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ABSTRACT

This paper describes how a fourth grade class at a Canadian laboratory school used an approach to knowledge building that had students participating as intentional learners as they specialized in interest groups for their study of light. It examines how, later in the year, the goal of building collective knowledge became the focus for this group of knowledge builders. The paper looks at the various inventions and design principles that were used to facilitate this transition. In particular, it analyzes the utility of one database invention, the Light Learnings view, which was designed to aid in the sharing of the specialized knowledge across the research groups. Data come from pre- and post-tests of the concepts of light, ratings of students' portfolio notes about their understanding of light (before and after the introduction of the Light Learnings view), and information from the Analytical Tool Kit. This paper examines the transition that took place as the class moved from intentional learners to a knowledge building community that used the Knowledge Forum software and other classroom processes to successfully build knowledge about the curriculum area of light. Appendixes include: "Illuminating Shakespeare" figure, ATK Results, a "Light" Survey, "Images" and "Sources of Light" figures, "Light Learnings" figure, and student samples of pre- and post-Light Learnings view "My Understanding of Light Portfolio Notes." (SM)

Intentional Learners, Cooperative Knowledge Building, and Classroom Inventions

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Abstract

Knowledge building situates intentional learners in a community where the creation and sharing of knowledge is the primary goal (Scardamalia & Bereiter, 1996). For their part, intentional learners know the limits of their understanding and engage in a process of progressive problem solving by continually reinvesting freed-up information capacity in new learning efforts (Bereiter & Scardamalia, 1993). It is quite possible to be an intentional learner without being involved in knowledge building or in a knowledge building community. The mark of a knowledge building community is when specialized knowledge is being shared across all groups and the whole group is reinvesting its freed up resources in deeper and deeper problems (Scardamalia & Bereiter, 1999). This paper describes how a Grade 4 class began with an approach to knowledge building that had students participating as intentional learners as they specialized in interest groups for their study of light. Then it will describe, further on in the year, how the goal of building collective knowledge became the focus for this group of knowledge builders. This paper will examine the various "inventions" and design principles that were used to facilitate this transition. In particular, an analysis will be made of the utility of one database invention, the "Light Learnings" view, which was designed to aid in the sharing of the specialized knowledge across the research groups. Data is drawn from pre and post tests of the concepts of light, rating of students' portfolio notes about their understanding of light (before and after the introduction of the Light Learnings view) and data from the Anaytical Tool Kit (Burtis, 2000). The discussion focuses on the transition that took place as the class moved from Factory Model as Intentional Learners to a Knowledge Building Community that used the Knowledge Forum™ software and other classroom processes to successfully build knowledge about the curriculum area of light.

Introduction

This paper reports on a case study of an initial attempt by a grade 4 class to take a knowledge building approach to pedagogy. Given that there is currently no one best way to run a knowledge building classroom a qualitative methodology was employed in order to capture as much of the classroom activities related to knowledge building as possible. Eventually, the goal of this three-year long research project is to begin a process for the defining, refining and improving of approaches to knowledge building. However, during the first year of this study the challenge was to establish a functional knowledge building community within this grade 4 classroom. What follows is a description of the knowledge building community that developed in the grade four classroom and the transition from a group of intentional learners to a knowledge building community. Special attention is paid to how the issue of knowledge sharing was dealt with by the class as they developed a better sense of themselves as a Knowledge Building Community. A small-scale design experiment was done to explore what interventions seemed to improve the knowledge sharing of the group (Collins, 1999; Brown, 1992). That this form of design experimentation could be used in subsequent years to improve upon the work of this class is discussed. Also discussed is how the inventions and interventions that were developed by this class could be of value to others attempting to implement a knowledge building approach to pedagogy in their own classrooms. The need for future studies regarding how knowledge building groups can best use Knowledge Forum™ to communicate the knowledge they have developed is also discussed.

Method

Given that the underlying goal of this research was descriptive in nature, a qualitative methodology was employed. At minimum, the goal of this study was to describe the development of a knowledge building community through the classroom inventions and processes that were used to make it possible. Descriptive data is drawn from the Knowledge Forum™ database the children used to do their knowledge building in and the notes the teacher and participating researchers entered into the Calendar of Inquiry journal that was keep about the work of this classroom. This descriptive strategy made it possible to observe and track the transition from a group of intentional learners to a knowledge building community. During the period of time that the teacher decided an intervention was needed to encourage sharing of knowledge within the database a design experiment methodology was used. Data for the small-scale design experiment includes a pre-test and a post test along with database statistics gathered using the Analytic Tool Kit (Burtis, 2000).

Participants and School Context

The class comprised twenty-two grade four students at the Institute of Child Study - Laboratory School at the University of Toronto. The students came from middle-class backgrounds and no entrance requirements needed to be met in order to attend the school. The classroom teacher, myself, was a thirty-four year old male in my seventh year of teaching, seconded to the Institute of Child Study. My first six years of teaching experience had ranged from grade one to grade eight in a local Board of Education, but I had no experience with grade four students prior to this year. There were two intern teachers in the class, the first from September to December, the second from January to April. This was the first experience for the teacher, the children and the interns with Knowledge Forum™. The classroom was a small room with 4 working tables used as desks by the students. Along a wall was a computer lab set up with six networked computers that were connected to the Internet. The class database was served from a computer at the Ontario Institute for Studies in Education. The teacher had a computer on his desk as well.

Knowledge Building and Knowledge Forum™

Knowledge Forum™ is comprised of a networked database in which students can create text notes on a problem they are investigating. It provides a medium for preserving questions and ideas in notes that are continually available for further discussion and revision without a time constraint. These notes are readable by all students in the classroom. Others may attach comments, "build-ons", if they have information to add to the original note or are seeking clarification. The build-ons are also public notes, i.e. readable by everyone. A new note appears as a small rectangle on the screen with the note title next to it. In order to "open" a note, one needs to click the icon and the text of the note appears. A build-on note would be linked to the original note with a straight line. Only the author of each note can modify/revise his/her own notes. Students are encouraged to include a question in the "problem window" of the note to identify the purpose of the note. Important vocabulary in the note can be highlighted by the author. This identification of "key words" helps students identify to focus core of the note and also provides an opportunity for others to find the note if a search by key words is conducted. Searches may also be organized by note problem or author.

Scaffolds are available to help sort the text of the note. The scaffolds include: My Theory, I Need to Understand, Evidence, A Better Theory, New Information, etc. Students may suggest changes (additions or deletions) to the scaffold selection, customizing the scaffolds to support the discourse. The teacher is provided with the ability to make the changes agreed upon by the class. Authors can also create pictures and diagrams within the note.

Each note is titled and automatically displayed in the view it was created in. A classroom database may include several views to help categorize the notes. The creation of each view derives from student suggestion during class discussions. Views are titled are may contain a background illustration created by the students. Links from one view to the others are provided to make navigation within the database quite simple.

Notes that deal with similar problems or investigations may be collected and placed within a new note called a rise-above. In rise-aboves, students can summarize and organize the knowledge recorded in the collected individual notes using new scaffolds that express a collective group understanding: "Our Theories", "Our Evidence", "What We Still Need to Understand".

Classroom Environment

The Grade 4 classroom had 7 computers, limiting 1/3 of the 22 students to be working on Knowledge Forum™ during "Knowledge Building/Inquiry Time". Two hours each Monday and Thursday were scheduled for our study of light. Therefore each week, students had the opportunity to be working on the computers in our classroom for 40 minutes twice a week. The entire class collectively had one full hour on Fridays at a University of Toronto computer lab to work on the database. The time on the computers is an approximation. There were computers available in other classrooms that were often used throughout the week, and as the groups became more self-directed, they determined how much time and how often they needed to be on the database. Since Knowledge Forum™ is an asynchronous communication medium, meaning the participants do not have to be on the database at the same time, students could contribute to notes that were written days earlier. They could also choose when it was appropriate for them to be on the database to contribute to the knowledge building.

Scardamalia and Bereiter distinguish between knowledge building and learning. The role of a knowledge builder is to create new knowledge, learning is identified as a by-product of the knowledge production (Scardamalia & Bereiter, 1996). In a classroom that focuses on collaborative knowledge building, the students then are less so learners than they are collective knowledge constructors. As a result of this understanding, I evolved to use less of a didactic approach to teaching, defining my role as an active participant in the collection of material directed by the interest and problems of the students.

Curriculum

The science and technology expectations of The Ontario Curriculum are organized into five strands: Life Systems, Matter and Materials, Energy and Control, Structures and Mechanisms, Earth and Space Systems. The grade four topic for each strand are: Habitats and Communities; Materials that Transmit, Reflect, or Absorb Light or Sound; Light and Sound Energy; Pulleys and Gears; Rocks, Minerals, and Erosion. The Institute of Child Study operates as a private school; each classroom teacher is, in essence, free to design the curriculum for the year. Although I was not mandated to teach the knowledge and skills prescribed by Ontario Ministry of Education and Training, I knew (perhaps due to my experience working in a public school board) that I would feel more comfortable if I did follow them.

Upon discovering the interest and "culture" of the students in the first weeks of school, I realized that the group was particularly interested in the Dramatic Arts. A unique opportunity was presented to me when a local theatre was presenting a performance of Shakespeare's "A Mid Summer Night's Dream". I felt this might serve as the introduction to a Language Arts unit based on Shakespeare's comedy. I planned to utilize Knowledge Forum™ for this study. I had wanted to focus on Social Studies rather than Science in the first term so as to complement our Language Arts study with a look at the Elizabethan time period. The students had another idea. After viewing the performance, it was apparent that the students were interested in examining light and special effects. Conveniently (for my own comfort), light was a strand of Science I had planned to teach as it was prescribed in the Ontario Curriculum. I was not aware that the study would last for three months led by the interest and enthusiasm of the students. Thus the "Knowledge Building/Inquiry" time was exclusively dedicated to the study of light.

We did not study sound as I had planned. When I presented to the class the fact that we were not covering the material other grade four students would have learned in a public school, the response I received was quite "illuminating". One child responded that they probably know more about light than any other grade four student because of how much time was spent in the study and the way they had built the knowledge by sharing it on the database. They also added that if they ever wanted to learn about sound, for example, they now knew how to conduct an inquiry: state a question, then offer a conjecture / personal theories, research through reading and experimentation, share your knowledge advances on Knowledge Forum™ and build the knowledge together. In fact, the confidence of their knowledge was quite high: when a field trip was planned to a science center to participate in a "light and sound" presentation, the students commented prior to the session that although they had not studied sound themselves, they would be able to determine how well the presenter knew his "sound material" based on how informed he was on the subject of light.

Following our in depth and lengthy Science study, the students directed the inquiry to Social Studies with a focus on Elizabethan England. The students chose different social groups to research and used Knowledge Forum™ to share their findings. The groups were: Royalty, Lord Chamberlain's Men, Nobility, Drake and the Explorers, Clergy, Villagers.

When I reflect back on the year, I realize I covered only a small fraction of the topics that I had intended to. I am aware that a transformation occurred in my approach to planning. Rather than limit the students to passive "clients" to a curriculum I had designed, I observed the incredible energy and interest of the students that sustained the knowledge building when they were encouraged to express their ideas and become more involved in the design of the curriculum. "For if schools are to constitute the learning organizations in which students gain experience, the role of student must change from that of client to that of members"(Scardamalia & Bereiter, 1999, p.275).

Transition to Knowledge Building Community

Setting the Stage

The Grade 4 database was entitled "Illuminating Shakespeare". The 1999-2000 school year began with a study of the play "A Mid Summer Night's Dream" by William Shakespeare. The class went on a field trip to see a production of the play. Two views were created in the database at that time: "What was Shakespeare Thinking?" and "Difference Between Reading and Seeing the Play". Students had no prior experience to working with Knowledge Forum™, and thus their notes in these two views were their first in the database.[1] The students used a typing tutor program in September to increase their key-boarding abilities.

Concurrently, in Language Arts, one of the forms of writing the class was studying was comparison writing. Using a venn diagram on the blackboard, I used the example of comparing the theatrical production the class had seen with what a production of the play might have looked like during Elizabethan Times. Students noted that the "special effects", that is, the sound and lighting effects, would not have been present in Shakespeare's time. One student who had prior knowledge of the open formation of the Globe Theatre said that sunlight was the only light used in the Sixteenth Century, and that a lit candle was used to represent evening/darkness.

[1] See Appendix A for grade four database "Welcome" page

Another student added that, "there must have been less light in Shakespeare's time". This misconception was not challenged by the students.

By way of their various questions the students demonstrated that they were clearly interested in investigating these differences and wanted to engage in a study of light. Responding to the student-directed study choice, I wrote a question as the title of a next view in the database: "What Is Light and Where Does It Come From?" The students were asked to record their theories and list any questions they had about light.

Factory Model

In order to organize the study of light, I felt that a framework needed to be created. As the teacher I identified three essential components of the study: time to research/gather information, opportunities for discovery through research and experimentation, and time on the computers to record findings and further questions that would be shared with the rest of the class. As there were 22 students and 7 computers in the class, it made sense in the early stages of the study, to divide the class into three random groups. A three-part cycle was created consisting of 40 minute sessions, two to three "Knowledge Building" cycles per week.

As there were three groups working simultaneously with only one or two adults in the room (depending on the day), it was important to implement a procedure that would allow the groups to independently and effectively deal with resource materials. The students and I decided to cease using books that were designed for junior grades because for all their merit when it comes to organizing knowledge, they often left the students with shallow summaries and premature closures on important ideas. Instead the resources used in the classroom were above grade level, often of high-school level, initially chosen by the teacher. As a result, an adapted version of reciprocal teaching (Brown & Campione, 1996, p. 296) was introduced to the class as a whole and then modeled with each group separately. Reciprocal teaching was a tool for groups to enhance their comprehension of important material that may have been too difficult to understand without the support of each group member. Each group of students would have a leader that would ask questions in order to clarify the core content of the material read. The group would decide what information was important and understood. These points were recorded as dot-jot notes. Each student was given a black lab book (research journal) to record his/her notes.

The experiment/exploration part of the cycle was designed to support and promote the students' curiosity and questioning spirit. Experiments were conducted on a designated table in the classroom. Often the students were asked to follow planned steps (teacher-designed experiments) and record the data in their research journals. The experiments were conducted by the students and were designed to complement the reading during reciprocal teaching. The students could be heard using the new vocabulary they had learned in their readings at the experiment table. Since inquiry in Science follows no single pathway, experimentation led to many new questions. The groups asked to conduct new investigations. The idea of a teacher-directed experiment table derived from my factory model approach to teaching. (Interestingly, I had considered myself to be a child-centered teacher prior to this experience.) Initially I felt comfortable thinking that knowledge building was occurring because students were not only reading but were doing experiments – "hands-on learning". I slowly realized that they were trying to solve my knowledge problems rather than their own. Experiments, on their own, do not guarantee that children are knowledge building. Authentic knowledge building takes place when students are making sense of information about a problem that is of interest to them (Scardamalia & Bereiter, 1999, p. 279). With this new understanding, I encouraged the students to design and conduct their own experiments to answer their own questions. This said, there was still a period of adjustment for myself. I needed to "let-go" of controlling the investigative process and allow the children to explore, even though I often felt it seemed as though they were "playing" with the materials. I was surprised that what I often perceived to be time wasted "filling jars with water, sand and leaves, and then shining a flashlight through it" brought meaningful insight to the students when I would later conference with them (student: like in the reciprocal teaching, I learned that only some light traveled through, so the muddy water must be translucent). The students were reconstructing what they had read so that it made sense in light of the new information from their experiments. Scardamalia and Bereiter state:

> "…students who are actively trying to solve a knowledge problem will move more readily between developing ideas of their own and trying to negotiate a fit between their own ideas and information obtained from authoritative source."
> (Scardamalia & Bereiter, 1999, p.279)

With my confidence restored, the students and I decided how best to record an inquiry process for student-directed experiments, that is, how to design, carry out and document the inquiry. Thus we developed our own scientific method. And the experiments moved off the table and into the school hallway, the caretaker's closet, the school yard….

The cycle was made complete with the time on the computers using Knowledge Forum™. This was the opportunity for the group members to state their research problem, offer their theories and record their attempts to improve upon their conjectures by writing the knowledge advances they experienced from experiments and readings. Since satisfying answers to their problems where often unattainable, new questions were added to the database and the inquiry process would begin again.

Two new views were added as a means of clearing the clutter of notes and build-ons in the original light view: "Uses of Light" and "Shadows and Reflection". For myself, the notes in these three views provided vital information as to the understanding of the material and the direction of the study interest. Yet there were problems with this teacher-controlled cycle-model. The third group to arrive at the computers would often complain that all of the new knowledge had already been recorded in a note by members of the previous two groups. They were right. Since initially all three groups were given the identical reading, and more or less the same experiments to follow, there was little or no reason to share information on the database. Also the students stated that the reciprocal teaching group were too large and difficult to manage. I realized that the uniformity created by the "factory model" approach that I had designed (teacher-focused, same task for each group, random group formation) needed to be changed quickly if there was to be any authentic knowledge building.

Specialization Model

In their notes and in the design of their experiments, the students indicated areas of the study of light that were of particular interest to them as individuals. The students and the teachers worked together in "identifying" the areas of interests. Six were identified and later re-named by their group members (ranging from 3 – 4 students). They were: "Sources of Light", "Images", "Angles and Reflection", "Colours of Light", "Colours of Opaque Objects", and "Mirrors".

This re-structuring created much excitement. Students began to bring in their own resources for reciprocal teaching found on the internet or at public libraries. Reciprocal teaching became more opportunistic, experiments were initiated by the groups. Each group created and managed its own view. The original three views were categorized as "Old Light Views" on the database welcome page, and each new group was free to copy any pre-existing notes from them to their current view if the members thought the notes were pertinent to their study focus.

The three-part cycle remained but it became much more organic in that each group would decide which part they needed to work on. The time restraints for completing a task were eliminated. Now groups could spend as much time as they felt necessary to obtain understanding, driven by their individual curiosity and cognitive abilities. Each group felt they had ownership of their aspect of the study of light, their area of expertise.

The role of the teacher shifted to more of a facilitator, guiding the groups to deeper understanding, by anticipating their readiness through continuous dialogue. The students began to realize that they were directing their own learning within their area of specialty and that the teacher was a member of the learning community, not the knowledge provider. It was liberating to engage in the knowledge building along with the students. I did not feel the pressure to need to know the answer to each question posed by the research groups and thus did not limit the diverging study to my personal understanding of light. Due to the depth of the study, many of the problems were new to me. Instead I could help direct where the information might be located, provide opportunities for the group to make appropriate discoveries by designing and/or conducting an experiment. I was an authentic member of the knowledge building community. As a result, I found myself becoming more interested in how the understanding was advancing in the classroom. Many of the "Problems of Understanding" that I brought to class discussions were centered around the pursuit of understanding. I would ask the students to reflect on: our methods of investigation, how they knew understanding had taken place, if they thought recording theories was important, etc.

An adaptive form of crosstalk (Brown) was introduced to the class. In this formalized exchange, students from the six research groups could report a "Knowledge Advance" (reporting their findings to date), or present a "Problem of Understanding" to the other groups in the hopes that one of the other groups might have information to help provide comprehension or clarification. An example of a crosstalk success was when the Mirror Group was provided with clarification from the Reflection Group members regarding the law of reflection. One of the earlier "Problems of Understanding" was whether the creation of shadows were dependant on light or vice versa. "Technical (computer or social) Problems" could also be brought to a crosstalk. Steps that needed to be followed to avoid loosing notes, what to do when the computer crashes, how to include a diagram, etc., these were all answered by students. If no one in the class had the answer to a technical question, we directed the problem to the teacher-researcher in the school who was also our computer expert on staff.

Crosstalks was the opportunity for students to remind each of the principles of knowledge building. One student wanted the rest of the class to know that build-ons should not be used to merely state that a note was good (be complementary), "that's something you can tell your friend outside at recess, but since we have so little time on the computers, build-ons should only be used to advance knowledge!" Knowledge telling notes, that is notes wherein a student simply demonstrates what he/she knows rather than attempting to advance knowledge were criticized. Crosstalk was scheduled weekly for 30 minutes.

This "Specialization Model" of inquiry learning had many benefits. It was student focused, tasks were group specific and the membership was interest-based. A classroom of intentional learners had been fostered. But the acquisition of knowledge was at the small group level, it was not a social activity, that is, as a collective, the class did not share the goal of understanding light. The students had created a mission statement for their study, "To understand as much about light as we possibly can", yet the specialization of each group prevented the class as acting as a whole. The "we" of the mission statement did not speak of the class as a community of knowledge builders, but merely a tabulation of what the separate groups understood. Experts in their own areas, each group knew little about the knowledge outside of their field of expertise. Members of one group would rarely read, let alone build onto, the notes in another group's research view.[2] The goal of CSILE/Knowledge Forum™ is to find a means to objectify knowledge and bring it to the "forefront of classroom activity" so that the knowledge itself improves (Scardamalia, Bereiter, and Lamon p.207). This is only possible if a shift is created from individual groups to a collective understanding of light.

I was also concerned that the study was becoming too narrow for each group. Clearly there was not the problem of coverage-oriented instruction,

[2] See Appendix B for table of ATK results

where topics are merely checked off and students move on whether there is understanding or not, but I needed to decide what should be known by all students (more about this procedure later). In the book *Understanding by Design,* 1998 by Wiggins and McTighe, the authors explain that depth of knowledge provides the fluidity and "flexible knowledge of how and why things work" (page 101). But they state that depth alone is not sufficient. Effective researchers need to see how their findings and ideas link with those of others in order to create a larger meaning. "Breadth implies the extensions, variety, and connections needed to relate disparate facts and ideas" (page 101). The challenge for me was to blend the current specialized (in-depth) study that each group was engaged in with a breadth of what each of the other groups was working on in order for the students to see the larger picture.

Knowledge Building Community Model - Small-Scale Design Experiment

Within the database, students were expected to keep a note in their portfolio about their complete understanding of light. Based on the growth of these portfolio notes, it was clear that although they were being intentional learners, they were not acting as a knowledge building community. The students were only writing about their own area of research. Students were exposed to the findings of other groups during crosstalks and simply by being in the same environment while a group was conducting an experiment, yet they did not feel comfortable writing about any light principles that they themselves did not investigate. This was quite evident in a conversation overheard between two students from different groups working on the database. A students who was a member of the Colours of Opaque Objects Group was experiencing writer's block while writing in his portfolio. The student next to him, who was a member of the Reflection Group, suggested he write about "luminous", as that was a definition that everyone was exposed to at a recent crosstalk. The first student refused to include this concept in his portfolio "My Understanding of Light" note, explaining that luminous is for the "Light Sources" group, "my group didn't study about that".

In order to make this transition from a group of intentional learners to a collaborative knowledge building class, certain database and classroom "inventions" were needed.

As a result of a pencil and paper test covering all six areas of light study, the students realized that they knew more than they were writing about in their portfolio notes. The results of the test exceeded my expectations.[3]

[3] See Appendix C for sample of test

It was also evident during a field trip to the local Science Centre, that the students seemed to understand more than their area of specialty (they did possess some breadth of the other groups' discoveries). Prior to the trip, a member of the Colous of Opaque Objects Group presented a "Knowledge Advance" during crosstalk regarding the colour-sensitive cones in human eyes. He explained that if you stare at a blue object for a length of time, you would be exhausting your blue-sensitive cones leaving the red and green cones to be functioning normally. Thus if you quickly looked at something white, you would perceive it to be yellow because your red and green cones (minus blue needed to make white appear white) would be active to indicate the secondary colour yellow. At the field trip, a presenter was conducting a similar experiment, only this time asking the audience to stare at a magenta-coloured screen. In this case, two cones would be getting tired (red and blue used to create the secondary colour of magenta). A student in another view group anticipated the presenter's question and stated "I know, we are going to stare at something white after and it will seem green". She was able to extend the knowledge presented at the crosstalk to a higher level, indicating a developing understanding of how eyes see colour and light colour mixing. Perkins, in the book *Teaching for Understanding* (Wiske, 1997), defines understanding as, "the ability to think and act flexibly with what one knows ...a flexible performance capability as opposed to rote recall or plugging in of answers" (p.40). This is an example of real knowledge and understanding being used in new ways.

In an attempt to broaden their understanding of light by reading the notes in other views, they were confronted with new vocabulary and confusing concepts. To solve this, each group created a "glossary" note and teaching notes as was suggested by a student at a crosstalk. This invention helped but the research views still remained complex and difficult to navigate.[4]

The portfolio notes began to include more knowledge from the other groups. Generally, when the students were writing in their portfolio, the teacher observed that many remained frustrated in deciphering the clutter of each group view and seemed to instead rely on recalling the information from memory, from crosstalk discussions, from the experiments of other groups that they may have witnessed themselves or from teacher conducted benchmark lessons. In essence, they were taking advantage of the fact that they shared the same physical environment. The database did not seem to be the major contributor to the development of breadth in the portfolios. The structure of the portfolio note now included a lengthy section on the student's own area of specialty with bits of facts from the other five areas

[4] See Appendix D for samples of group views

muddled together in no apparent order. As the children remembered the concepts, they would add it to their list.

To improve the coherence of the views, rise-above notes were used to collect similar notes together. A student had presented the idea of creating rise-aboves at a crosstalk. Using the analogy of a vacuum "sucking up notes" that were similar in content. He explained that this would help in "cleaning up" the views by collecting the notes within the rise-aboves while also serving to sort the notes to understand them better. The boy was seriously challenged by a member of another group who was concerned about the ownership of the notes placed in the rise-above. The opposing student realized that once her note was placed in a rise-above by another group, she would no longer be able to modify her note. Ultimately a solution was brought forward: first "authorization" (the student's actual wording) needed to be granted to include someone's note in your rise-above, and the authors of each note included in a rise-above would be added as co-authors to the rise-above allowing any future addition to the note. New scaffolds were created to organize the notes and knowledge within the rise-above notes (Our Theories, Our Evidence, Putting Our Knowledge Together).

The rise-above notes empowered the groups. They chose what knowledge from their view should be gathered together, identified in a rise-above and ultimately shared with the other groups. The rise-above notes focused on a particular concept. Some of the titles were: "Our Understanding of Angles and Reflection", "Our Understanding of Lenses", "Our Understanding of Sources of Light". Students working on rise-aboves commented that by using the scaffolds to organize their notes, (for example "Putting Our Knowledge Together"), it helped them develop an even better understanding of their knowledge. It seemed as if by organizing and categorizing the knowledge from the pre-existing notes into the rise-above using scaffolds, the group was "handling" (manipulating) the knowledge as if it were a product. Knowledge did not seem to exist only in the minds of the students but was something tangible that could be improved upon and/or given to new uses – used to help in the collective knowledge advancement of the class. This process also made the authors of the rise-aboves aware of what they still did not understand. Thus a new scaffold was added: "What We Still Need to Know" to direct future inquiry and help students to understand that we are not seeking simple answers to straight-forward questions, but are engaged in something much closer to the way scientific advancement takes place.

The answer to the my earlier question as to what content each student should understand (have a breadth of understanding to complement his/her deep specialized understanding) was answered by the creation of the riseabovеs by the separate groups. Each group decided what should be organized in a rise-above and which rise-above to offer the other groups. The focus of the class had shifted for the third time. With the factory model the teacher was the focus. The specialization model had the focus placed on the students. Now the focus was on the class as a whole. The interest-based groups made way for a knowledge-based classroom community.

The selected rise-above notes were collected in a new view entitled "Light Learnings". It included a mini-photograph of each group view welcome page. On this background, the corresponding rise-above notes were placed. The quantity of rise-aboves per group was decided by the members and varied from one to four. The database "invention" of the Light Learnings View made it easier for students to learn from each other's research findings.[5]

The portfolios following the creation of the Light Learnings View evolved dramatically.[6] Students independently began to organize their "Understanding of Light" note in paragraphs, one for each area studied by the groups. The paragraphs or sections were well-developed and fairly consistent. It was clear to each student which concepts he/she was expected to understand. Interestingly, when the class compared the notes created by the six groups and their own individual portfolio notes ("My Understanding

[5] See Appendix E for sample of Light Learnings View

of Light" with the specific expectations for understanding basic concepts created by the Ontario Ministry of Education and Training in the Science Guideline for teaching light to grade four, it was perceived by the students that they had built more knowledge (in terms of light) than was expected of a grade four class.

Results and Discussion

The class had been asked to demonstrate some light concepts to the junior kindergarten students who were also investigating light. The students planned what they felt would be appropriate and designed experiments for the four year olds. At the same time, the class was informed that a grade four class in another public school would like to view and hopefully learn from their Light Learnings View. Following these experiences, the students reflected in a crosstalk about their beliefs on how learning happens. They were concerned that simply providing another class with "the answers" would not be an effective way of learning. The students felt the other class needed to engage in experiments, as the junior kindergarten students had, or contribute to the database. The discussion evolved to include different teaching styles. One girl said "you know you really understand something when you can teach it to someone else, especially a younger kid". The

[6] See Appendix F for the samples of pre-light learnings view portfolio notes and the post-light learnings portfolio notes

students articulated that, simply reading and memorizing facts, was not enough, rather the students felt that the participants needed to be actively involved in constructing the knowledge for themselves.

In the broader classroom context, additional "inventions" were created to facilitate the transition to a knowledge building community. In terms of the crosstalk, a system of filling our a "crosstalk card" was developed to help determine what was going to be discussed during crosstalk time. If there were no cards, there was no crosstalk. Within this system, the students had an opportunity to use and benefit from the knowledge of the entire in solving a "Problem of Understanding". Because the community believed the knowledge building time to be precious and for the benefit of the entire class, the students and teacher decided this method would be a way to prevent time wasted on unnecessary crosstalks.

Other opportunistic "inventions" were folders to store reading resources (readings provided either by the teacher or group members) for each group, and a light vocabulary wall where students would post a word from their study they felt was important to share with the entire community. In order to free-up the teacher from solving computer problems or teaching technical skills, students were empowered to instruct one another. As a need arose, a knowledgeable student or adult (most often the school teacher-researcher), would guide the student through the steps needed to solve the problem, making the student an "expert" in that skill. A poster was used to advertise which student to consult for support.

Following the creation of the Light Learnings View and the modified portfolio notes, the students were given a post-test which was an exact replica of the original test. The quality of the responses on this post-test improved, perhaps indicating some degree of benefit from the creation of the Light Learnings View.[7]

The final invention derived from a crosstalk discussing the purpose of building knowledge. The students requested an end of the year parent night that would showcase their knowledge advances. One student described himself as a "cup overflowing with information", "I need to share this knowledge with others!" By this point in the year, the class had also been studying Elizabethan England. Six views were created on the "Illuminating Shakespeare" database, each representing a different social group (Nobility, Clergy, Actors, etc.). The students felt this meeting with the parents would be an opportunity to tie the entire year's worth of learning together. They decided to print out their portfolio notes on light and Elizabethan England along with notes in their views that they were particularly proud of. These were mounted on posters. The groups had constructed various structures from Shakespeare's time (Tudor homes, the Globe Theatre, Sir Drake's

[7] See Appendix G for selected samples of pre-test and post-test responses

ship) and decided to display these projects. And finally the students, worked in their character groups, writing a play about going to see the opening production of "A Mid Summer Night's Dream" at the Globe Theatre. The challenge posed to the students was to include as many light concepts in their short plays as possible. The event was a great celebration. The students were the teachers (extremely enthusiastic) and the adults were the (very proud) students. Following the plays, students guided their parents around the models and addressed their individual portfolio posters. Many brought their parents onto the database to show their work. Students noticed errors in their notes and began to correct them, while their parents watched on. Howard Gardner, in his book *The Disciplined Mind,* writes of the need to give students the opportunity to perform their understanding (page 128). The parent night, along with the visit to the junior kindergarten class mid-way through the study, advanced the understanding of the grade four students; the learning didn't stop.

The focus of the design experiment was to create a knowledge building community. This paper attempts to observe the transition from a focus on intentional learners, organized into interest-based groups, to a whole group with a collaborative knowledge building focus. The opportunistic creation of inventions, the tools that facilitated the shift were studied. They are: crosstalk cards, reciprocal teaching folders, vocabulary wall, poster advertising technical experts, end of study parent night, and the creation of the Light Learnings View.

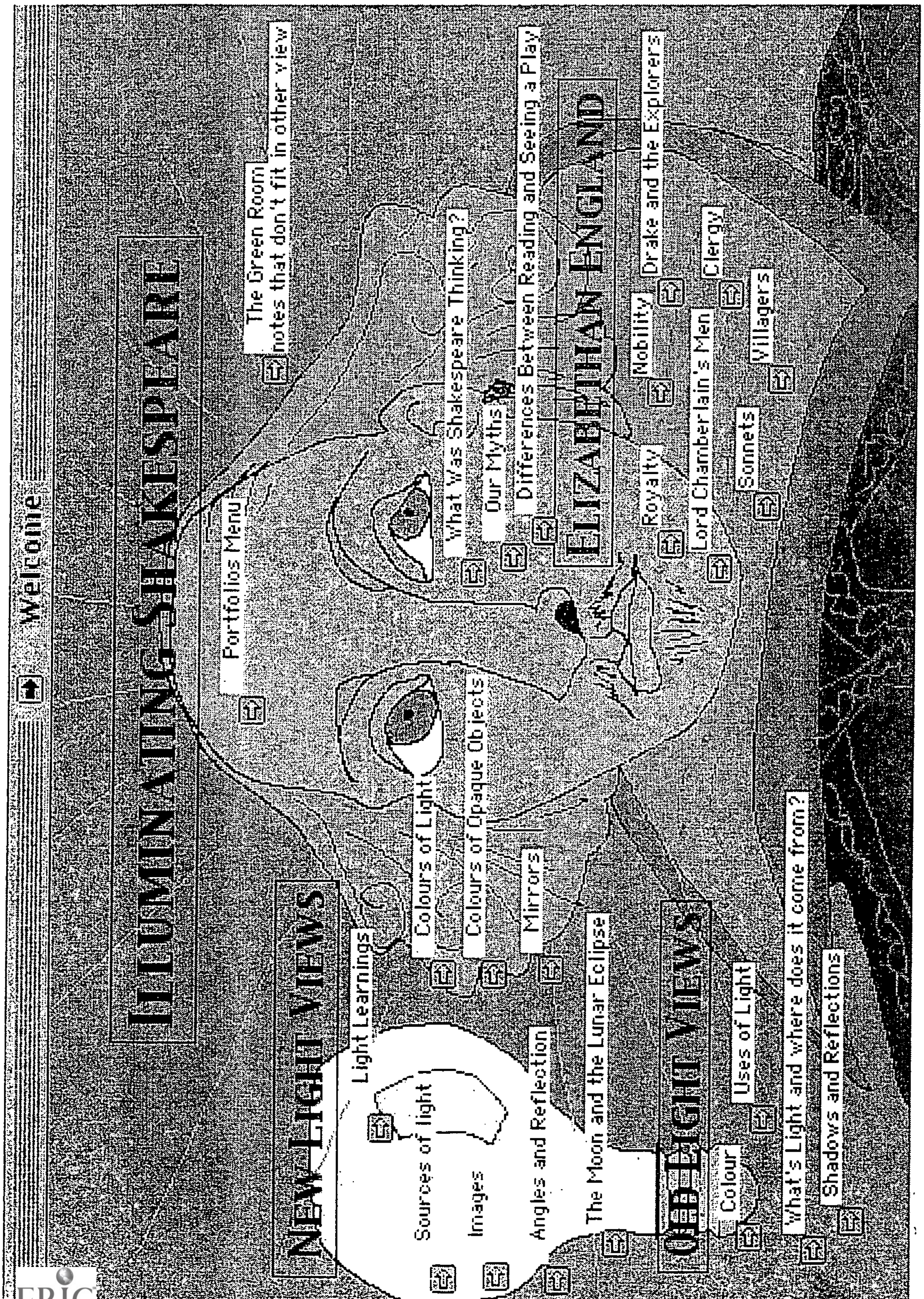
Summary and Future Research Direction

The goal of this three-year long research project is to begin a process for the defining, refining and improving of approaches to knowledge building. The challenge for the first year of this study was to establish a functional knowledge building community within this grade 4 classroom. A description of the knowledge building community that developed in the grade four classroom was presented and the transition from a group of intentional learners to a knowledge building community. The process presented was essential for this group and myself as the teacher. That other communities may benefit from seeing the evolution of this classroom is possible through access to the inventions and interventions that were developed by this class. Access to these elements of a knowledge building classroom could be of value to others attempting to implement a knowledge building approach to pedagogy in their own classrooms. Though it is unclear if others will need to go through the transition in order to create a knowledge building community. Perhaps this transition process always needs to be present but could be sped up so that the class reaches status as a knowledge building community sooner. Alternatively, maybe this transition is not necessary and can be eliminated through a new approach to the beginning of the school year. Future studies could also examine how knowledge building groups can best use Knowledge Forum™ to communicate the knowledge they have developed. The independent variables could be examined and modifications suggested to make the transition more efficient, or even perhaps, unnecessary for other knowledge building communities.

Although a study of how to facilitate a more efficient change to knowledge building communities would be beneficial, this will not be possible next year with the grade 4 class as they are already participating in a knowledge building community in their grade 3 class. During this school year, the Institute of Child Study had four classrooms knowledge building using Knowledge Forum™: grades one, three, four and a five/six class. This means that the students entering into grade four in the 2000-2001 school year bring with them an understanding of what it means to be a knowledge building community.

An alternative study that could take place would examine how students within a knowledge building community could share their knowledge across classrooms. This appears to be a question worth examining. This study has dealt with the development of a knowledge building community within a single classroom. This leaves students isolated from other communities that are engaged in building understanding of the same and different content knowledge. Could the knowledge that is created in one classroom have value beyond the local group? Given the need for curriculum coverage and the importance of depth of study, could knowledge building classrooms divide the strands of the curriculum in a given subject matter, science for example. Each class studying one area deeply and consecutively share the knowledge advances with the other class. This was explored in a pilot study that built onto the small-scale design experiment just presented. The Light Learnings View was shared in hard copy form with a grade four class in another school that had also been studying light. The experience indicated that attention needs to be paid to written composition and language in the notes. Knowledge building pedagogy shifts the focus from person-to-person communication to a communication that is implicitly directed toward everyone. Research in this area is needed to ensure that the notes and views that get developed are accessible to others, especially if they are going to start building knowledge between classes and schools.

Appendix A


Welcome
ILLUMINATING SHAKESPEARE
Portfolios Menu
The Green Room
notes that don't fit in other view
What Was Shakespeare Thinking?
Our Myths
Differences Between Reading and Seeing a Play
ELIZABETHAN ENGLAND
Royalty
Nobility
Drake and the Explorers
Lord Chamberlain's Men
Clergy
Sonnets
Villagers
NEW LIGHT VIEWS
Light Learnings
Sources of light
Images
Colours of Light
Colours of Opaque Objects
Mirrors
Angles and Reflection
The Moon and the Lunar Eclipse
OLD LIGHT VIEWS
Colour
Uses of Light
What's Light and where does it come from?
Shadows and Reflections

Appendix B

ATK Results

Student	Percent of notes read in own group view	Percent of notes read in the five other group views (omitting own group view notes)	Percent of rise-aboves read in light learnings view
Zoe	78	12	55
Noam	97	43	91
Derek	98	35	73
Isaac	81	80	73
Sam	91	40	27
Ryan	100	98	100
Sarah C.	100	77	91
ICM	100	43	100
Simon	87	58	100
Louisa	90	31	45
MM	100	18	18
Celine	100	20	64
CW	100	34	64
Gideon	100	39	82
JS	67	35	36
MB	100	40	82
SC	100	33	64
Clara	95	37	55
David	100	61	73
Sarah S	100	88	55
Nadia	100	20	27
HM	100	89	55
average total	95	47	65

Appendix C

A "Light" Survey Name:____________________

Write your answers in the space provided.

1. a)What is the definition of a luminous object?

   b)Which of the following objects are luminous? (Circle the objects).

   stars the moon the sun a switched-on flash light

2. a)Explain the difference between transparent, translucent and opaque materials.

   b)Sort the following in the table below:
   air, window glass, frosted glass, wood, bricks

   Transparent Materials:

   Translucent Materials:

   Opaque Materials:

3. What colour of clothing that will keep you cool on a hot, summer day. Explain why.

4. What are the names of the main parts of a shadow? How is each part formed?

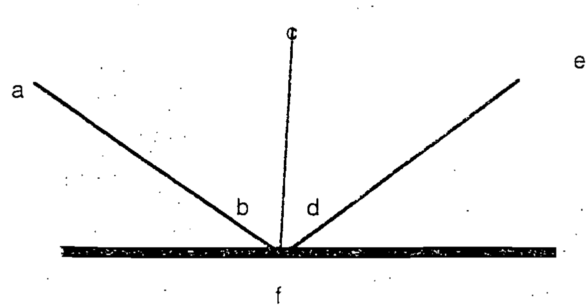
5. Draw a labelled diagram of a lunar eclipse.

6. Describe how you know light travels in a straight line. You may describe a demonstration you have observed or you may illustrate an experiment that would prove it.

7. Imagine you are standing under a bright street lamp. Watch your shadow as you walk away from the lamp post. What happens to the lent of your shadow as you get farther from the street lamp? You may draw a diagram to illustrate your answer.

8. What is meant by the term: regular reflection?

9. Match the letter in the diagram to the labels.



point of incidence:_____
normal:____
angle of reflection:_____
Incident ray:______
reflection ray:______
angle of incidence:______

10. What is the "law of reflection" in a plane mirror?

11. What is meant by the term diffuse reflection?

12. What is the difference between a concave mirror and a convex mirror? You may draw a diagram for each.

13. Fill in the blank: Light rays parallel to the principal axis that hit a concave mirror reflect toward the _______________.

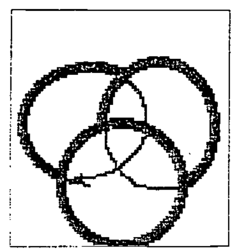
14. Read these 2 explanations of rainbows.

Statement A: White light is made of the spectral colours. These colours appear when light passes through water droplets.

Statement B: Water droplets add colour to white light to produce the spectral colours.

Write a short paragraph to explain the statement you believe to be correct.

15. Label each primary colour and the colours they produce when added together.



16. If you stare intently at a bright green object, then
a) look at a white surface. What colour would you see?

b)Explain why this happens.

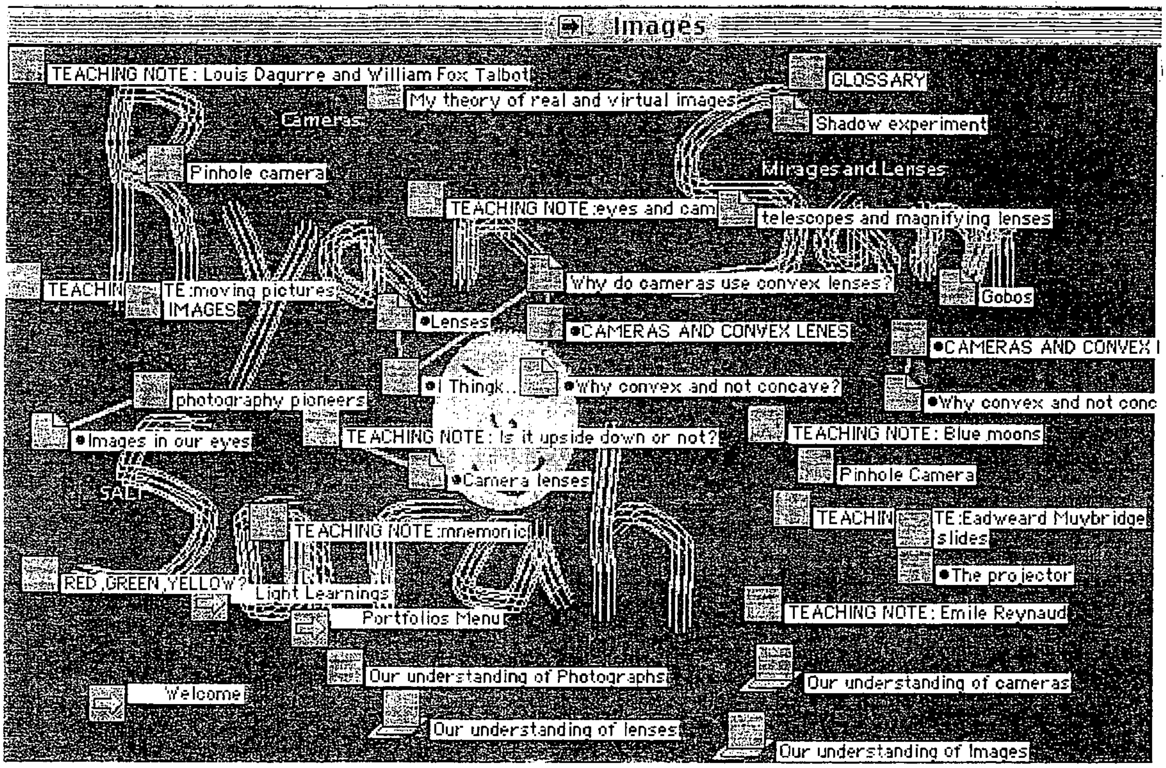
17. a)What light colours does a blue object reflect?

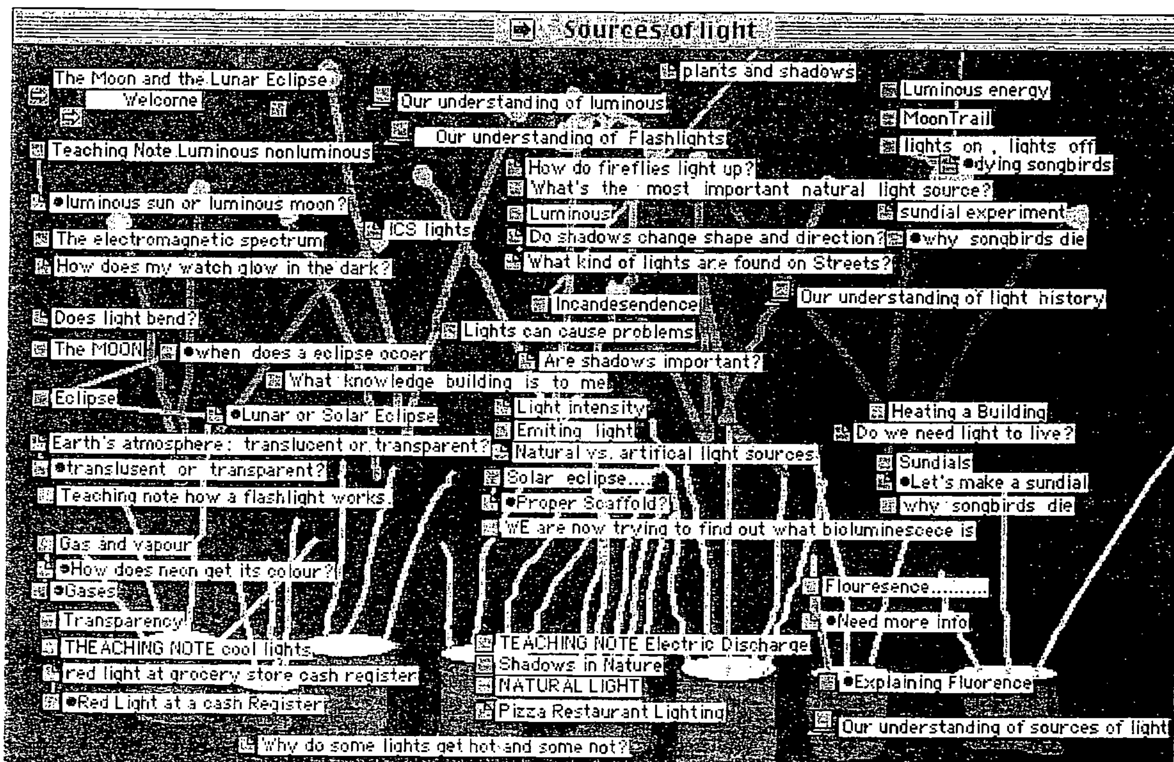
b)What light colours does a blue object absorb?

18. If three light sources, one red, one blue and the other green, were shining on an opaque object from different sides, what light colours would you see behind the object? Draw a diagram to help you.

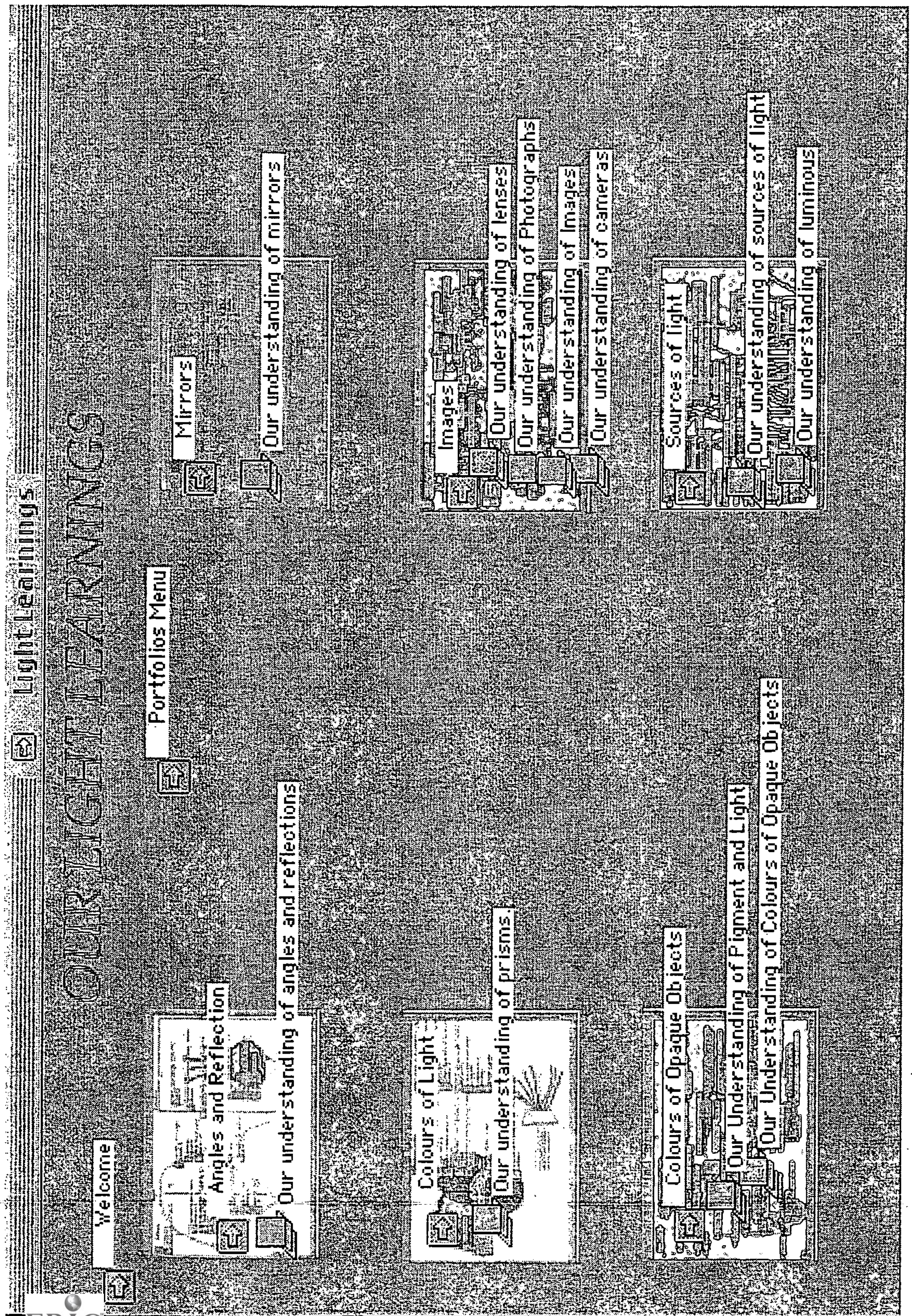
19. The first light experiment we did in class was the one with the light that seemed to bend into the water bucket. We know that light travels in straight lines. Then how did the light get into the bucket? Please explain.

Appendix D


Images
TEACHING NOTE: Louis Dagurre and William Fox Talbot
My theory of real and virtual images
GLOSSARY
Shadow experiment
Cameras
Pinhole camera
Mirages and Lenses
TEACHING NOTE:eyes and cam
telescopes and magnifying lenses
Why do cameras use convex lenses?
Gobos
TEACHIN
TE:moving pictures
IMAGES
•Lenses
•CAMERAS AND CONVEX LENES
•CAMERAS AND CONVEX
•I Thingk..
•Why convex and not concave?
•Why convex and not conc
photography pioneers
•Images in our eyes
TEACHING NOTE: Is it upside down or not?
TEACHING NOTE: Blue moons
Pinhole Camera
•Camera lenses
TEACHING NOTE:mnemonic
TEACHIN
TE:Eadweard Muybridge
slides
•The projector
RED,GREEN,YELLOW?
Light Learnings
Portfolios Menu
TEACHING NOTE: Emile Reynaud
Our understanding of Photographs
Our understanding of cameras
Welcome
Our understanding of lenses
Our understanding of Images


Sources of light
The Moon and the Lunar Eclipse
plants and shadows
Luminous energy
Welcome
Our understanding of luminous
MoonTrail
Our understanding of Flashlights
Teaching Note Luminous nonluminous
lights on , lights off
How do fireflies light up?
•dying songbirds
What's the most important natural light source?
•luminous sun or luminous moon?
Luminous?
sundial experiment
ICS lights
The electromagnetic spectrum
Do shadows change shape and direction?
•why songbirds die
How does my watch glow in the dark?
What kind of lights are found on Streets?
Our understanding of light history
Incandesendence
Does light bend?
Lights can cause problems
The MOON
•when does a eclipse occer
Are shadows important?
What knowledge building is to me
Eclipse
Light intensity
Heating a Building
•Lunar or Solar Eclipse
Emiting light
Do we need light to live?
Earth's atmosphere : translucent or transparent?
Natural vs. artifical light sources
•translusent or transparent?
Sundials
Solar eclipse....
•Let's make a sundial
Teaching note how a flashlight works
•Proper Scaffold?
why songbirds die
WE are now trying to find out what bioluminescece is
Gas and vapour
•How does neon get its colour?
Flouresence..........
•Gases
Transparency
•Need more info
THEACHING NOTE cool lights
TEACHING NOTE Electric Discharge
red light at grocery store cash register
Shadows in Nature
•Explaining Fluorence
•Red Light at a cash Register
NATURAL LIGHT
Pizza Restaurant Lighting
Our understanding of sources of light
Why do some lights get hot and some not?

Appendix E



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Appendix F

(3 student samples of pre-Light Learnings View "My Understanding of Light Portfolio Notes" and post-Light Learnings View "My Understanding of Light Portfolio Notes")

Ryan's Light Learning

Problem

My Understanding of Light

On hot days, mirages can cause you to see pudles of water on the road or sidewalk. A zoetrope is a thick piece of paper thats spins around. Light travels in straght lines. Light does not go through opeque objects, but goes through "TRANSPARENT" objects. Lumiöus is a light soursethat gives its own light. Protractors are used to mesure "ANGLES". [1]

[1] Ryan. (Mar. 10, 2000). "Ryan's understanding of light" [Knowledge Forum™ Note]. ICS - Fantastic Fours [Online]. Available: database address [date referenced].

Ryan's understanding of light - Ryan

Problem: Ryan's understanding of light

My Understanding of Light. On hot days, mirages can cause you to see pudles of water on the road or sidewalk. A zoetrope is a thick piece of paper thats spins around. Light travels in straght lines. Light does not go through opeque objects, but goes through "TRANSPARENT" objects. Luminus is a light sourse that gives its own light.

Protractors are used to mesure "ANGLES". The angle of insidence=the angle of reflection.

If you mix RED and GREEN it makes YELLOW, GREEN and BLUE make CYAN, BLUE and RED make MAJENTA, RED, BLUE and GREEN makes WHITE, BLUE and YELLOW makes WHITE, RED and CYAN makes WHITE, GREEN and MAJENTA makes WHITE!! The secondary colour's are YELLOW, CYAN and MAJENTA!!

There are three coulerd eye cones blue, green and red. If you stare at a blue object your blue eye cones get tired. If you stare at a red object your red eye cones get tired. If you stare at a green object your green eye cones will get tired. A concave miror looks like this), but a convex looks like this (. SALT is a good way to remember charicteristecs of light S for size, A is for attitude, L is for location and T is for type.

If you shine white light thruogh a prism you will get all the coulers of the rianbow. A chemical that absorbs obcretian colours but reflects others, is a pigment. A mixture of yellow, cyan and magenta pigment /paint absorbs blue, green and red light. No colour is reflected so the mixture appears black. Glass, diamonds and crystals all act like prisms. A prisim is a solid, tranparent piece of glass or plastic.

Cameras take photographs by using batteries and what they do is they take some parts of an eye and make the technology act like an eye so when you press the button to take a picture than the lens would take the picture in an eye and put it onto the film. Infra red light is light that the human eye can not see. To see Infra Red light you need a specical type of visor or gogle.

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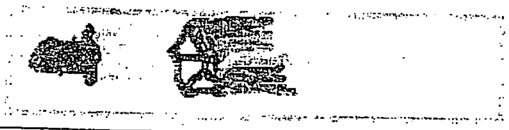
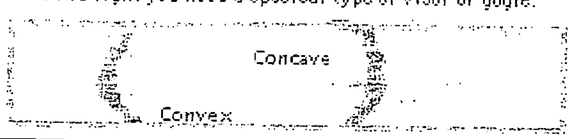
Cameras take photographs by using batteries and what they do is they take some parts of an eye and make the technology act like an eye so when you press the button to take a picture than the lens would take the picture in an eye and put it onto the film. Infra red light is light that the human eye can not see. To see Infra Red light you need a specical type of visor or gogle.





Keywords: colour, white, eyes, salt, yellow, cyan, blue, green, red, majenta, cameras

Clara's Light Learning -

Problem

My Understanding of Light
is mostly about angles and reflections.I know that the angle of incidence equals the angle of reflection and that when light goes from water to air,or air to water,it refracts or bends.Light is made up of the visible spectrum which includes: red ,orange ,yellow,green,blue,indigo and violet, all the colours of the rainbow.The normal ray is the imaginary line in between the angle of incidence and the angle of reflection when light goes straight to the middle of a plane mirror and straight back.The angle of incidence is the angle at which light hits the plane mirror.The angle of reflection is the angle at which the light bounces off the plane mirror.They are always exactly equal. [1]

[1] Clara. (Mar. 10, 2000). "Clara's Understanding of Light" [Knowledge Forum™ Note]. ICS - Fantastic Fours [Online]. Available: database address [date referenced].

Clara's Understanding of Light - Clara

Problem

My Understanding of Light is mostly about angles and reflections.I know that the angle of incidence equals the angle of reflection and that when light goes from water to air,or air to water,it refracts or bends.

Light made up of the visible spectrum which includes: red ,orange ,yellow,green,blue,indigo and violet, all the colours of the rainbow.

The normal ray is the imaginary line in between the angle of incidence and the angle of reflection when light goes straight to the middle of a plane mirror and straight back.The angle of incidence is the angle at which light hits the plane mirror.The angle of reflection is the angle at which the light bounces off the plane mirror.They are always exactly equal.That is the law of reflection.

The primary colours of light are:red, green and blue.The secondary colours of light are magenta cyan and yellow.Red and blue make magenta .Green and blue make cyan.Red and green make yellow.

Opaque means solid so no light can get through. Transparent means totally see through and translucent means so.so. Something translucent lets light through but you can't see through it easily.Luminous gives off it's own light and non-luminous means it doesn't give off it's own light.The primary colours of light are red ,blue and green.Altogether they make white light.There are some colours of light that humans cannot see.For example,ultra-violet light is after violet light, (in the spectrum,)and infra-red light comes before red.A prism is a solid,transparent piece of glass or plastic that splits white light into the spectrum.

There are two kinds of lenses,concave and convex.Concave goes in and convex goes out. Convex and concave mirrors are very important.We use convex mirrors to see around corners in stores.A shadow is made when light is blocked by an opaque object.A penumbra is a shadow made when light is partly blocked and an umbra is when it's fully blocked.There are two kinds of light,artificial and natural.An example of artificial light would be a light bulb.Natural light is a sun or a candle.Light colours reflect light and dark colours absorb light.There are four ways to describe an image.They are:size,attitude,location and type.Size means whether it grows or shrinks.Attitude means if it's upside down or rightside up. Location is where the image is and Type is whether it's real or virtual.Altogether these spell S.A.L.T.

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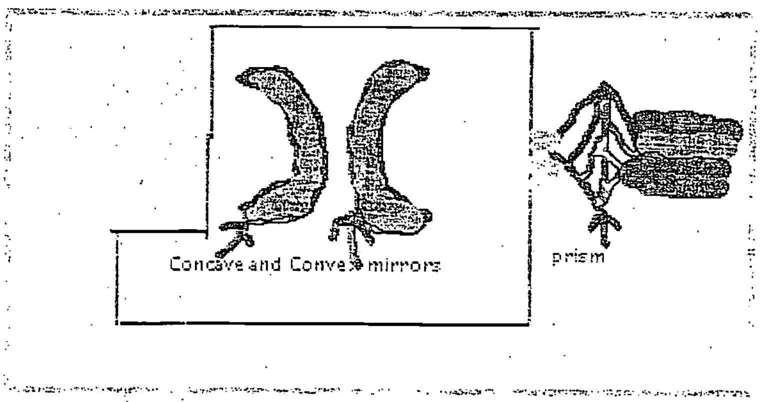


Sarah C's Light Learning -

Problem

My Understanding of Light:
is about Angles. I learned in the Angles view that if a beam of light hits a mirror at an 80 degree angle than on the other side of the normal line than it will reflect off the mirror on an 80 degree angle. This is means the angle of incidence equals the angle of reflection.That is called the law of reflection.
I also learned about luminous and non-luminous. Luminous is a light source that can turn off and on,like a flashlight.Non-luminous is a light source that can't turn on and off like a like the Sun. [1]

[1] Sarah C.. (Mar. 10, 2000). "Sarah C's understanding of light" [Knowledge Forum™ Note]. ICS - Fantastic Fours [Online]. Available: database address [date referenced].

Sarah C's understanding of light - Sarah C.

Problem: My understanding of light.

My Understanding of Light: is about alot of stuff so I'll start off with.....
Angles:
I learned in the Angles view that if a beam of light hits a mirror at an 80 degree angle than on the other side of the normal line than it will reflect off the mirror on an 80 degree angle. This is means the angle of incidence equals the angle of reflection.That is called the law of reflection and the reflection is called a regular reflection. I also learned in order to find an angle you use a protratctor which has different angles on it. You use the bottom line on the protractor to place on the bottom of the angle then you see where the other line is and you se what the angle is by looking at the numbers on the protractor. A diffused reflection is made when light is shone on a rough surface.

Sources of light:
I also learned about luminous and non-luminous. Luminous is a light source that can turn off and on,like a flashlight.Non-luminous is a light source that can't turn on and off like the Sun. Water droplet in the atmosphere act like water droplets. To make a green shadow an oblect would have to block the red light from getting to the green light. If red is blocked from green than they can't mix to make yellow. So if the red and green can't mix then the shadow would be green. I found interesting that when you shine a blue light source then only half of the rainbow is it's normal colours and the other half is just blue. But what's strange is that when you shine a red light source through a prism than the whole rainbow turns red. A natural light source is a light source that is not made by something such as batterries etc.,but an artificial light source is a light source that uses batteries etc. unlike the sun. Electricity is a very important part to making artificial light.

Colours of Light:
I learned that the three primary colours of light are Red,Green and Blue. I also learned that the secondary colours of light are yellow,cyan and magenta.I found out that if you look at a object that has the colour of one of the three primary colours if light then that primary light eye cone will get tired but the other two won't get tired and the two will mix and then when you look at a white sheet of paper the two not tired eye cone colours will mix and you will see the mixed colour on the paper. This is one of the experiments that we did in class on colours of shadows. The colours of the rainbow and the order is red,yellow,orange,green,blue,indigo and violet. The visible spectrum are the colours of the rainbow.
Images: I learned that a real image is an image that can't be projected onto a screen and a virtual image is an image that can be projected onto a screen. I also learned through an experiment that a pinhole camera is a little box with a whole in the center and when you use it to look at an object then the image will appear upside-down.
ow in the place that the blue light is blocked.is that blue, green and red mixed together make white light, and when you put an object in front of the white light you would get a magenta, a cyan and yellow shadows. But my theory is that when the object blocks the blue light, the red and green light mix together, and since when you mix those two colours together you get yellow, so if the blue light is blocked, together the green and red light will make a yellow shad [1]

Mirrors:
I learned that if a ray of light bounces off a mirror when it bounces back it will bounce toward the principal focus. I also learned from the mirrors group that a concave mirror,when you back away from it the image will get bigger and eventually the image will be upside-down. If you back away from a convex mirror then the image will get smaller and smaller. SALT stands for Size which is the size of the image, Attitude which is if it's upright or upside-down, Loacation is where the image is and Type which is if it's diffused,real or virtual.

Colours of Opaque Objects:I learned in the colours of opaque objects view that pigment is a chemical that absorbs some colours and reflects the others. Pigments absorb colours except the ones we see.The three primary colours of pigment are yellow,cyan and magenta. The colour that you get when you mix the three together you don't get white but you do get black.

Other: I learned in the beginning of our light unit that the two parts of a shadow are an umbra and a penumbra. I also learned that white coloured object etc. reflects light so that object will stay cool instead of the object getting hotter and hotter. A black coloured object absorbs light so therefore the black object will get hotter and hotter and not like a white object. When the Science Outreach people came they said the light traveled around the world in less than a second.

I need to understand how ultra infrared light works.

Appendix G

(3 student samples of pre-Light Learnings View test answers and post-Light Learnings View test answers)

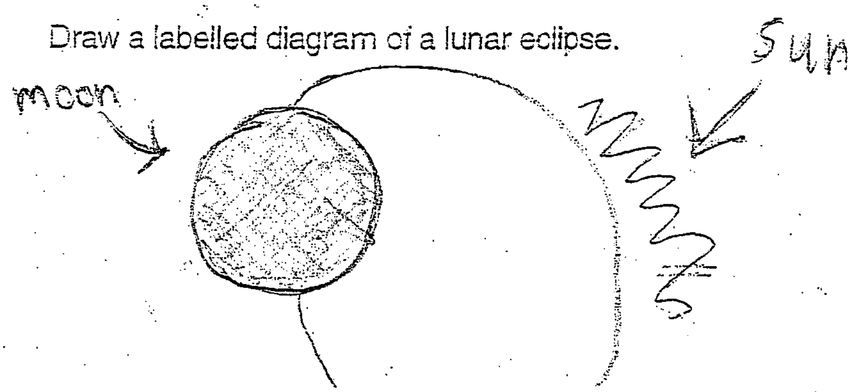
3. What colour of clothing will keep you cool on a hot, summer day? Explain why.

white because it reflects all light

4. What are the names of the main parts of a shadow? How is each part formed?

penumbra, umbra

5. Draw a labelled diagram of a lunar eclipse.



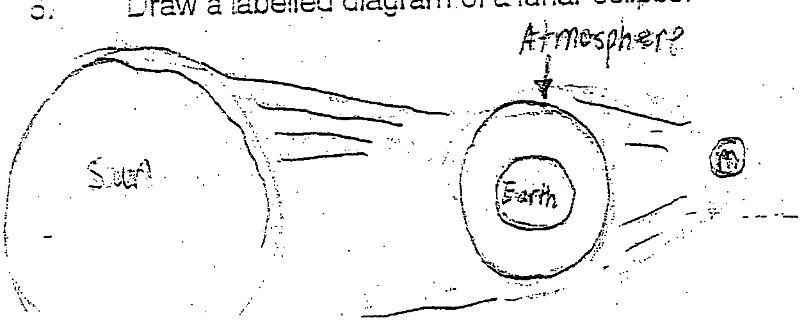
3. What colour of clothing will keep you cool on a hot, summer day? Explain why.

white because white reflects all colours of light

4. What are the names of the main parts of a shadow? How is each part formed?

umbra and penumbra

5. Draw a labelled diagram of a lunar eclipse.



14. Read these 2 explanations of rainbows.

Statement A: White light is made of the spectral colours. These colours appear when light passes through water droplets.

Statement B: Water droplets add colour to white light to produce the spectral colours.

Write a short paragraph to explain the statement you believe to be correct.

A because spectral colours light up water droplets

14. Read these 2 explanations of rainbows.

Statement (A): White light is made of the spectral colours. These colours appear when light passes through water droplets.

Statement B: Water droplets add colour to white light to produce the spectral colours.

Write a short paragraph to explain the statement you believe to be correct.

When write light passes throug water droplet the light turns to the spectral coulours

16. If you stare intently at a bright green object, then
a) look at a white surface. What colour would you see?
magenta
b) Explain why this happens.
because your geen eye cones get tired and mix your red and blew eye cones together and makes magentaw

16. If you stare intently at a bright green object, then
a) look at a white surface. What colour would you see?
yellow
b) Explain why this happens. because your blue eye cones get tiered and they mix green and Red and make yellow

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