Media Fusion: A Tool that Supports Learning through Experience, Reflection, and Collaboration

Rachel Bellamy, Wayne Grant, Eric Cooper, Rick Borovoy, and Steve Adams
Apple Computer, Inc.

Abstract
Media Fusion is a tool that seeks to support learning by linking video and data analysis tools. The video motivates students and provides them with vicarious experience. The data analysis tools extend video from a purely vicarious experience to a reflective one. In addition, because we recognize the inherently social nature of human learning, the system also supports collaboration. This paper provides a formative evaluation of Media Fusion.

Introduction

“The trick to teaching is to entice and motivate the students’ excitement and interest in the topic, and then to give them the proper tools to reflect, to explore, compare, and contrast, to form the proper conceptual structures” (Norman, 1993)

Don Norman’s statement captures our design goals for Media Fusion. We use video to motivate users and then provide data and data analysis tools to allow them the opportunity for deeper reflection on the issues presented in the video. In addition, because of the social nature of human learning, we provide support for collaboration.

When we watch a “good” video we are transported into the situation it depicts. In this way, video provides vicarious experience. This kind of experience is a vital part of learning because it enables learners to see how abstract concepts are made concrete in a particular situation (Lave, 1991). Video can also motivate students’ interest in a subject, both because the narrative structure makes it easy to follow and because topical videos, such as current events programs and news broadcasts, deal with authentic issues, activities, and events. Collins, Brown & Newman (1989) have stressed authenticity as an important component for the learning process.

As Norman argues, an educational tool must provide more than just an interesting and motivating experience; it must also provide students
with the opportunity for reflection. Linking video to data and data analysis tools supports reflection, because it allows students to view, explore, and manipulate the kinds of data that are being used to support opinions presented in the video. Through reflection, learners can change their knowledge structures—an important part of coming to understand a subject in depth (Bruner, 1960; Greeno, 1988).

Reformulating knowledge is not a passive process, but an active one. Research suggests that successful learners actively seek to reorganize their existing knowledge (Resnick & Neches, 1984; Bereiter, 1985; Chan & Burtis, 1985; Lave & Wenger, 1991; Scardimalia & Bereiter, 1993). They actively seek to prove or disprove their beliefs based on new information they discover in the world. The exploratory nature of Media Fusion supports such active construction of knowledge. Students can explore both the existing messages and the data in any order they wish and at their own pace.

Our design work extends Norman’s view of what is required to support learning. We hypothesize that to support learning an environment must, in addition to providing tools that are motivating and support reflection, provide tools that enable the formation of a community of learners. Such a community is important because knowledge is socially constructed (Roschelle & Clancey, 1991; Pea, 1992). Through collaboration, the community negotiates an understanding of an issue. Compared with an isolated individual learner, the community has access to a much more varied and rich pool of information, because all of the members of the community can pool their knowledge and cognitive resources in order to understand an issue.

Media Fusion enables such collaborative discussion of the data by supporting users in making their own video or text messages and by allowing them to embed “live links” to the data, in the form of graphs, in their messages. The links are live because the receiver not only can inspect the graph embedded within a message, but also can manipulate that graph. These graphs serve as conversational props and, as such, are central to scientific conversation (Pea, 1992). In Media Fusion, the graphs that students fuse with their video or text messages serve as a scaffold, because users come to understand a message through direct manipulation of a graph contained in it.

This paper describes a formative evaluation of Media Fusion. In the study, Media Fusion was used by students in California and in Washington, D.C., to collaborate on issues related to global warming. To initiate the collaboration and exploration, a video message consisting of a debate
about global warming, taken from the “MacNeil/Lehrer News Hour,” was sent to all the students. Pointers to real-world data about variables that might affect global warming were placed in the video. Students watched the video and explored the data in order to come to their own understanding of global warming. Using Tabletop (Hancock, Kaput & Goldsmith, 1992), a data analysis tool, students constructed views of the data to argue their point of view as they engaged in discussions, via video or text messages, with the other students involved in the study. This study served to investigate a number of hypotheses we had concerning how Media Fusion supports the learning process:

• Video that is timely and deals with authentic issues provides a vicarious experience and motivates students’ interest in a subject.
• Linking video to data analysis supports reflective learning because, through exploration and interpretation of the data, students can actively construct an understanding of the opinions presented in an accompanying video clip.
• Sending and receiving video and text messages supports the social construction of knowledge; being part of an authentic community motivates learners; and peer-assessment encourages greater self-assessment.

A Formative Evaluation of Media Fusion

Formative evaluation seeks to influence the design of technology by studying the use of initial prototypes in realistic situations. It discovers what is good and bad about the prototype with respect to its initial design goals. This information is used in the subsequent redesign of the technology, which is then subjected to further study. We recognize that it is not just the nature of the technology itself that is important in determining usability and usefulness; the context and participants are also important factors. Thus, our formative evaluation process starts with participatory design (involving researchers, teachers, students, collaborative partners, and more) of both the technology and the situation in which the technology will ultimately be studied. In the following sections, we describe this formative evaluation of Media Fusion.

The Technology

Media Fusion is a tool that integrates a number of separate technologies: video, data analysis, and communications.

Model-Based Communication (MBC)1: A major component of this technology
is called Model-Based Communication (Borovoy & Cooper, 1992). It provides a means of constructing digital video (or text) messages that can contain embedded pointers to various applications. For example, in Figure 1 the video message titled “MacNeil/Lehrer News Hour” contains two pointers, which are positioned along its scroll bar. As the QuickTime® digital video clip plays, the scroll box moves along the scroll bar. When the scroll box reaches the first pointer, it launches a data analysis application, called Tabletop, and configures a prespecified graph derived from a particular database. All this information (the application, the file, and the various parameters that describe the scatter plot) was encoded into the pointer when the message was created.

With MBC capabilities, users who have a video camera and a digitizing board can create their own video messages. Clicking on the “New Video” button brings up a live video window that shows exactly what the camera’s viewfinder shows. The user also gets a “Record” button, which will start recording a digital video when pressed. (During recording, it turns into a “Stop” button.) Users can also specify various analyses of the data (in Tabletop). These analyses can then be dragged onto the QuickTime digital video. The pointers can be moved around or deleted. When the user is satisfied that the video message conveys the appropriate information, it can be saved.

MBC allows the user to create a narrative that explicates a path of reasoning. For example, a single video message might have several pointers. All might refer to the same application and the same database file, but each of them might show a different way of looking at the data. In some cases, this might mean plotting different fields against each other. In other cases, this might mean changing the scales of an axis. In still other cases, this might mean highlighting certain data points in one view and others in subsequent views. Collectively, these graphs can be used as evidence to support a line of argument delivered in the message. The receiver of such a message not only can inspect the graph embedded within a message, but also can manipulate that graph. This lets users come to understand the data not only in terms of the graphical view constructed by the sender of the message, but also in their own terms. In turn, the receivers of a message can create their own view of the data (through direct manipulation of the graph that they have received) and can embed their new view of the data in their response. Users can discuss issues shown in the video, use data to augment their reasoning about those issues, and share their understandings with others. The collection of messages developed in this manner serves as a history of the community’s
inquiry and documents its understanding of the issues being discussed.

Video: For this study, we decided that the video should be taken from a current events television show, because the authentic issues such a show presents would be of interest to the students. “MacNeil/Lehrer” was chosen for a number of reasons: we were working in collaboration with PBS, this particular show treats issues in depth, and it represents an issue from multiple perspectives—a format that invites response.

Once selected, the video clip is digitized and pointers to views of the database are then linked to it. In this study, for example, segments from a recent “MacNeil/Lehrer” video clip on global warming were digitized and then fused with a database on global warming. This resulted in a short “MacNeil/Lehrer” video message on global warming, which contained two live graphs supporting two of the points discussed in the video.

Data Analysis Tools: Tabletop, a data analysis tool designed at the Technology Education Research Center, in Cambridge, Massachusetts, was chosen to be used in Media Fusion. Tabletop is ideally suited for this use because it has been designed specifically to enable students to make authentic inquiries of data. Tabletop provides a simple, nonrelational database that can be viewed via Venn diagrams and scatter plots. Tabletop is highly interactive in that views are constructed via direct manipulation of the interface. For example, a scatter plot is created by selecting the variable name specified for the axis and then choosing one of the list of possible variable names that appears on a pop-up menu. When a change has been made to an axis, the points on the screen gradually move to their new positions. By showing the plot reorganization as a gradual process instead of an instantaneous one, Tabletop gives students feedback on the way in which changing the graph’s specifications affects the data.

Databases: The databases were designed to serve as a common pool of information upon which students could draw. One function of the databases was to tie into, and expand upon, points presented in the digitized video clip. For example, in one digitized segment of the “MacNeil/Lehrer” video clip, a scientist comments on ways of reducing warming trends and CO2 production. He points out that the economies of Japan and Germany are more than twice as energy efficient as the economy of the United States. When students replay this section, a graph derived from the database, and showing a comparison of the energy
efficiencies of these countries, automatically appears on the left side of
the screen.

The databases, not narrowly restricted to topics presented in the
video, also provided students with other pertinent data. For example, the
database used in this study of global warming addressed factors relating
to the production of greenhouse gases, which are released by the burning
of fossil fuels and other industrial processes. Along with information
about CO2 and methane, the database included such economic variables as
whether a country’s economy is developing or industrialized, the amount
of its gross national product, the price of gasoline, and the number of
automobiles. Because Media Fusion is not limited to a single database,
multiple databases can be used, and the data can be structured in different
ways. In this study, most of the data were organized by country. However,
to facilitate comparisons between countries, the databases contained
fields such as the location of a country and its type of economy.

A characteristic of the databases that has been implicit in this
discussion is that they contained “real” data. This is consistent with our
argument that, to be motivating, learning situations should be authentic.
The use of real data makes working on this project different from using
the storybook situations sometimes invented for textbooks. Here, students
are given access to the same kinds of data used by analysts and policy-
makers. For example, the data sources for this study included reports from
the United Nations and the Organization for Economic Cooperation and
Development, technical journals, and almanacs of environmental data.

Asynchronous Communications: Messages are exchanged via satellite.
Through our collaboration with PBS, we had access to a VSat connection.
Currently, the messages made in Media Fusion are not automatically and
immediately exchanged. Rather, this exchange happens overnight and is
directed by a researcher at each site.

Preparing the Situation
Two schools took part in the study; a middle school in Marin County,
California, and a junior high school in Washington, D.C. At each site, three
teachers and approximately
12 students participated.

During the technology development stage of the project, we visited
the schools to observe students working with a preliminary version of the
Media Fusion software. We used this visit to confirm the validity of our
design goals, iron out technical issues, and collect feedback from teachers
and students about the design. It became clear at this point that the students’ lack of familiarity with the Tabletop data analysis tools was affecting their ability to exploit the potential of Media Fusion. Also, we realized that the teachers needed to have more experience using Media Fusion before they could think about it from a teacher’s perspective.

To address these issues, we conducted a Media Fusion workshop a few months before the actual study was to begin. In the workshop, teachers learned how to use Tabletop and how to make Media Fusion messages. They had time to explore the technology, and they became sufficiently familiar with it that they could prepare their students for the user study.

Following the workshop, we collaborated with the teachers to develop the Media Fusion curriculum for this study. The domain of inquiry, for example, was constrained by a number of factors: which topics would be of interest to students, which could we get sufficient data for, and what video clips PBS could give us access to. After much consideration, we chose the topic of global warming.

We also discussed the activities that should be part of the user study. One particular discussion focused on whether we should have an activity in which students were able to add their own data to the database. Although we agreed that this was a good idea, we decided not to implement it for this study. (Students could, however, write or talk about other data in their messages.) There were three reasons for our decision: we realized it would be difficult to resolve differences between the databases, we wanted to observe what happened when students interacted with existing data, and we thought that limitations in the dataset would provide teachers with the opportunity to discuss more general issues about possible limitations of datasets.

Together, we developed databases about global warming and a set of database explanation sheets. These explanation sheets listed the name of each field in the database, its definition, its units, and the source from which it was obtained. Prior to the user study, the students reviewed these sheets. During the user study, the students had access to them and were encouraged to consult them.

“Seed messages” were also developed to introduce the database and to provide some relevant background information, as well as to illustrate sample analyses that could be done and to give examples of ways of using the data analysis tool. The seed messages consisted of a composite of a textual or video message with an accompanying graph derived from the database. To involve an expert in the community of users of the system,
we asked an expert on global warming and environmental issues to develop some of the seed messages.

It was important that students at both schools be familiar with the Media Fusion software and, in particular, with the Tabletop component. With this in mind, teachers involved the students in a number of preparatory exercises. By the time the user study began, the students had at least an initial familiarity with both the Tabletop and the Media Fusion software. They knew how to make scatter plots and Venn diagrams using Tabletop, as well as how to compose, read, and respond to both text and video messages.

The Study
The user study took place over four days, for two hours per day. Students working in groups of three, four, or five used Macintosh Quadra 700 computers outfitted with 20 megabytes of RAM, a 13-inch color monitor, a video digitizing board, and a video camera.

The study commenced with the students watching the full “MacNeil/Lehrer” video from which the digitized video clip had been taken. Following this, the teachers led a discussion of global warming. The discussions differed slightly between schools. At the California school (School 2), the discussion focused on what was presented in the video clip, in particular on the structure of the arguments offered by either side. At the Washington, D.C., school (School 1), the discussion was organized around the central issues of global warming. There, the students considered the big issues in global warming and discussed the possible questions that they might investigate using Media Fusion.

Following the discussion, students at both schools worked with Media Fusion for the remainder of the session. They could look at the messages existing in the system—the “MacNeil/Lehrer” clip and expert seed messages—and compose their first video or text messages. That evening, the messages the students composed were exchanged.

For the remaining three days of the user study, students received messages from one another, discussed them, and composed new messages that were exchanged the following evening. Each session started with a brief discussion to draw the students back into the activity. Then the students worked with Media Fusion, reading messages that had been received and composing responses or messages on a new topic.

A number of different methods were used to collect data during the user study: pre- and postusage study questionnaires, pre- and postparticipant discussions of global warming, and interviews with both
teachers and students after the user study had finished. We also had video recordings of students using Media Fusion as well as the entire collection of Media Fusion video and text messages.

Analysis
The data collected are being subjected to many different kinds of analyses. Currently, a database of the students' messages has been developed that categorizes the messages in terms of the argument structure. The pre- and posttest questionnaires have also been put into a database. Transcripts of all the interviews have been obtained, and an initial review of the video data has been performed. The preliminary results from these analyses are discussed in the following section.

Video as a Motivator and Provider of Vicarious Experience: Being able to create video messages was particularly motivating. Out of 66 messages created, 48 were video messages. In fact, the excitement surrounding the receiving and sending of video messages was so great that teachers found it hard to keep students away from the machines during the hours when they were not participating in the study.

Teacher 4: “Sometimes I think they don’t even realize what they’re doing, that they are actually in school and it’s actually studying or learning, because they see it as fun.”

In our original design goals for Media Fusion, we hypothesized that several factors—including timeliness and authenticity—affected how motivating an initiating video might be. As expected, both students and teachers thought that these were important factors. In addition, students felt that the video needed to be relevant to their own lives and to provide lots of real-world examples, rather than just talking heads.

It is difficult to assess whether the video provided students with a vicarious experience. In their poststudy discussion, students recalled specific examples that had been used in the video to illustrate how people contributed to greenhouse gases—one of the major causes of global warming. They also frequently reviewed parts of the initiating video when they were trying to understand the specifics of the data. However, as mentioned earlier, students felt that the initiating video did not provide enough examples of the effects of global warming.

Supporting Reflection by Linking Video and Data Analysis: As expected, the
students gained a more detailed and integrated understanding of global warming issues by exploring the data. The following messages, though made by different groups of students, show how exploration of the data helped students come to a deeper understanding of the issue. The first message was made immediately after students watched the video clip—before they explored the embedded data. The second was made after the students had explored the data.

School 2, Group B: “...I agree with Oppenheimer more because I think that we shouldn’t spend more billions of dollars on something we are almost positive about. I think that if we do not stop global warming now, we will not be able to stop it twenty years from now.”

School 1, Group C: “...Aren’t the industrialized countries guilty on two counts (the burning of fossil fuels and industrial purposes) of destroying the atmosphere? And, if this is so, should they not pay for the Earth’s atmosphere according to their C02?

The first message indicates that, though video may have engaged the students, it had not provoked them to think deeply about the issues of global warming. However, the second message shows that, after exploring the data, students were able to think much more critically about the issue.

In addition to learning about global warming, students also developed a good understanding of what it meant to use data to support a view, and they learned how to investigate hypotheses using the data analysis tools. This is shown in the following protocol taken from the poststudy discussion.

Researcher: “... if you had both those different graphs, the automobiles with C02 and the bicycles with carbon dioxide, what would you expect to see?”

Student 15: “I’d expect that countries that had a lot of bicycles—that those had low C02 emissions and countries that had a lot of cars would have high C02 emissions.”

Researcher: “So the greater the number of bicycles the lower the C02. And how would it look? Would they look like, the opposite of each other, the
In this example, the student is exhibiting an understanding of what the graph actually means. The student argues that there are other variables that can affect the graph, variables that are not shown on the axes. This is a vital concept in understanding correlations. Our data show that several students grasped this concept directly through interaction with Media Fusion.

Students had also developed an understanding of what questions to ask, and how to answer those questions using the database. For example, when trying to respond to a message about a correlation between the amount of CO2 produced and the amount of energy consumed by a country, one student said:

Student 3: “I think that to find out about CO2 Industry 89—what kind of industry that’s based on—you might want to look at cars, transport, population, you might want to look at gas, stuff like that. Let’s see how much that contributes to what is called CO2 Industry 89.”

In general, using Media Fusion gave students the opportunity for deeper reflection on the issues related to global warming. It also allowed students to understand the power and meaning of data analysis as a tool for making sense of opinions and encouraged them to think about how to use data to support an argument.

Supporting the Social Construction of Knowledge Through Collaboration: Being able to send messages about issues enables the formation of a community of learners. Such a community is important because knowledge is socially constructed. Through collaboration, the community negotiates an understanding of an issue. As one student put it:

Student 1: “Well, because with this you learn differently than you would learn in a classroom. In the classroom, you sit there and listen to your teacher and do your work. But here you can exchange opinions about this, you can disagree with each other, like the teacher, the teacher’s right all
the time... but with this, you learn from them, they learn from me, and we learn together.”

Having to negotiate an understanding may have been a factor in students’ ability to reason about the data. In previous studies of Tabletop, researchers noted that students held onto their own opinions—even in the face of data that seemed to contradict them. That was not evident in this study. Also, when a student stated something that was not shown in the graph, other students would notice and correct the view, and the first student would then reevaluate the original statement in light of the correction.

Three things were required before a group gained further understanding about global warming issues: someone else's message, the arguments it expresses, and the graphs that prove those arguments. In this way, the members of the community scaffold one another's learning. One of the most difficult things for students to grasp was learning how to continue a discussion on an issue while supporting their arguments with data from the data set. There are two reasons why this might have been so difficult. First, Media Fusion did not provide an adequate model of this behavior. We used the expert seed messages to model the kinds of behaviors that we thought were important, (for example, using different kinds of graphs to support different points, and using text messages to make some points and using video messages to make others.) A surprising result in our study was that students didn't much use these seed messages. Maybe this resulted from lack of time, however one would have expected them to look at them more on the first day. Maybe it was due to the quality of the sound, although sound quality did not stop students from listening enthusiastically to one another’s messages. Maybe it was because our expert was quite gruff and frightened the students, however this seems unlikely. Most likely is that the expert wasn’t part of the community, though this separateness had been a conscious design decision. (We were worried that if the expert had been part of the community, expert-student conversations would detract from the student-student conversations.) Seeing the result, the teachers conjectured that expert communications are not meaningful to the students unless the experts are part of the community.

A second reason that students found it difficult to have an ongoing discussion about an issue was that the Media Fusion message browser simply listed messages by title. As a result, the students had difficulty finding messages on a particular topic. During the study, we reorganized
the browser so that messages were listed according to discussion topic. This reorganization made it far easier for students to find messages and to continue an ongoing discussion.

Altogether we had four discussions: CFCs and GNP, CO2 and GNP, Opinions, and Social. These contained 7, 11, 5, and 10 messages respectively. There were also two subdiscussions: a CO2 and CFCs discussion that arose from the CFCs and GNP discussion, and a “romance” discussion that was a subset of the social exchanges. Out of the total 66 messages, 61 were messages that were part of a discussion. Apart from the opinion and social discussion, these discussions centered on specific issues arising from the students’ exploration of the data. The students created arguments and used the data to support their arguments. Much of the discussion centered around alternative interpretations of the data or questioned whether the data really supported the argument. In one example, the concept of GNP was discussed in detail because one student made a video message containing a graph that showed the total GNP for a country. The student sending the message said that GNP was defined as millions of dollars per person. The students receiving the message, noting that this did not make sense, suggested a different definition of GNP. The original author acknowledged the appropriate definition of GNP and revised his interpretation of the graph accordingly.

Compared with an isolated individual learner, the community has access to more information, because community members can pool their knowledge and cognitive resources in order to understand an issue. For example, in the discussion about GNP described above, the student who sent the original message found one of the responses hard to understand. However, he reflected in the poststudy interview that this was not a problem because the explanation in the second response was very clear. In retrospect, however, the amount of knowledge available in this study was not as great as it could have been had experts been fully integrated into the community. Other studies have shown that experts provide valuable resources to learners when they are part of a networked learning community, though careful measures must be taken to ensure that expert-student discussions do not detract from the valuable peer-peer discussions (Woolsey & Kerns, 1993).

Discussion
As our economy becomes increasingly information centered, the ability to rapidly understand new information becomes a critical skill. We need to provide tools that allow people to grasp, and then reflect upon, that
information. Tools like Media Fusion not only motivate students through the use of compelling video, and give them access to different interpretations and presentations of information, but also support students in exploring the information relevant to the opinions, events, and phenomena presented in a video. To be effective, such tools must also provide access to a community that is constructing a deep understanding of that information. This study has shown that Media Fusion has the potential to become a tool that can support such activities.

We have also discovered certain aspects of Media Fusion that need to be redesigned so that it better supports learning. In particular, future versions of Media Fusion should provide more appropriate support for the organization and retrieval of messages. We are currently working on a concept of dynamic viewers to address this issue. A second important area on which our redesign work concentrates is the development of guidelines for appropriate video and data to use to stimulate Media Fusion discussions. For instance, the video must contain examples of phenomena that are pertinent to students' topics of study and that are closely tied to the data in the database. Finally, we have realized that a community of learners needs to contain experts who can provide important insights to novices. Future studies of Media Fusion need to fully integrate experts into the learning community.

From a formative evaluation perspective, this study has shown the importance of designing not only tools, but also tasks and situations. Much of the effort in this study was placed on designing the situation in which the technology would be used. This was important because it enabled us to go beyond a purely technological focus to incorporate details about supporting materials and social issues in our evaluation. We think that expanding the design space beyond examining how the tools support learning—to look at how the tools function in the context of the task and the situation—is an important aspect of this work. And it is critical when the tools are to be placed in organizations, such as schools, that have entrenched approaches to the use of educational support materials.

References


Nervous System Functions for Research and Practice in Education, Chicago.


1 The MBC technology was developed by Apple Computer, Inc.; U.S. Patent pending (Borovoy & Cooper, 1992).
2 It is important to point out that this type of embedding is significantly different from other seemingly similar types of linking. Some applications allow the user to insert bitmap images of other applications, but these are static pictures that do not support exploration. Some applications allow the user to create a “hot link” to another file (possibly opened by another application), but these typically take the user to a fixed document, (such as a word processing document or a HyperCard stack).

© 1994 Apple Computer, Inc. All rights reserved. Apple, the Apple logo, and QuickTime are registered trademarks of Apple Computer, Inc. ACOT is a service mark of Apple Computer, Inc.