Using innovative learning technologies to promote inquiry and engagement in an urban science classroom

Barbara Hug, Joseph S. Krajcik and Ronald W. Marx
University of Michigan, Ann Arbor MI

Recent reform movements within the United States have called for "science for all" and educational reforms to support this goal (AAAS, 1989). In light of these reform movements and concerns over learning within urban schools, science educators and policy makers have pushed for the incorporation of technology within schools as a way of creating equity and promoting learning among diverse learners (Atwater, 2000; Lynch, 2000). Atwater specifically suggests using new technologies and the Internet to create relevant standards-based curriculum to engage and motivate urban African American students (Atwater, 2000). The Center for Learning Technologies in Urban Schools (LeTUS) has been working to create and adopt standards and project-based science curricula in a large systemic reform effort (Blumenfeld, Fishman, Krajcik, & Marx, 2000). A core challenge of this partnership has been to embed learning technologies within these units to support active and engaged learning. This paper examines how two interactive learning technologies embedded within an extended project based science curriculum unit are capable of engaging urban students. The two interactive technologies, MIT Media Laboratory's Thinking Tags, and the University of Michigan's Artemis (Middle Years Digital Library), when facilitated by the teacher, provided an opportunity for observation and analysis of students' inquiry and engagement. The work of LeTUS provides a unique setting in which students use the technologies within the context of a large systemic reform effort.

Objectives

The purpose of this paper is to describe an initial study on the use of embedded learning technologies within a unique project-based curriculum enacted in an urban public school. The unit, "Can Good Friends Make You Sick?" enables eighth grade science students to investigate the biology of communicable diseases with an emphasis on sexually transmitted diseases. We focused on the following questions:

- What characteristics of inquiry are seen when urban students and their teacher use new technologies embedded within a project-based science unit?
- What levels of engagement are seen when urban students carry out technology supported inquiry?

Theoretical Framework

Recent reform documents have called for "Science for All" and instructional changes to support this goal (AAAS, 1989; NRC 1996). Urban American public schools face a wide range of challenges in carrying out these new reforms. These challenges include over crowded buildings and classrooms, a lack of resources, a constant need for additional qualified teachers, student attendance problems and lack of curricula that support the ideas put forth in reform documents (Lynch, 2000). Systemic reforms in urban school districts have begun to address these challenges through a wide range of measures. One aspect of school reform has been targeted at the school curriculum and school text. Review of the current science textbooks has highlighted the shortcomings of the commercial materials (AAAS, 2000; Stern & Roseman, 2000). Lynch and colleagues (1996) have called for systematic development of science curricula with accompanying technology to support learning and eliminate inequities in science classrooms. In looking at the issues surrounding a specific urban school population, African American students, Atwater suggests that by using engaging standards-based curricula, computers and Internet access, these students will be able to narrow the current achievement and attitude gaps (Atwater, 2000). This paper highlights a curriculum that was created to meet these goals and begins to analyze if the use of learning technologies within the curriculum is successful in achieving these goals.

Learning technologies, such as those called for by Atwater (2000), Lynch and colleagues (1996) include the Internet, probes, modeling tools, and visualization software. Learning technologies can be used by students to extend their thinking and create multiple representations of their understanding; they can help students and teachers communicate, experience scientific phenomena, conduct investigations, and develop products (Edelson, 1998; Linn, 1998; Spitulnik, Stratford, Krajcik, & Soloway, 1998). Since students ask questions about natural phenomena through the use of learning technologies, they can potentially become more motivated and engaged (Blumenfeld et al., 1991; Krajcik, Blumenfeld, Marx, & Soloway, 2000). A central challenge in the development and enactment of LeTUS curricula has been how to embed different learning technologies in order to successfully engage students in learning (Blumenfeld et al., 2000; Singer, Marx, Krajcik, & Clay Chambers, 2000).

This paper focuses on the initial use of two types of learning technologies within an urban classroom. Artemis, a web based tool, has been used successfully by middle school students in carrying out inquiry based projects. Students use Artemis to search a pre-selected collection of sites in a digital library and save their work to a permanent workspace (Hoffman, 1999; Hoffman & Krajcik, 1999; Wallace, Kupperman, & Krajcik, 2000). In this learning environment, students are provided with on-line supports to help them manage their work and successfully handle some of the challenges that searching the Internet often creates. These initial studies on Artemis did not take place within an extended project based science unit in which students needed to find information related to the overall inquiry unit (Hoffman, 1999; Hoffman & Krajcik, 1999; Wallace et al., 2000). In addition, these studies did not take place in an urban setting with the unique issues that such a setting provides. These issues are explored in this current study and begin to add to our understanding of how to design instruction using innovative learning technologies in urban schools.

The second learning technology, Thinking Tags, provides the students with a tool in which they can explore the phenomena of how a disease can spread through a population. Thinking Tags are small wearable programmable computer badges with infrared sensing devices used to communicate between badges with a variety of digital displays for students to use in data collection. Thinking Tags are one of the tools developed by MIT's Media Laboratory used by students to experience scientific phenomena and create personal understanding (Colella, Borovoy, & Resnick, 1998; Resnick, Martin, Randy, & Silverman, 1996). This type of experience has been termed "participatory simulations", where students are participants of the simulation, not simply observers (Colella, 2000). Thinking Tags allow the students to experience the phenomena repeatedly and under different experimental conditions as they investigate the simulation. This learning technology also helps develop cooperative and collaborative interactions among students (Borovoy, McDonald, Martin, & Resnick, 1996).

Thinking Tags and other hand held technologies have been shown to increase student engagement in part because students ask questions and begin to answer these questions as they carry out investigations (McFarlane & Friedler, 1998; Soloway et al., 1999). Using the Thinking Tags in a participatory simulation, Colella and colleagues (Colella, 2000; Colella et al., 1998) found students were able to engage in inquiry activities and construct new understandings about the simulations through repeated use of the Thinking Tags and classroom discussion.

In this study, we build upon these previous studies by examining how these two different technologies, when embedded within an extended inquiry unit, allow for student participation in inquiry and engagement in science. We are interested in describing general characteristics of student inquiry and engagement that were supported by the use of the two learning technologies. The National Science Education Standards called for increased attention to be given to inquiry in the science class (NRC, 1996). Inquiry by allowing students to ask questions, plan experiments, and collect, analyze and share information allows students to experience scientific phenomena and to become cognitively engaged in their learning.

Engagement is being defined as the mindful investment and commitment on the part of the students to create a deep understanding of science concepts and processes (McCormick & Pressley, 1997). This cognitive engagement is inferred through students' behavior and artifacts. Student engagement has been shown to vary with the type of task that students are asked to carry out (Lee & Anderson, 1993; Blumenfeld & Meece, 1988). How to successfully challenge students to become cognitively engaged in their inquiry activities is crucial if we want to have students learning through this type of activity as recommended by reform (Marks, 2000). Based on these studies, we examined different aspects of student engagement: attention to, connecting to, and planning the investigations. In this study, we report on theses particular characteristics of student inquiry and student engagement as they used the two learning technologies in an urban school setting.

Background

LeTUS is a collaboration between two research institutions, the University of Michigan and Northwestern University and two large public school districts, the Detroit Public School and the Chicago Public School systems. LeTUS takes as its core challenge the improvement of learning for all students by the infusion of technology in urban classrooms. To accomplish this, LeTUS has developed curricula units based on principles of social constructivism. Several resulting design principles (Singer, Marx, Krajcik & Clay Chambers, 2000) include the use of extended inquiry projects situated in real life contexts, the use of embedded technology tools, and collaborative work. LeTUS curricula are created to address national and state standards.

Setting: This study was conducted in a middle school in a large urban center with a single eighth grade class (N=33) and their teacher. The teacher is certified in science and had been teaching science for seven years. The school had adequate but not extensive technology access (two computer labs with Internet access). The student population was largely minority (primarily African-American and Hispanic), scoring below grade level performance on state mandated achievement tests and having a large percentage of students on free and reduced lunch. The Thinking Tags were used in the classroom while Artemis was used in a computer laboratory.

Curriculum: The 8-week curriculum unit addresses national standards related to cells, systems, and disease through investigations into the driving question "Can Good Friends Make You Sick?" An initial activity about the spread of disease introduces students to the concept of disease and the devastating impact it can have on an individual and a community. Students return to concepts introduced in this activity through a variety of different activities throughout the unit.

The two learning technologies are embedded within the unit. Using Artemis, students investigate different aspects of infectious disease, and the measures used to stop these infections in humans. Students select an infectious disease and investigate a range of criteria about this disease using Artemis. This Disease Investigation is done throughout the unit and culminates with a final class presentation about the disease. Using the Thinking Tags, students model the relationships of these infectious agents to known diseases and investigate how such diseases are transmitted. Students explore a variety of scientific concepts that are embedded in understanding a disease epidemic. This embedded technology activity is similar to the initial activity that uses liquids of different pH and a pH indicator to highlight the presence of a contaminant (or a disease). The technology-based simulation allows students to investigate issues that were introduced with the liquid based activity but with more detailed and extensive activities not afforded by the liquid simulation. Using the Thinking Tags, students can investigate the concept of immunity, incubation period and disease source. Students are able to design their own investigations and to carryout and modify them based on the results of previous trials.

Methodology

Data Collection

The classroom was videotaped throughout the enactment of the unit by the curriculum developer and classroom support person. Students were videotaped throughout their use of the two technologies. These tapes were examined for evidence of student engagement and for characteristics of inquiry supported by the use of the two technology tools. Approximately 10 hours of classroom tape were analyzed for this study. Informal interviews were done throughout the period of enactment where student opinions were probed about the activity and the use of technology. Final presentation artifacts were collected and examined for confirming evidence of student engagement.

Classroom context

The classroom context of this study is an important factor in the analysis of the data. This enactment was the first time that the participating teacher had taught an extended project based science unit and the first time that the students had participated in such instruction. Issues of classroom management were present in the classroom throughout the unit; for this study they were simply noted as part of the context. In addition, the findings are based on the classroom enactment captured on videotape, individually taped student conversations, and student artifacts. In the videotape, conversations were identified from approximately 10 students; the remainder of the class cannot be commented upon. Due to the limited nature of these data sources, the results can be directly applied to only this situation, but the results add to the growing body of evidence on patterns of student inquiry and engagement with technology. The results of this study can aide the revision process of both the curriculum and the learning technologies.

Analysis

We analyzed student inquiry and engagement for specific characteristics during two technology embedded inquiry activities: the Spread of Disease Investigation incorporating the Thinking Tags and the Disease Investigation incorporating Artemis. This analysis was done through a series of data reductions, starting with a detailed summary of classroom videotape where the two technologies were being used and identifying events with the enactment that addressed the two questions (modified from Taines, Schneider and Blumenfeld, 2000; Krajcik, Blumenfeld, Marx, Bass, & Fredricks, 1998) and trends were noted. Original videotape was then used to get the detailed conversations where needed. This summary contained descriptions of the student and teacher behavior as well as conversations pertaining to the use of technology. These behaviors and conversations were coded for characteristics of students' inquiry and engagement. The level of student engagement are embedded within the framework of inquiry. This method of analysis allows for the examination of student engagement around the process of doing science.

Descriptive Characteristics of Student Inquiry

Characteristics of student inquiry examined in this study include: asking questions, collecting information, designing and carrying out the investigation, data collection, analysis and drawing conclusions; and making presentations. In examining the characteristics of student inquiry, videotape was analyzed using criteria modified from Krajcik, et al, (1998), presented in Table 1. Throughout this current paper, worthwhile means addresses appropriate content for the unit or activity. Meaningful refers to the relevance that the event has for the student. One example of this would be does the event (a question, investigation trial or presentation) have meaning for the student outside of class. Trends were looked for across both learning technologies and a descriptive synthesis was made using the available data.

Table 1: Questions used during analysis of data

Inquiry Component	Questions used during analysis
Asking questions	Were the questions worthwhile? Were the questions meaningful for the students?
Collecting information	Was the research investigation worthwhile? Were the topics meaningful for the students?
Designing and carrying out the investigation	Was the investigation planned out? Were students specific in their investigation plan? Did students follow the plan? Was the experiment meaningful?
Data collection, analysis and drawing conclusions	Was data collection carried out in a thoughtful and planned? Was data used in making the conclusions?
Presentations and communicating findings	Did they relate their conclusions to their question? Did they connect finding to the “real” world or to their own lives?

Levels of Student Engagement

Levels of student engagement were determined using the same inquiry components and identifying the different engagement trends. These trends were identified by verbal conversations and by visual cues present on the videotape and confirming student artifacts. The analysis of these characteristics resulted in general trends of low, mid, mid to high and high engagement based upon types and duration of characteristic measured events (Table 2).

Table 2: Descriptions of Engagement Levels

Level	Trend Description
Low	Off-task regarding inquiry component.
Mid	Few observable events of the inquiry component observed in a procedural manner.
Mid-High	Some observable events of the inquiry component observed with involved students.
High	Multiple observable events of the inquiry component observed with substantially involved students.

Findings

This paper reports how the MIT Media Laboratory’s Thinking Tags and the University of Michigan’s Artemis provided opportunities for students to become engaged in two different types of inquiry activities within a project based science unit on communicable diseases. Particular themes are discussed in detail below.

I. Asking questions: worthwhile and meaningful

Many of the questions that the students posed throughout the two activities were worthwhile and meaningful, though the quality and complexity of the questions varied. During the Spread of Disease activity, using the Thinking Tags, students posed a number of questions that addressed identify the disease source. This is illustrated with Frank's direct question of "Where did it get started…?". This type of question showed that students were engaged with trying to understand the simulation and the content, hence this type of question would be worthwhile. It addresses the concept of identifying the origin of a disease, a key concept in this activity. This question was answered by doing additional Spread of Disease investigations that students designed themselves. Questions that built upon these initial questions illustrated that students were engaged with the concepts and processes illustrated in the simulation as well.

Additional and more sophisticated concepts asked by students were about the rate of transmission and length of incubation before showing symptoms of the disease. Students were paying attention to the issues that could be addressed in the inquiry activity and were discussing their ideas and raising additional questions that they wanted answered as seen in the following two examples.

> Eric: …how long does it take for a disease to pass on to someone else?
>
> Ruby: No matter what type of disease it is, I want to know about the different diseases, and the different "time slots" for different diseases or is it all the same (Ruby continues and makes specific reference to AIDS. Throughout the whole activity, Ruby referred to the period during which the badge showed no symptoms as "time slots".)

These two students realized that there was a period of incubation before the badges showed that they were infected. Both Eric and Ruby ask similar questions, but Ruby connects the simulation to the real world with the comment about wanting to know about AIDS, hence she showed a higher level of engagement. Both students raise worthwhile questions in regards to the content addressed, but Ruby's question is meaningful through connections to a socially relevant and important disease. Ruby continues this interest with the real world later in the unit when she makes reference to a TV show about herpes that she had recently seen and connects it back to the Thinking Tag activity.

Students were also able to connect their questions from one investigation to another. This was seen when several students wanted to investigate the concept of immunity to a disease. The students raised this issue because some of the students interacted between 15 and 20 times in the first trial and did not get sick. This type of connecting through questions to previous investigations shows a high degree of engagement that was fostered by the Thinking Tag simulation. This ability to connect previous questions and investigations likely allowed students to stay focused on the activity.

Students rarely use the scientific language that would explain the concepts that they wanted to investigate. Even though students did not have a scientific language to use, they still asked worthwhile questions as is shown in the two examples below.

> Tommy: I would like to know why certain people didn't catch it—
>
> Francis: Why some people stayed clear, and had a large number of interactions and some of the people that they interacted with went red.

Francis' question shows a level of complexity that is absent in Tommy's question. Tommy's question is a basic question about immunity, while Francis asks about immunity and about the ability to be a carrier and not get sick. The language that students use was often in direct reference to them as participants to the simulations. This finding is similar to the finding reported by Colella (2000).

The structure of Artemis requires that students create questions as they carry out their on line-investigation about a specific disease. In order to do this, students first need to select a disease that they want to investigate. Following this selection, students create a driving question folder specific to their question. This folder becomes a place that students can use to store notes and web site addresses they have found during their investigation that pertain to their questions. Due to data collection constraints, only a few questions were seen and analyzed in depth. Analysis of students' questions showed that students tended to create simple questions that addressed a disease concept. While final questions initially appeared not to be meaningful, they in fact were. This was identified in the analysis of the rationale for selecting the disease being questioned and creating a question, as illustrated in the conversation detailed below. The use of Artemis has allowed for a meaningful connection between science content and what one student wants to learn about for later in life to be created.

> Andy: We already know…what the flu is, (he reads the flu symptoms from the sheet).
> Maggie The cold, flu or pneumonia. (Reading as well.)
> Andy: Listen, let's study one of these (pointing to the other diseases on the list which include STD) when you get older you might get one of these and you don't know anything about these.
> Maggie: I don't care.
> Andy: …because from all of these you can die.
> Maggie: I don't care- you can die from pneumonia.
> Andy: That's not very likely- one in a million.
> Maggie: I could be the one person out of the million.

They decide on a specific straightforward question about pneumonia. The rationale for deciding on this disease was based on personal reasons, the possibility of dieing from the disease. Andy shows a personal rationale for wanting to study a sexually transmitted disease that Maggie is unwilling to address. This exchange shows how one student can impact another student and cause the level of engagement to change. Maggie's level of engagement would be classified as mid level engagement. She is doing the investigation but is not doing anything more than she needs to do or what is expected of her. Andy is at this point a mid-high level engaged student, though he is convinced by Maggie to do only what is expected of them.

This initial study into students generating questions around the use of the Thinking Tags and Artemis shows that students are capable of generating questions that they can then investigate. A higher complexity of questions was seen in the questions created for the Thinking Tag investigation. Student questions satisfied the feasible criteria when they were analyzed for both technologies. Unlike previous studies into students generating questions (Krajcik et al, 1998) which identified a potential problem with students drawing too heavily from personal preference and experience and not from unit science content, these technologies allowed students to ask questions that connected the unit science content and real life to the investigations and technology used. An important difference between the two studies was in the type of science content that the students were investigating.

II. Finding information: worthwhile but with difficulties

Finding information through research was unique to Artemis due to the nature of the tools. While the Thinking Tags were a technology that the students could easily master and use successfully, Artemis remained difficult for the students throughout the entire Disease Investigation. Artemis proved to be difficult for the students as they began their investigation and attempted to find information. This is illustrated in the conversation between Andy and Maggie.

> Maggie: (Looking at a MYDL note card)… it doesn't have anything to do with pneumonia- Now you find something that has to do with pneumonia. (Andy tries to please her and does another search and finds additional sites.)
> Maggie: You can't do that—see you can't do that. (when Andy tries to go to another site from the search results.)
> Andy: Do you still want to do pneumonia?
> Maggie Well we can't find anything on it. Well, why don't we do the flu, like I suggested in the first place?
> Andy: Ok Maggie, the flu. The flu is in there- (pointing to a site in the MYDL interface.)
> Maggie: See same thing (pointing to the results that they just got for the flu in comparison to the results for pneumonia.)
> Maggie It won't go to it, I'm going to go back and try it again.

These students are struggling with the complexity of the interface and the necessity to select multiple terms in doing their search. One term was required for the subject area and a second term was required for their keyword. Due to technology issues, these two fields often did not work, as they should have. This issue caused different searches to return the same results and is illustrated in Maggie's comments about "see the same thing" for both "flu" and "pneumonia."

Regardless of the technical troubles that students faced in using Artemis, students did stay on task for a large portion of the period and that they are making progress in initiating their investigation and selection of a disease to investigate. In addition to staying on task, students were able to find worthwhile information specific to their investigations, which were reflected in the information presented in the final Disease Investigation presentations (see section V).

III. Designing and carrying out the investigations: connections and challenges

The Thinking Tags allowed students to carry out meaningful investigations though these investigations meet with varying successes. As part of the Thinking Tag simulation, students designed a series of investigations that addressed the issue of incubation period and tracing the disease to the initial source. One student, Ruby felt strongly that the simulation investigation would help her understand what had happened to her when she was sick with the flu.

> Ruby: now listen to this, you all know when I was sick a couple of weeks ago, I had the flu, my parents had the flu but I never caught it, I caught it now—it was inside of me, but something inside of me was trying to fight it, but [when] it caught me, my resistance was still high but I caught it. How can we test this? Be quiet (Ruby tells the class) How could we test this with the badges? When we did it (referring to the first simulation), it [the thinking tags] turned red five minutes later, did I have it exactly then? As time went on I caught it- so when did I caught (catch) it?

While using the Thinking Tags in their investigations, students showed strong connections to not only the real world as is illustrated in by Ruby's comment but also to previous Thinking Tag investigations.

> Francis: I think that you know how we had two groups yesterday and that the group over here wasn't infected until someone walked over here—I think that people should pair up and interact and then see what people get it.

Francis realizes what happened the previous day is allowing her to see what would happen in smaller groups—she is connecting the previous activity with what they are trying to do now and she wants people to have the same badges from previous day so that they can pick up from where they left off. This connection is allowing Francis to be cognitively engaged with the investigation and with the idea of identifying the source of the disease.

While the students could make connections to the simulation and what it represented to them, they had initially had difficulty in specifying exactly what they should do to carryout an investigation.

> Francis: If I showed like how to do it, could you word it right? Cause I don't know how to word it right. You take one of them and like have them interact, have them interact with one and then wait to see if they get infected.

Students commonly had difficulties in designing the investigation in a procedural manner. Students did not understand how to design the step-by-step investigation. The issue of controls and only changing one variable at a time was difficult for them to understand. But once students became familiar with what they could do with the thinking Tags and they settled in on particular concept to address, they could come up with a series of investigations that allowed them to eventually identify the source of disease, though they continued to have difficulty in following their procedures accurately. One example of this that led to an interesting discussion happened when the class divided into communities and only interacted in these two smaller communities. Because of how the Thinking Tags were programmed, only one disease source was present in the whole class, but both communities became sick. Students eventually identified the problem and talked about how one Thinking Tag brought the disease into the second community.

The actual carrying out and doing of the investigation proved to be highly engaging for the students, students often asked if they could do the investigation again or if they could do a different one. Judging by the physical reaction to having a tag turning red, the students were amazed and horrified when it happened to them. Alycia reacted vocally when her badge turned red during one of the simulations.

> Alycia: I don't know who I got this from, but I'm very mad about this. Get away from me.

When asked how they felt when they found out that their Thinking Tags were infected, the majority of the students did not like it. One student expressed his reaction as embarrassment and explained that he wanted to figure out "why I got it, who had it, where it came from and how they got it and how I could get rid of it." These examples are illustrations of how the badges were meaningful for the students and led to cognitive engagement around the scientific concepts.

IV. Data collection, analysis and drawing conclusions: involvement and the necessary next steps

Students often did not do careful data collection or observation note taking while using the Thinking Tags in a simulation. Students often did not write down whom they had interacted with or did not do this in the correct order even though the teacher gave clear instructions and stressed the importance of doing this collection.

> Teacher: Each time you interact, write down the number and the name, each time you interact…Write down the interaction and the results.

In analyzing the videotapes, one can hear students asking whom they had interacted with and in what order the interactions had taken place. Because of this ambiguity, it was often difficult for the students to identify the correct pattern of infection. This was one point in the investigation that the high degree of engagement was actually a determinant to completing the goals of the investigation.

In addition, students often did not apply all the information that they had to make and state conclusions. One example was seen when Thomas goes through his notes and talks about more students getting sick. By doing this initial analysis, he begins to lay out who was sick first and then who got sick, but he does not complete this analysis before stating "Michelle is clean, she must have immunity. My conclusion is that Francis is the source." His conclusion is not based on the complete data set of interactions; it is only after the whole class joins in the discussion do they realize that Francis cannot be the source of disease.

As the students became more familiar with how the Thinking Tags operated and what sort of data they would be getting, students began to draw conclusions that were supported by data and to design investigations based on the results of the previous investigation. Based on a whole class discussion, the students decide to continue with the general trend of the investigation on order to figure out the disease source. At the start of this section, the students start a conversation that continues as the investigation starts.

> Michelle: …if you get infected you can use the list to identify who got you sick and they can then use their list to trace it back even further…
> (Thomas decides to time for a two minute incubation, people will interact with one person and then don't interact with anyone for two minutes.)
> Frank: Anyone turn red? (Students interact again.)
> Someone: did anyone turn red?
> Students: Rebecca's is red—we have one red.
> Teacher: Tell me your history.
> Rebecca: Eddy, Frank and another student (she is questioned why there are three interactions, when there should only be two interactions.)
> Frank: I've got cooties, anyone else want cooties? (Class is trying to figure out who Eddy interacted with, and who Frank interacted with—they find out that Thomas had interacted with one of them.)
> Students: Why didn't his turn red? He might have immunity. (The class next tries to isolate the Tags that were are at the tables of Rebecca and Eddy.

> Teacher: Should we wait longer?
> Ruby: No, we need to do it over and see those two (Rebecca and Eddy).

The students carried out another series of trials and eventually identified the disease source as coming from Eddy's Thinking Tag.

When students were asked directly during the informal interviews about what they thought of the Thinking Tag activity, their responses indicated that they were in fact cognitively engaged with the activity, in addition to enjoying the investigation.

> Ruby: It was fun, you had to think about it—everyone was turning red and I was thinking how were you going to find out. You had to put your thinking caps on, because other[wise] you wouldn't be able to find out. People had to think together and we came with the idea of who had the disease.

While students enjoyed doing the investigations and reaching a conclusion about the different concepts addressed, students struggled with the design of the inquiry procedure and the successful completion of the multiple trials.

V. Presentations and communicating findings: strong connections to the driving question and the real world

Both the Thinking Tag activity and the Artemis Disease Investigation allowed students to make strong connections to their own lives in a meaningful manner. Students related to the Thinking Tags in a very personal way—the Tags became an extension of themselves. At one point in a discussion following a simulation, someone in the class had to remind the rest of the students that the simulation was only a model of how disease could spread and that everyone should not take things so personally.

Students repeatedly related the Thinking Tag activity to real life and to the driving question. This type of connection can be seen in the example about catching the flu.

> Maggie: everyone in the class knows each other and it's like, something that could be compared in real life, like if someone had the cold and they talked to their friends in class their friends could get sick.

Connections were often more personal in nature as is seen in the example that Frank gives in his explanation about how the Thinking Tags can be used to illustrate how he got chicken pox and spread it to his siblings. Or it could be more serious and address the more controversial topic in the unit, sexually transmitted disease as is seen in the comment made by during an informal interview.

> Eric: Herpes—yea it can, say example for sex can be an interaction with a female and a male, if one of (them) the male or the female have the disease genital herpes, say the male, if the male interacts with her, maybe later in a month or a week or the incubation time, it can flare up on her.

While Eric is making the connections between the Thinking Tags and a particular disease, he is still uncertain about the details of the disease. In the Disease Investigation, students were to investigate specific diseases and present these diseases to the larger class in a final presentation. Eric was able to report on the details of the disease during his presentation but when pressed about the specifics of his disease, herpes, he was unable to answer. All students who were interviewed were able to make a direct connection between their Disease Investigation and the Thinking Tag activity. During these informal interviews, one student volunteered a role that the Thinking Tags might have a in the real world as a tool "for scientists that track diseases" to show people how a specific epidemic might have happened.

The final Disease Investigation presentation provided an opportunity to look at student artifacts as well as student behavior to judge student engagement. Students were highly engaged during their presentations, as they perceived themselves to be the expert teaching their classmates. Two presentations in particular were of interest because these groups chose to teach their classmates specifically about the dangers of the disease they investigated. One group instructed their classmates "Do not have sex over the summer, if you do anything that you are not supposed to do use protection and use it right. A second group led by Ruby told the class.

> Like I was going to say, like how good friends can be infected, they can make you sick, I mean, before they are going to have intercourse, because it looks like they don't have a disease--like nothing is going to happen but once it happens, it happens (it here refers to infection). I had to revise this over and over, know that once it happens, once you get infected, there is no cure for it. So know that once you are infected, you are infected. It is best to abstain from sex, period.

Ruby felt strongly enough about the content and the implications of the content that she was talking about to give her classmates a small lecture about what they should or should not do.

This was in direct response to Ruby and her group successfully finding information about their Disease Investigation using Artemis.

Discussion

This paper is a first step in the analysis of two novel learning technologies embedded within a curriculum which provides opportunities for urban students to engage in a project based science curriculum. The findings reported here show that these two learning technologies supported the students in asking meaningful and worthwhile questions, find information, design and carry out simple investigations. In addition, the technologies provided opportunities for students to begin discussing the ideas behind these questions and investigations in a manner that brought up the scientific concepts in a meaningful and worthwhile way.

These results will help in the revisions of the curriculum and the learning technologies. Findings presented in this paper suggest that students can ask meaningful and worthwhile questions and have discussions about the scientific concepts aided by the learning technology while naïve in the use of technical and scientific terms. This language is the next step for these students once they have mastered the idea of the concept. This transition from novice to expert in the use of a technical language is a challenge that needs to be addressed in the next version of the curriculum that supports the use of this technology. Using these two technologies, students were able to make strong personal connections between the science content and the investigations that they did. The personal nature of the communicable disease unit might help lend strength to connections that the students will create. This finding illustrates the importance of matching technologies and the curriculum goals to help support students in their inquiry activities and can be used when creating the context of other project based science units. But this strong personal connection is not sufficient to drive student learning, this was seen in the lack of detail that some students expressed when asked about the disease that they have investigated using Artemis. This finding was similar to that reported by Hoffman and Krajcik (1999). This lack of detail illustrates the importance of in class supports and academic press from the teacher to make certain that students learn the stated goals of the curriculum.

We found that students need additional curriculum and teacher supports in order to successfully design and complete more complex investigations and to fully understand the complex issues behind the pattern of disease transmission. The inquiry activities structured around the use of the Thinking Tags need to be examined and restructured if we want students to be able to master the creation and completion of complex investigations. In addition the design of the learning technologies needs to be restructured to provide a more engaged experience for the students and teacher. Specifically, the interface of Artemis has been redesign and restructured so that it is easier to successfully complete a search. Students can now ask straightforward questions without requiring multiple fields to be completed in a specific order. The Thinking Tags can easily accommodate multiple runs of the same simulation, but it is difficult to run an entirely new simulation within the same class period due to programming constraints. The modification of variables within the Thinking Tags requires additional programming. This issue is being addressed with the design of a new application for the hand held computer, where teachers can easily modify the different parameters that the students want to address through the questions that they raise. With these modifications to the technologies and to the curriculum, students will be better able to engage in the inquiry activities asked of them. With this engagement, students will have more opportunities to reach the goals of scientific literacy suggested by the current educational reforms.

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