 3 4**

| | | | |
|---|---|---|---|
| **Major** inaccuracies | Some inaccuracies | Correct basic information | Correct info and some in-depth investigation is apparent |

**Accuracy of gel blots 1 2 3 4**

| | | | |
|---|---|---|---|
| Gel blot is missing | Gel blot is wrong | Gel blot is slightly wrong Not all blots are present or labeled | Gel blot labeled correctly and done correctly |

**Interpretation of gel blots 1 2 3 4 5**

| | | | | |
|---|---|---|---|---|
| No interpretation | Some Inaccurate interpretation | Slight misconception of meaning of gel blot, e.g., confusing terms; over interpreting results | some interpretation | Understanding and interpretation is clear |

**Statement to Family 1 6 9 12 15**

| | | | | |
|---|---|---|---|---|
| No diagnosis or counsel given | gives poor/vague counsel | Correct diagnosis but offers no counsel for family | Correct diagnosis & presents ethical issues or treatment or resources to family | Mentions ethical issues, treatment &/or resources to family |

**Creativity and Design 1 2 3 4**

| | | | |
|---|---|---|---|
| No background | Background not pertinent | Background pertinent to topic, but difficult to read the text | Background pertinent to the topic and text can be read easily |

**Pertinent Photos and Animation 1 2 3 4 5**

| | | | | |
|---|---|---|---|---|
| No photos or animation | Some photos and animation, but not pertinent to the topic | Photos and animation pretty good, but some not pertinent to the topic | Pertinent photos and animation, but not used to clarify info in the text | Photos and animation pertinent to the topic and used to clarify information in the text |

**Grammar 1 2 3**

| | | |
|---|---|---|
| Many organizational, spelling or grammar problems | Some problems | Good organization of information, few spelling or grammar errors |