National Geographic Unplugged: Classroom-Centered Design of Interactive Nature Films

Brian K. Smith
MIT Media Laboratory
20 Ames Street, E15-313
Cambridge, MA 02139 USA
+1 617 253 6537
bsmith@media.mit.edu

Brian J. Reiser
School of Education and Social Policy
Northwestern University
Evanston, IL 60208 USA
+1 847 467 2205
reiser@nwu.edu

ABSTRACT
Designing computer-based learning environments must account for the context in which activity occurs, the tasks that students perform, and the tools that facilitate these tasks. When designing for school use, it is also crucial to consider how the software will be integrated into the organization of the classroom workplace and how teacher practices influence the adoption and success of interactive learning environments. This paper discusses our experiences in designing and deploying an interactive video tool to high school classrooms. We stress a classroom-centered design that tries to integrate usable software with interactions that occur "outside of the box" to alter traditional school learning.

Keywords
Children, collaborative learning, educational applications, interaction design, multimedia, social issues, video.

INTRODUCTION

This paper focuses on the design of an interactive video system called *Animal Landlord*. Developed for high school biology classrooms, students interact with digital video clips showing the Serengeti lion hunting its prey to learn concepts in behavioral ecology such as resource competition, social organization, and optimal foraging theory. The system provides computational tools to help students extract "field data" from the video, create narrative explanations of the observed behaviors, and, ultimately, generalize explanatory models accounting for the causal influences on lion predation and prey evasion. Students become documentary narrators, using the software tools to interpret and explain visual events.

Our goal is to change the typically passive viewing of documentary films into a problem solving task, where students interact with computer tools to observe and explain complex, visual behaviors. In some sense, this means changing the nature of classroom activity. The traditional view of learning is one where students passively absorb information transmitted by a teacher, a textbook, or a film [6, 12, 20]. In contrast, we would like to see students develop their own understandings through inquiry, interpretation, and argumentation with peers. Computational media can provide rich, interactive environments to explore and construct ideas, but they must also provide explicit help for students, as they are not accustomed to these types of reasoning in classroom settings.

The issue is to introduce computer technologies into classrooms in ways that benefit teaching and learning. We have been influenced by a learner-centered design framework [20], acknowledging that the tasks students perform, the tools needed to perform these tasks, and the context in which activity occurs all contribute to the success of computer-based learning environments. In addition, developing usable software is not enough to ensure learning. We must also account for the roles of teachers and non-technological media, introducing our computer systems into the existing work cultures of schools — classroom-centered design, if you will. By integrating the engineering of computer software with the reengineering of the classroom workplace, we hope to improve learning practices.

We review the design iterations of Animal Landlord, focusing on changes resulting from an increasing awareness of the relationship between context, tasks, and tools. We highlight features of the classroom setting and their influence on the overall interaction. In particular, we suggest that teachers, as well as students, are users of computer-based learning environments as a result of their important role in instruction. We also stress the social collaborations taking place around the computer and the use of non-technological media in facilitating learning.

PRODUCING INTERACTIVE NATURE FILMS

Our research concerns the development of learning environments to help students engage in inquiry around actual, scientific research issues [8, 21]. We provide environ-

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ments where students can generate and test hypotheses and create causal explanations of complex phenomena. Standard laboratory activities in high school classrooms provide some opportunities for this kind of problem solving, but they tend to prescribe the exact data to be collected, hypotheses to be tested, and conclusions to be drawn [4]. Our environments are meant to extend these structured laboratories by providing more open-ended avenues for students to reason about complex problems.

Why Film?

Animal Landlord's curriculum deals with the hunting behaviors of the Serengeti lion. When we ask students how often they think lions successfully capture their prey, their predictions are quite high (50-90%). In reality, only 15-30% of all attempted hunts actually result in a successful capture [14]. This mismatch between the lion's mythology and scientific observations raises curiosity and sets the stage for learning topics in behavioral ecology such as social organization, resource competition, variation between individuals and species, and environmental pressures. To understand why lion hunting success is lower than expected, one needs to understand the causal interactions between the lion, its prey, and the environment.

Nature documentary films provide a good medium for observing such behaviors, but they tend to provide topical overviews and surface accounts of behavior, neglecting many interesting domain processes in favor of straightforward outcomes. For instance, a film might mention that a creature performs a particular behavior without going into the complexities of why it does so. Narration is the primary source of knowledge in these films [3, 22], yet there is a great deal of implicit information in the video that students could observe and explain for themselves.

We use these films as the basis for our curriculum because students and teachers are accustomed to viewing them in classrooms. We were hoping this familiarity would ease the transition to new activities and ways of learning. We can use their knowledge of the information found in documentary narrations to develop new understandings of what these narratives could be. Essentially, we are trying to hold one aspect of the learning culture constant — the video — while changing another — the activity around video.

Nature films also hold a wealth of "raw data" that can be observed, analyzed, and explained scientifically. Students can become multimedia researchers [5], decomposing these films into salient events, analyzing and drawing connections between these events, and collaborating with others to construct meaningful representations of the visual data. In a sense, students can study nature films to learn about behavior in the same ways that behavioral ecologists study animals in their natural habitats.

A number of existing software environments assist students in learning by interacting with video. Some of these allow students to take quantitative measurements of objects and actions directly from digital video [3, 14, 15], encouraging the development of mathematical ideas around real-world phenomena. Many authoring environments allow students to express ideas by creating various multimedia presentations [1, 5, 11]. There is also a focus on establishing learning collaborations by using video as data to coordinate group activities [2, 9]. These projects shift students away from the passive viewing of video by creating tasks requiring construction and/or interpretation of multimedia artifacts.

Our work is motivated by these systems but differs in our emphasis on qualitative modeling of causal phenomena. With Animal Landlord, students create explanatory narratives for a corpus of video clips. To do this, they view documentary footage seeking answers to an assigned question (*e.g.*, "Why is the lion a 'bad' hunter?"). Instead of simply watching films, students capture and manipulate video frames as a primary data source. Gradually, they move from raw video footage to working with evidence in the form of significant frames. As students and teachers collaborate to argue over and refine ideas posed through the video, an interactive experience emerges around nature films.

Classroom-Centered Design

A learner-centered design framework suggests that the design of effective learning environments must take into account the context in which software is used, the tasks that students will perform, the tools provided to engage in these tasks, and the user interface to these tools [20]. The central claim is that explicit supports, or *scaffolds*, can be embedded in software to help learners accomplish tasks that might otherwise be beyond their abilities. These scaffolds make problem solving strategies explicit for students. For instance, we will discuss several ways that we have tried to scaffold students through the steps of decomposing behaviors into smaller, constituent actions.

In designing Animal Landlord, we had to consider more than the software itself. It is often tempting to computerize all of the learning scaffolds, but this can lead us to overlook many of the resources that classrooms offer. Teachers play a role in student learning, and we need to involve them in the design process and the overall interaction. As well, schools have social and work cultures that cannot be ignored [6, 16, 17]. Often, these existing practices offer better task solutions than software implementations. In a sense, we have engaged in classroom-centered design, distributing tasks and tools between the computer, the teacher, and existing work materials (*e.g.*, chalkboards, videocassettes, and so on).

This classroom-centered design emerged through collaboration with ecologists, students, and teachers. Ecologists helped us understand the tasks that they perform and the sorts of reasoning required when observing and explaining animal behavior. Teachers helped us interpret the classroom context, co-developing activities and offering insights into their expectations of student performance. Finally, student interviews and analyses of their work helped us scaffold tasks with tools. Below, we discuss tasks, tools, and context and how our design partners influenced curriculum development.

Tasks

We collaborated with behavioral ecologists early in the design of Animal Landlord to understand how they conduct field observations. After several working sessions with them, we developed a sense for the strategies that help them focus their investigations of behavior. This expertise was distilled into an investigation model that attempts to capture important features of their observation and argumentation [21]. In particular, the model makes explicit the components of the investigation task and the salient features of an ecological argument.

In practice, a behavioral ecologist might begin by cataloguing the behaviors in a hunt (*e.g.*, stalking, chasing, scanning) to understand the space of activity. Behavior patterns begin to emerge as actions found in different hunts are compared. For instance, lions may not stalk in some percentage of their hunting attempts. When variations are found, it is useful to look for selection pressures that may account for the behavior. A lion may break into a chase without stalking if it is close to its prey or if there is dense vegetation in the area. Generally, this leads to additional questions requiring additional observational data (*e.g.*, "How close is 'close enough'?). Finally, considering the costs and benefits of actions by relating them to strategic factors can lead to evolutionary explanations of behavior.

This can be thought of as four subtasks that are useful for analyzing and interpreting complex behaviors:

- Decompose complex behaviors into smaller, related actions.
- Compare similar events to look for variations.
- Identify factors responsible for these variations.
- Relate factors to behaviors to form an evolutionary explanation.

These subtasks can be performed whether the phenomenon is being observed in the Serengeti or on a computer screen. Behavioral ecologists understand this process and seem to follow it when interpreting the causal structure of complex behavior. High school students do not have this expertise, and we have tried to help them through the process by providing effective scaffolds for each individual subtask.

Tools

Our design tries to lead students through the elements of this investigation model, helping them to make sense of complex, visual data. A software annotation tool focuses students on the first subtask, detecting intermediate actions that lead to an outcome. Comparing and identifying strategic factors that vary across events are also facilitated through a tool that allows annotated films to be compared against one another. A modeling activity at the end serves to link everything together, forming a qualitative explanation of hunting behavior. These tools were iteratively refined through discussions with students and teachers and observations of classroom activity.

However, some of the tools are not computational. For instance, we have students draw relationships between strategic factors and hunting behaviors with pencil and paper and then write their diagrams on large posterboards. We also make extensive use of videotape (in addition to the digital video on the computer) during classroom discussions. Two issues were considered when deciding whether to embed scaffolds directly into the software. First, although software should assist task performance, it is possible to eliminate learning benefits by having the computer do too much [13]. It is beneficial for students to construct ideas, and this often means doing so without computational scaffolds. Second, observations of classroom work practices often suggested that software was not the best medium for the tools, and we discuss this below.

Context

Schools and classrooms are organizations with elaborate work practices, and successful software environments must respect these practices [6, 16, 17]. For instance, although students are the target audience, it is equally important to consider teachers as users of the system. At the simplest level, teachers are the ones judging the software's utility in their classrooms — if they do not approve of it, students will never see it. More importantly, designing for active classroom participation requires teachers to facilitate activities, as students need guidance when learning and collaborating. Teachers orchestrate classroom activities "outside of the box", and their role in the learning environment effects learning outcomes. In short, teachers are users too.

Large numbers of students sit in classrooms, and things often get noisy and chaotic. Rather than trying to build individualized systems for such settings, we have tried to leverage off of the social interactions in the classroom, developing activities that allow students to collaborate and argue around the computer tools. Such collaboration can be useful when observing and interpreting video, as students are more likely to make their thoughts explicit, pose alternative ideas, and critically interpret and learn from their colleagues. Because computer monitors offer limited viewing space, some tasks are best achieved through traditional media such as blackboards, posters, and so forth. As we mentioned earlier, some of the tools in the Animal Landlord intervention are paper constructions because it is easier for large groups of students to gather and discuss ideas around them.

ANIMAL LANDLORD

In this section, we discuss the result of integrating context, tasks, and tools by describing the evolution of Animal Landlord over several iterations. We have conducted four, week-long user trials with 300+ students in twelve, introductory biology classrooms. During each iteration, we looked to see what kinds of activities were occurring in the classroom, focusing on the conversations taking place, the teacher's role in sustaining these conversations, and the products created by students. We describe the iterations and the design changes resulting from observations of students and teachers interacting with the curricular materials.

Trial 1: Annotation

Animal Landlord provides nine video clips, each depicting different ways that lions obtain their prey. These 1-2 minute segments vary across factors such as size and composition of the lion/prey groups, prey species, time of day, hunting methods (stalking, ambushing), and hunt success or failure. This allows students to make comparisons between films to identify strategic factors influencing hunt outcomes and their range of possible values. For example, students might notice that the size of the hunting party changes across films, and that this seems to be related to the size of the prey animal being captured.

Groups of 3-4 students work with these clips, presented as QuickTime video without narration on the computer, and use a tool which allows them to capture and annotate frames of the film to explain their significance. Their task is to develop a model of how lions (and their prey) behave during hunting episodes that will later be used to think about how evolution led to these behaviors. The first step towards this is to interpret and articulate plot structures for the film clips. Students must observe visual events, decide which events contribute to hunting success or failure, and annotate each event with an explanation of its significance.

In early meetings with teachers, it was suggested that students were not accustomed to decomposing complex behaviors into constituent parts, that they would think of hunting as a simple outcome — the predator eats or goes hungry. Our initial implementation probed this hypothesis by simply giving students a QuickTime movie viewer coupled to a text document as a tool. Students could click on a button to transfer the current video frame to the text document for annotation. We noticed that students would generally grab the final frame of the video and make comments such as, "The lion failed its hunt because it was slower than the warthog." In talking to the students that produced these minimal annotations, it appeared that they were aware of other influences on the hunts, but they were accustomed to articulating final outcomes rather than causal relationships.

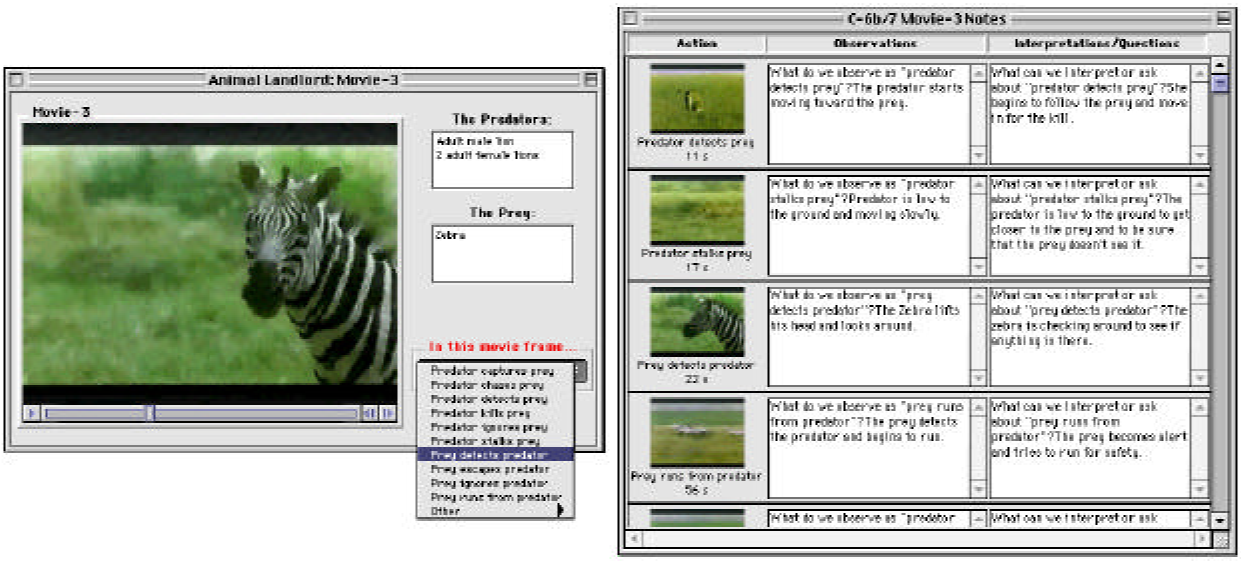

Figure 1: Animal Landlord's movie viewer and annotation tool by the fourth user trial. The exposed menu is used to label movie frames from a palette of actions. The frame is sent to the annotation window on the left where students make observations and interpretations around the event. Alternatively, students can drag and drop frames from the movie viewer to the annotation window.

Trial 2: Annotation Revisited & Decision Variables

It appeared that our teachers were correct, that students would not spontaneously generate detailed annotations. To provide more structure for students, our second trial provided an explicit scaffold in the form of a menu of possible interactions between predator and prey (Figure 1). Since students were only marking the film outcomes, we felt that suggesting intermediate actions might motivate them to attend to these in the films. The quality of their annotations changed dramatically as a result. Not only were they able to identify the features present in the menu, but they also identified additional, more subtle features (which can be added to the menu and shared with other groups), possibly because they stood out against those events listed on the action menu.

The menu focuses students on possible action choices, but we also felt that the task needed to be modeled for students. We created a videotape of hunting segments that the class would view before the computer activities. The first of these clips showed chimpanzees hunting red colobus monkeys; it is the only film in our curriculum containing a narration. Teachers lead students through an in-depth analysis of the hunt events, and they also point out pros and cons of the narration. For instance, this particular film clip does an excellent job of explaining the social interactions of the chimpanzees. On the other hand, it mentions that chimps hunt in the wet season without explaining why that might be. Teachers pull out these subtle distinctions in the quality of explanations and use them to model what they expect of students during computer work. In addition, they refer to the chimpanzee film throughout the week to help students understand the various subtasks of the investigation model.

The remaining clips on the videotape show the lion in action, and teachers use these to reinforce the lessons learned from the chimpanzee hunt. They also try to get students to generate the items on the action selection menu as they watch the videotape, giving the modeling activity a constructive flavor. This initial classroom discussion and the action selection menu work together to scaffold students through the annotation process.

Figure 1 also shows the annotation window where students explain each event that they captured. Initially, there was a single text pane, and students would write annotations such as, "The predators changed their mind and let the prey get away because they are in a playful mood." These comments conflate observations of the film with possible inferences or conclusions. In traditional science classrooms, students are rarely taught to distinguish between observations and inferences [10], so we created the two types of annotations seen in the figure. In the "Observations" column, students comment on the actions that allowed them to identify and label the selected behavior. This information leads to the second column, "Interpretations/Questions", where students make inferences about the reasons for a particular behavior and/or can note questions that they might have about the visual events.

The annotation task allows students to work closely with video data and to make interpretations of behaviors. But every film tells a particular story about a hunting encounter, a story that has been carved into relevant events by the students. The next task is to understand how these stories can be assembled to create a complete picture of lion predation. That is, we can view predation as a space of activities ultimately leading to one of two outcomes — either the prey is captured or it escapes [7]. Along the path to these outcomes are a number of "decision points" influencing the predator's success or failure. Mapping this space is useful for understanding the interactions between the predator, its prey, and the environment.

We felt that we could leverage off of students' existing annotations by asking them to revisit the nine films, this time looking for variables that might influence hunting success (*e.g.,* time of day, number of predators) and adding these to their original annotations. Students quickly rebelled, saying that they had already done this task, yet there was no evidence of this in their work. It became clear through discussions with the students and teachers that there was a problem with the task implementation, namely that students are not accustomed to refining existing work. School cultures do not always encourage iterative refinement of work products; students are used to completing assignments and never dealing with them again. This aspect of schooling forced us to rethink the nature of the task and to design a *new* product that would encompass this deeper level of analysis.

Trial 3: Decision Trees

Students continued to annotate plot structures in the third trial. To encourage comparison across films, we asked students to create "decision trees", simple graphs of all possible activities that could occur in a hunt. The graphical representation encourages students to connect hunting actions, generating the space of possible alternatives. It is also a more explicit representation of the task that students had rebelled against in the previous trial. And because students perceived this as a very different task than annotating video, they were more than willing to cooperate.

Initially, we had students create these trees offline, on large sheets of poster paper — Figure 2 shows an example decision tree created by students from three of the films. Essentially, students create qualitative models of predator-prey interactions, specifically looking at decisions made during predation. These models are similar to those found in the ecological literature [7] and are used in class discussions to explore evolutionary reasons for behavior.

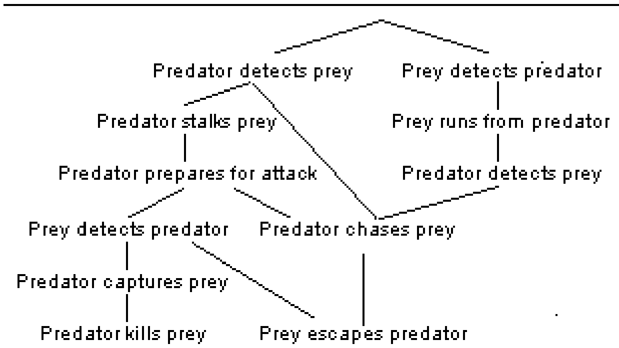

Figure 2: A partial decision tree generalized by a group of students from three films. Students create these on poster paper to highlight predator-prey interactions during hunting encounters.

It is also useful to consider the strategic factors associated with each node in the tree. For instance, a successful stalk relies on a number of factors, such as the amount of cover available, the sensory devices of the target prey, and so on. As students construct their decision trees, they also identify selection pressures influencing the shape of the hunt space. These pressures were generally written on separate pieces of paper but were also attached to the trees themselves.

We saw a great deal of collaboration around the creation of the decision trees. Different groups of students were assigned to become "experts" on certain films. Groups would shift throughout the classroom, exchanging ideas and revising their explanations based on feedback from other groups. By annotating videos, students had an opportunity to be media producers. During the construction of the decision trees, they became media critics, arguing about the validity of each other's annotations. The software became a conversational prop in these encounters, a way for students to back their critiques with evidence. It was quite common to see students using the annotation window's picture icons to click back to a frame, play the video at that spot, and argue about some aspect of behavior — "The lion trips, and then the wildebeest trips, and *that's* how it makes the kill."

In this user trial, the tasks performed by students changed, but the software support remained the same. We had planned to develop graphical tools for creating the decision trees, but after observing the classroom activity around their creation, we decided against it. Creating posters is part of the school work structure, and students seemed to enjoy walking away from the computers to present their work in a familiar format. As well, the posters were displayed around the room, providing artifacts for whole-class conversations.

Teacher involvement is crucial during decision tree construction. At times, they call class discussions to think about the meaning of the trees, generally using the chimpanzee film as an example. They lead students through discussions of possible evolutionary reasons for the tree structures (*e.g.*, Why do the female lions do most of the hunting?). They also select nodes in the trees to talk about optimal foraging and energy (*e.g.*, Why do the predators decide to give up the chase?). Eventually, they help students use the trees and strategic factors as "predictive" models. Students watch additional video clips, try to fit them into their models, and revise their structures where necessary.

Trial 4: Support for Comparison

Sometimes while creating decision trees, students would get tangled in syntactic details, focusing more on layout design than the meaning of the layout. Students commented that it was difficult to keep track of the branching tree structure by comparing printouts of their annotations. It seemed that they needed a way to look globally at their individual work products, so in our fourth user trial, we introduced a comparison "light table" (Figure 3).

Instead of going from annotations to decision trees, students now converse about their initial annotations after loading them into this light table. Each column shows a film's annotations, and students can select particular actions in the grid to see where similar events occur across films (Figure 3 shows the light table aligned at "Prey runs from predator"). Lining up similar actions in the light table often reveals differences in the surrounding states that may be important to understanding the hunt space. For instance, in some cases, a predator might not stalk before chasing; this may suggest something about the conditions required to initiate the action. Students also argued over the classification of events, sometimes clarifying terms ("What do you mean it's being *sneaky*? How can you *measure* sneaky?"), sometimes decomposing events even further ("Crouching and stalking are different because stalking means the lion is moving.").

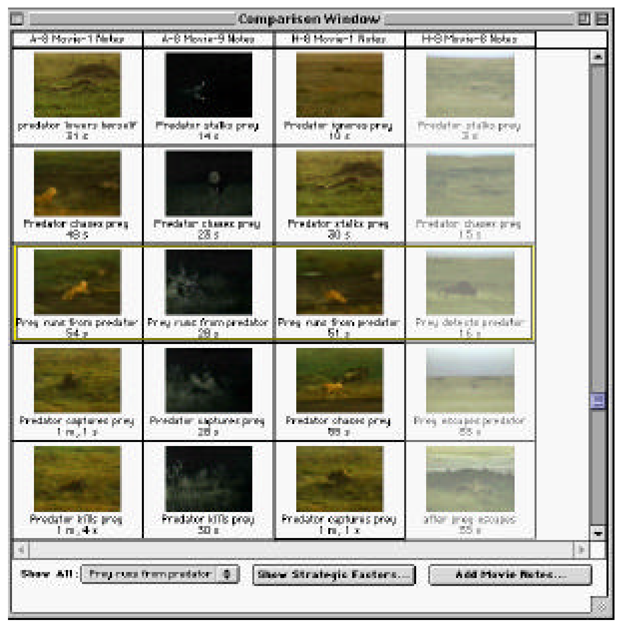

Figure 3: Animal Landlord's comparison light table. Students can align actions that occur across films. This table is aligned on "Prey runs from predator", and all films containing the action are highlighted in yellow. The film on the right does not contain the action, hence its column is grayed out.

We could have used the light table to generate decision trees for students, since the action labels are privy to the system. We did not for reasons discussed earlier — the software should not automate tasks where learning can take place [13]. The social cooperation that occurs as students make sense of hunting behaviors with the light table is crucial to the learning interactions. It appears that students were developing sophisticated notions of behavior through negotiations around the light table and decision trees.

For example, herbivore vigilance is an active area of research in behavioral ecology [7, 15], yet we have never seen it mentioned in high school biology textbooks. Nevertheless, several groups noticed patterns of prey animals alternating between feeding and scanning for predators. As students noticed these patterns by aligning events in the light table, the teacher would prompt them to form theories about how often animals need to scan, differences in scan times for different animals, and why these lead to evolutionary advantages. If the computer simply created a decision tree, it is doubtful that such learning opportunities would spontaneously arise. More so, this sense of discovery seemed to encourage students to share their findings with others; again, this is something that typically does not occur around nature film viewing.

Throughout the four trials, we have reshaped the curricular activities to encourage small-group and whole-class discussion and theory construction. The computer-based annotation and comparison tools allow students to create props for argumentation. In addition, videotapes and poster diagrams act as learning props. Teachers facilitate learning as they talk with students in small-group or whole-class discussions, directing their activities and encouraging argumentation around their findings. Yet, they are responding to student inquires, and, indeed, the issues raised in each classroom depend very much on the observations that students make. Ultimately, learning seems to emerge from student-initiated discussions moderated by teachers and fueled by observations made on the computer. This is very different than traditional lab activities in classrooms where teachers drive discussions.

PRELIMINARY RESULTS

The benefits of the Animal Landlord curriculum seem to stem from its reflection of the investigation model described earlier. Students come to realize that there can be multiple, competing explanations for an organism's behaviors, and structures like the annotations and the decision trees help to emphasize differences in student work. The light table proved to be a valuable asset during student collaboration, for they could easily inspect intermediate actions and detect salient variations. By scanning films in the light table, strategic factors could also be derived from the films. The decision trees provided a product that could be used in additional classroom activities apart from the computer.

It is obvious from classroom observations that fourteen-year-old students are motivated to watch videos of large creatures chasing down and eating larger creatures. Although there were some initial concerns about gender differences around the subject of predation, we found that both girls and boys are engaged in the activity. Focusing on a single topic for a week is atypical in high school, and teachers were surprised that 15-20 minutes of video could hold student attention. They also felt that the time was well spent and that their students gained valuable experiences in conducting their own investigations and collaborating to produce explanatory models.

We have collected data in the form of student and teacher interviews, work products, classroom video, and pre/post tests. We are still analyzing these data, and we have reported results from our final user trial concerning the pre/post tests elsewhere [19]. The open-ended essay questions used in the pre/post tests were drawn from university-level biology examinations and administered to students before and after the Animal Landlord intervention.

Consider one of these essay questions: What limits the amount of prey consumed by a predator? Initially, students wrote responses such as, "If they're not hungry, they won't eat," and "They know they have to save food." At the completion of the curriculum, their responses focused more on the behaviors of the creatures and tended to be more causal. Students articulated more points (*e.g.*, size of prey) for each question on the posttests (mean improvement from 2.4 to 3.9, $p < .001$). There were also more justifications (*e.g.*, size of prey is important because large animals may be difficult to subdue) for these points after working through the curriculum (mean improvement from 1.2 to 2.4, $p < .001$). These posttest justifications also contained more references to behavioral ecology issues such as interactions between organisms, environmental pressures, and energy consumption. And, in contrast to research showing that students often use less causal reasoning *after* viewing nature films [18], we see a significant increase in causal justification in our posttest results.

FUTURE WORK

It appears that students are learning to articulate scientifically plausible explanations during the Animal Landlord intervention. Further data are required to better understand these outcomes. For instance, we did not have a control classroom, so we cannot say whether there are learning gains beyond more traditional methods of instruction, including the standard viewing of nature films. It is clear that our students are discussing ideas that are deeper than those found in traditional nature films, but if such films *were* to mention these topics, would students learn just as much? We suspect that the actual interpretation of video contributes to the development of strategic reasoning around biological concepts, and we are now recruiting additional classrooms to help us investigate these issues.

Although we have only dealt with clips of lion predation in classrooms, Animal Landlord was designed to handle arbitrary visual content, and it is relatively straightforward to change the video clips and action selection menus using standard resource editors. However, simply changing the media does not ensure that additional domains will fit into the current investigation structure. To test the generality of our approach, we are working with additional examples of animal behavior for students and teachers. We are also developing interpretive activities in the arts and humanities to see what additions are necessary to make sense of visual data in domains unrelated to animal behavior. We expect that the general annotation and comparison tasks will be applicable in these areas, but much of the external, classroom supports will need to be revised.

Finally, after a week of activity, students produce film annotations and decision trees, but they never create text narrations similar to those in nature films. We will soon implement tools for students to sequence the original video clips, add audio tracks, and ultimately produce a documentary film that can be transferred to videotape. Moving the student-authored presentations "out of the box" so that they can be shared outside the classroom should be a powerful motivator.

CONCLUSION

In designing and testing Animal Landlord, we have developed a better understanding of the interaction between classroom work contexts, tasks, and tools and how this relates to the success of computer-based learning environments in schools. Instead of solely creating computational tools for students, we have tried to distribute activity throughout the classroom culture, taking advantage of teacher expertise and existing non-technological media. In doing this sort of classroom-centered design, it appears that we were able to alter work practices to promote social collaboration amongst students and teachers, collaborations that led to an interactive learning experience around nature films.

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