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Creation and Evaluation of Interactive Learning Modules for Computer Science Education

Milan Neema
Utah State University

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CREATION AND EVALUATION OF INTERACTIVE LEARNING MODULES FOR
COMPUTER SCIENCE EDUCATION

by

Milan Neema

A report submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Computer Science

Approved:

Dr. Vicki H. Allan
Major Professor

Dr. Renee Bryce
Committee Member

Dr. Curtis Dyreson
Committee Member

UTAH STATE UNIVERSITY
Logan, Utah

2010

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ABSTRACT

Creation and Evaluation of Interactive Learning Modules for Computer Science
Education

by

Milan Neema

Utah State University, 2010

Major Professor: Dr. Vicki H. Allan
Department: Computer Science

The National Science Foundation (NSF) spends substantial resources to improve math and science education in United States. The ultimate goals of these programs are to produce qualified students that pursue careers in math and science. In this project, we examine novel Interactive Learning Modules (ILMs) that may help to improve computer science education. This study examines the usefulness of using interactive learning modules with other traditional methods of teaching. Specifically, we provide an initial validation of this usefulness through an evaluation of students' attitudes toward computer science. The results from the Teacher Survey and ILM Survey show that an ILM helps students to understand a topic better if they are provided with a brief knowledge about the topic. Attitude Survey result shows that a student is willing to take more computing classes if s/he is confident, has interest in computing courses, or believes that it will help them in getting a good job.

(74 Pages)

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Milan Neema

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CHAPTER 1

INTRODUCTION

1.1 Significance

Rapid growth in technological fields has created a growing and urgent need for well trained scientists and engineers in the United States. In response to this, government programs, including those of NSF, fund projects intended to improve education to students. One of such grant has been issued to Drs. Vicki H Allan, Donald Cooley, Chad Mano, and Joel Duffin entitled CPATH CB: Computational Thinking Showcase: Computing Concepts Across the Curriculum (NSF ID: 0829563). As part of this grant, several software developers are hired to develop interactive learning modules (ILMs) to help students to better understand various computer science topics. The concept of an Interactive Learning Module is patterned after the successful National Library of Virtual Manipulatives (NLVM) [6]. The modules of the NLVM were often created to duplicate activities actually done in the classroom with physical objects with which the students interact. For example, a software abacus mimics the functioning of its physical counterpart. Other examples include peg puzzles, triominoes, tangrams, pattern blocks, and geo boards that are often used in classrooms for students to manipulate. Hence, the virtual representations of the educational mathematics tools are termed virtual manipulatives. However, in creating interactive learning modules (ILMs) for computer science, we have few proven physical teaching props to duplicate. Thus, evaluation is critical. Our evaluation comes in multiple forms: (1) student evaluation of ILMs, (2) teacher evaluation of ILMs, and (3) computing attitude survey. Our evaluation is preliminary and is intended to determine a process for evaluating future ILMs.

1.2 Problem

Often, introductory computing classes are unappealing as they focus on wearisome details [3]. According to a study done by AAUW [5], in school, girls are learning spreadsheets and word processing rather than computer programming. While programming is typically the first exposure to computer science, it fails to excite many students and such courses have a high dropout rate [7]. Students often find the introduction to computer science unappealing and intimidating. As Stanford University's John Gardner stated, "Twenty years from now we will look back at education as it is practiced in most schools today and wonder that we could have tolerated anything so primitive [1]." According to Peter Denning, to students it looks like programming is the "make or break entrée into the field; there's no way in unless you can program [4]." Many previous attempts at a "new way" to teach computer science offer the same approach – programming as a major component and a required calculus prerequisite.

The traditional methods of learning include formal classroom, reading, working problems, and experimentation. The problem with this is that for many students, the preferred method of learning does not include reading text and doing written homework has predictable limitations. The students do not have any method for trying out things on their own and for looking for solutions to possible questions like "What will happen if I do this instead of this?"

To address the above problems, interactive learning modules (ILMs) are developed on various topics of computer science to help students learn in a fun and interactive way. The modules introduce computer science using experiential learning. Many students know

very little about computer science, and even after taking an introductory course, view computer science as “just programming.” The goal of the ILM¹ approach is to introduce intriguing problems and basic underlying concepts that computer scientists address, and allow students to experiment with tools built on those concepts in an interactive and fun environment.

While many ILMs have been created, little has been done to evaluate their usability or effectiveness. To get this feedback, each ILM has an associated, optional survey for students to fill out. In addition, a survey is provided in which teachers can describe their experience with the ILMs. To know students’ attitude towards computer science, a survey was conducted from the questions provided from [2]. Appendices A, B, and C contain the survey questions.

1. All of the ILMs are available on web at csilm.usu.edu

CHAPTER 2

METHODS

This chapter describes the methods used to collect the data, our first step for improving ILMs.

2.1 Student Survey

For assessment of the ILMs, surveys for two of the ILMs were conducted with Logan High School students in order to determine whether students found the ILMs enjoyable to use as well as educational.

Student surveys are effective in capturing student likes and dislikes; however, they are less able to determine if ILMs are effective in teaching a concept. It is not common for high school students to be asked, "Is this activity a good use of your time?" or "Did this activity help you to learn the material?" Our preliminary results indicate that high school students are more interested in the entertainment value of the ILM rather than whether it obtains its educational objective.

2.2 Teacher Survey

The basic research question is, "Are ILMs an effective teaching technique?" However, there are so many variables that this is hard to determine. Variables include:

1. Enthusiasm of teacher for the ILMs
2. Expertise of teacher in the subject area
3. Variation in time on task
4. Educational background of students

5. Student attitude
6. Student computer skills
7. Novelty of new approach.

Due to the inability to control the external variables and limited data points, our evaluation of effectiveness relies on teacher perception of effectiveness.

If the instructors like the ILMs, it is more likely that the students will be asked to use the ILMs. If the teacher is not convinced that interactive learning through ILMS is a good approach, it is not likely the students will be encouraged to use them. The surveys attempt to capture teacher willingness to use the ILMs in a classroom situation. Briscoe sites a situation wherein teachers did not use new techniques in their classroom, even though they indicated they were willing to do so [8]. Moreover, curriculum and teacher attitude affect student attitude as shown in attitudes of seniors being less variable than freshman [9]. A teacher is also a great source to describe the problems his/her students faced while working on the ILM.

2.3 Usability Testing

After seeking feedback from the students and an instructor that specializes in software testing, data was collected to get reviews about the usability of the ILMs. Five students who are computer science majors were also asked to use the ILMs and give their reviews.

CHAPTER 3

ILM DETAILS

Surveys were conducted on two different set of students using two different ILMs. The two ILMs that were used are called the Boolean Logic ILM and the Loops ILM. Both ILMs were designed by Russ Weeks, a computer science and math teacher at Logan High School, during a Research Experiences for Teachers program at the Computer Science Department at Utah State University. These two ILMs were chosen for evaluation because of access to students using the ILMs in the classroom. A high school student classroom is ideal for evaluation. In a college classroom, ILMs tend to be used differently. Because time is more closely monitored and because most college classrooms do not have individual computers, on a college campus ILMs are primarily used as teacher demonstration or as part of homework exercises. Since we wanted to observe the ILMs in use, a high school classroom (fit with computers) at Logan High was selected. Not only did students complete surveys, but students were observed by the instructor, the two creators of the ILMs, and the PI of the grant. Descriptions of the ILMs follow.

3.1 Boolean Logic ILM

The Boolean logic ILM was developed by Kyle Feuz, a Computer Science student at Utah State University and member of the CPATH team, as part of the CPATH grant from NSF. The ILM focuses on teaching the function of Boolean operators. The basic layout of the ILM is shown in Figure 1.



Figure 1. Boolean logic ILM.

On the bottom left, the user has options to select various properties of the shapes (for example: isRectangular, isRound, isStriped, isSpotted, isTall, isWide, hasRed,

hasGreen, hasBlue) and on the upper left side, the user can select from several Boolean operators to form an expression in the text field provided at the bottom of the screen. Clicking on the “Apply Expression” button causes the ILM to evaluate the Boolean expression and move the shapes that result in true to the selected side. In the “Let me Try” mode, the user is able to drag shapes from the selected to unselected side and verify the results. In this mode, the “Apply Expression” button changes to “Check Expression” which gives the user feedback as to whether his/her selection of shapes is correct or incorrect. The user can also choose the difficulty levels based on his/her knowledge or understanding of Boolean operators. In the basic mode, the user gets an option of forming Boolean expressions using only basic Boolean operators including “AND”, “OR”, and “NOT”. In the normal mode, the user gets additional options like “XOR” operator, “SET DIFFERENCE” operator and the ability to use parentheses to change the precedence of operators. At the advanced level, the user can use more advanced operators such as “NAND”, “NOR”, and “XNOR”. The user can control the number of shapes on which s/he wants to apply the Boolean expression by selecting a number between one and six from the drop down menu entitled “Num. of Shapes.”

3.2 Loops ILM

I developed the Loops ILM as part of the NSF CPATH grant. The ILM allows students to experiment with “*For loops*” by creating blocks and changing loop parameters to arrange the created blocks to form a quilt. The basic layout of the ILM is shown in Figure 2.

The user can control loop parameters and other properties, such as colors for border, background color, pattern type, colors of block, rotation of pattern to any degree, and block size. The effect of multiple loops can be combined using the “Add to existing project” option. Clicking on “View Project” executes the pattern-creating loop(s), as shown in Figure 3.



Figure 2. Loops ILM.

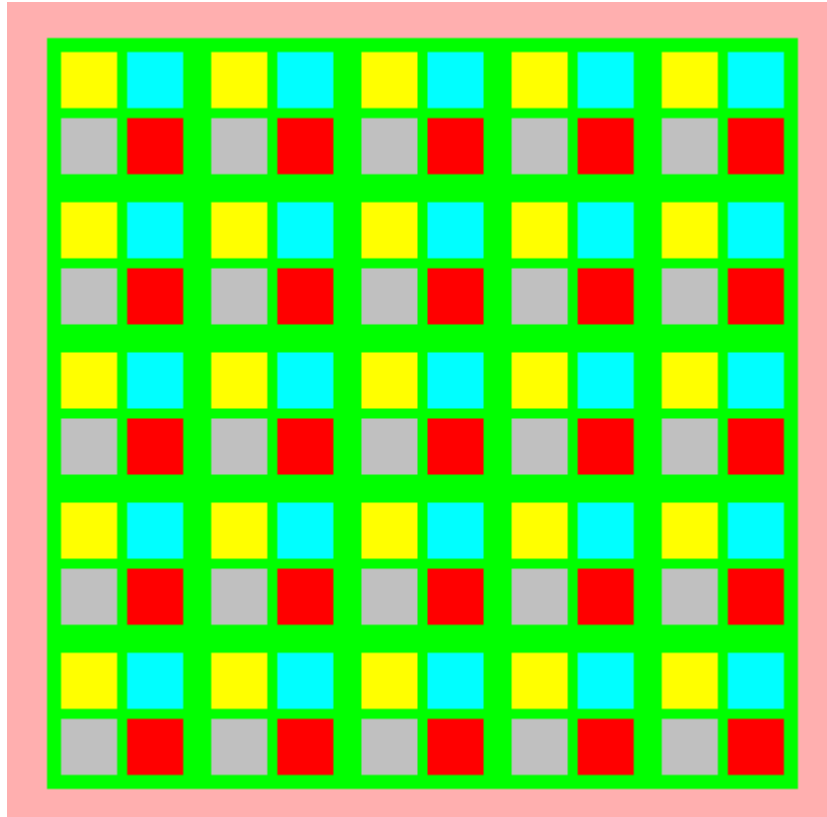


Figure 3. Output created from the loop in Figure 2.

The “Rotate block by angle” option allows the user to rotate the block s/he colored to the desired degree. Then, by clicking on the “View Project” button, the user can have the block printed on the quilt. The user can also adjust the block size to be printed using the “Block size (in Pixels)” option. The “Pseudo Code” button shows the pseudo code of all the “*For loops*” used to create the pattern. The user can also choose whether s/he wants to have a border on his/her quilt by checking/unchecking the “Use Border” button. One can also change the “Background color” and “Border Color” of the quilt by making an appropriate selection from the “Select a color below for” drop-down menu. The user can

choose a color from the twelve standard colors provided or can select the “More Colors” option for a greater variety of colors. Clicking on the “Sample Pattern” button causes another window to pop up containing several sample patterns for students to generate.

Appendices D and E contains instructions provided on the side bar of the Boolean logic ILM and the Loops ILM, respectively.

CHAPTER 4

SURVEY DETAILS

This chapter describes how the surveys were conducted.

4.1 First Session

The first session was conducted on the May 5, 2010 at Logan High School with a class of 18 students. The students were enrolled in the beginning programming class. The ILM used for this session was the Boolean logic ILM. Most students had some knowledge of Boolean logic and Boolean operators.

Initially, students were given a brief introduction on how to use the ILM along with an explanation of the various Boolean operators. While explaining the operators, students were quizzed on Boolean operators by being given directions such as “Stand up if you are blond **AND** tall” to see how well students could apply Boolean expressions in their normal life. Students were given ice-cream coupons for their cooperation in evaluation of the ILMs. The students were then asked to try the ILM on their own for the rest of the period. Before they started with the ILM, the students were informed about the survey at the end of the ILM to help us improve the ILMs. The survey was completely anonymous.

Out of 18 students, 14 filled out the survey. While some students enjoyed the ILM, some thought that it would have been much better if it were more visually appealing.

To test our hypothesis that many students do not attempt to read instructions, we asked the students, “Who prefers to learn by reading the instructions and who does not?”

Only 3 of 18 students indicated their standard method of learning involved first reading the instructions. We asked these students to read the instructions before starting the ILM, but told the others not to read the instructions. We observed that the students who indicated they did not generally read instructions were not tempted to read them, even when they did not understand something. In the survey, they complained that something was awkward or did not work, even though reading the instructions would have solved the problem.

4.2 Second Session

The second survey was conducted on May 25, 2010. Because of scheduling difficulties, the activity was conducted after school, and thus required voluntarily participation. The motivations for attending were pizza and extra credit points. Twelve students signed up for the activity. The arrival of the pizza constituted an unplanned test of the level of engagement of the ILM. Students who did not complete all the sample patterns were busy trying to generate the patterns and did not eat the pizza until they had finished, even when invited to begin eating. One difficulty in evaluation of the ILMs is to find a situation in which students are in the ideal situation to use the ILM: having the prerequisite explanation but desiring additional experience. This testing environment was not ideal in evaluating ILM teaching effectiveness, but was extremely useful in helping us to judge popularity and their ability to engage students. The first session with the Boolean Logic ILMs suggested several changes. Improvements included more shapes and more descriptors. These changes were made before the second evaluation. Currently, the Boolean logic ILM is depicted in Figure 4.

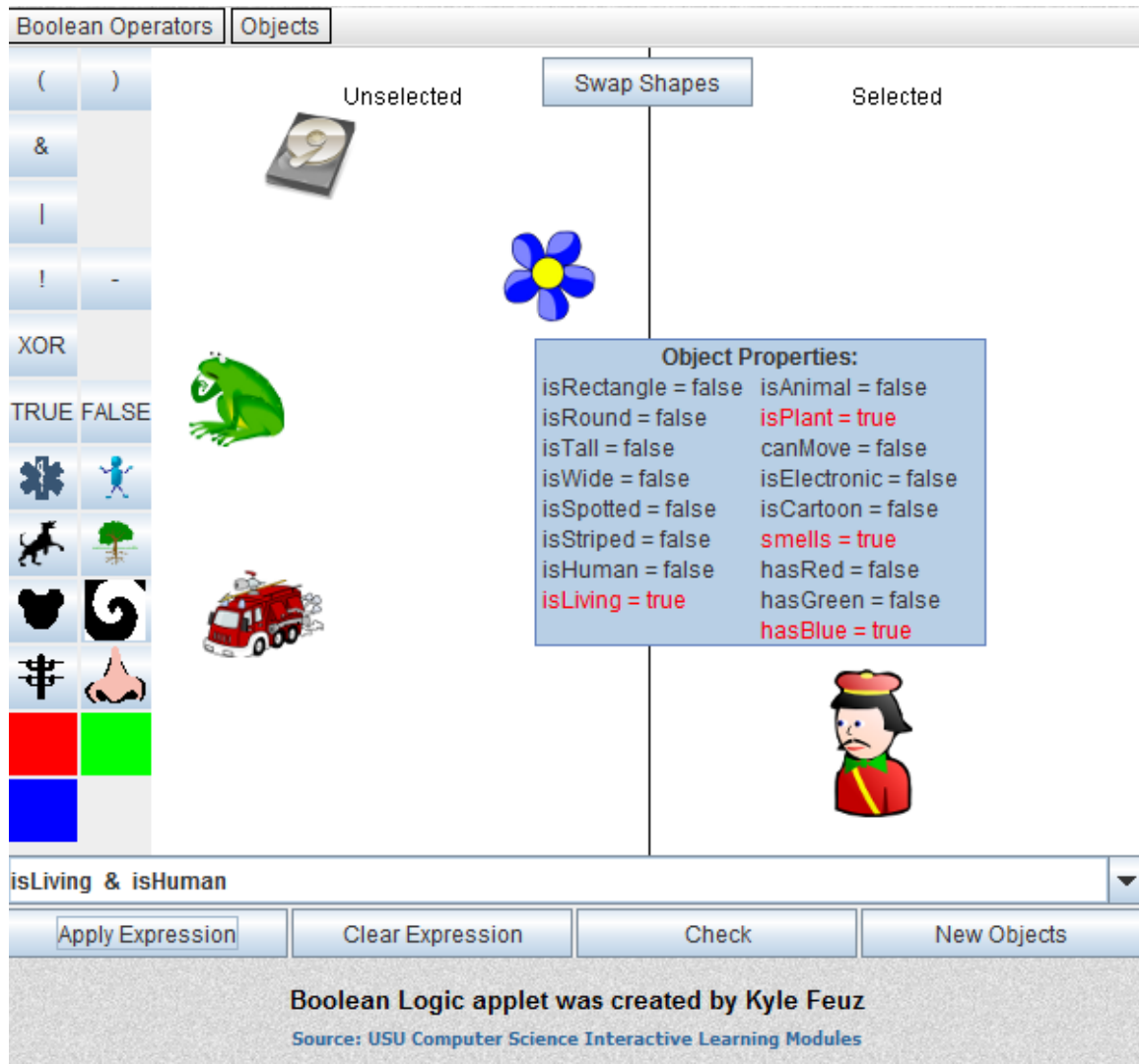


Figure 4. Improved Boolean logic ILM.

The new Boolean logic ILM includes more graphics and shapes as requested by several students on the first session. The “Let Me Try” mode is now the default mode, and instead of having the same button for “Apply Expression” and “Check Expression,” two

separate buttons are provided for each of them. The option for selecting the difficulty is now changed to “Boolean Operators” and has been moved on top of the ILM. The “Objects” button allows user to choose the number of Objects (between 1- 6) and type of object. The type of object can be either geometrical shapes or fun images. If a user selects the object type as images, new Boolean operands, such as “isLiving”, “isHuman”, “isAnimal”, “isPlant”, “isCartoon”, “canMove”, “isElectronic”, “smells” are provided.

We allowed students to choose between using the Boolean logic ILM and the Loops ILM. Megan Beavers, a technology teacher at Thomas Edison Charter School in North Logan, Utah, and member of the RET program, suggested that students are motivated by a challenge such as "See if you can produce X" rather than "Please follow the step by step instructions to produce X." Acting on this insight, sample patterns were added as an activity for students to generate. The various patterns were chosen to exercise a variety of features of the loops including rotation, increments, starting values, and even variable starting values (such as beginning with the row index). Figures 5 through 10 show the sample patterns used.

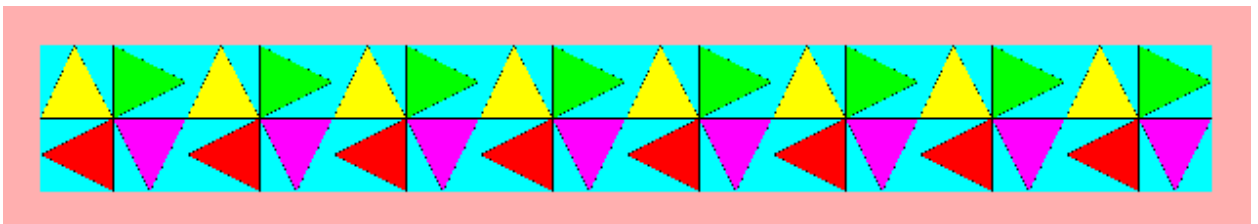


Figure 5. Loops ILM sample pattern 1.

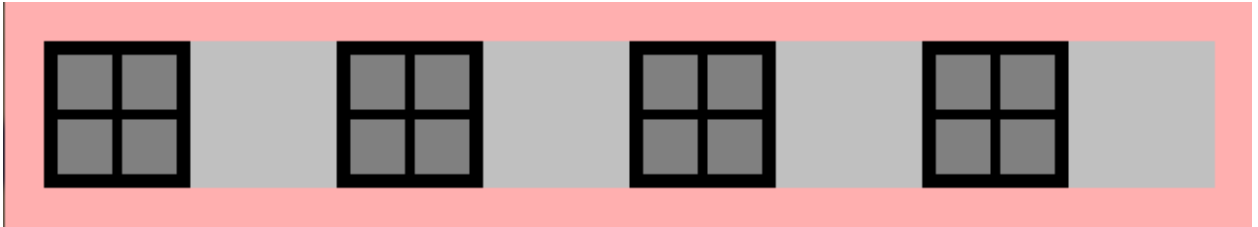


Figure 6. Loops ILM sample pattern 2.

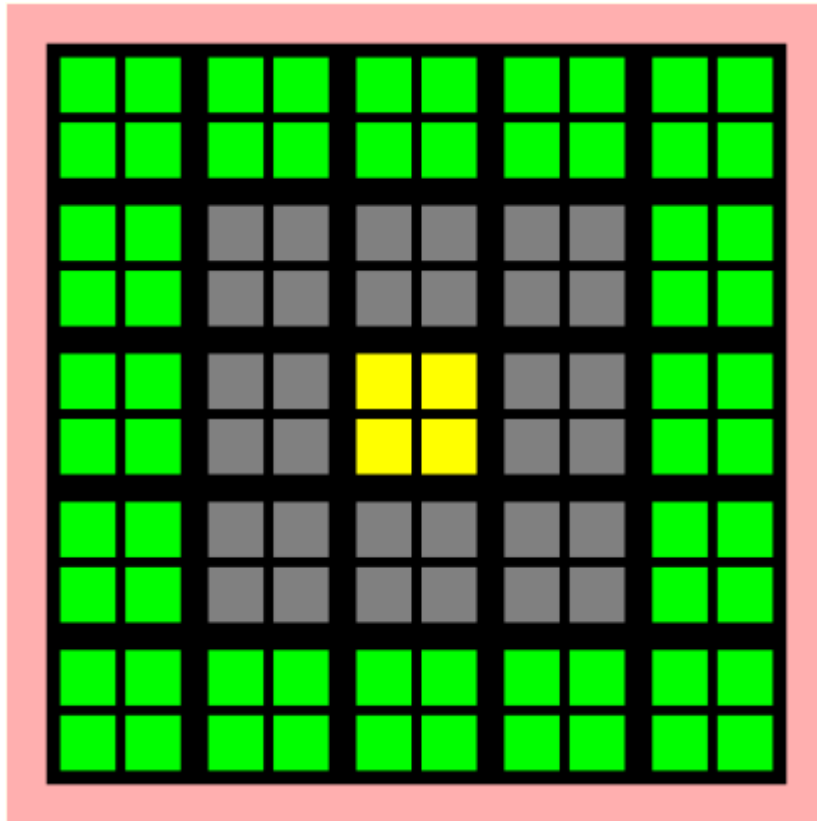


Figure 7. Loops ILM sample pattern 3.

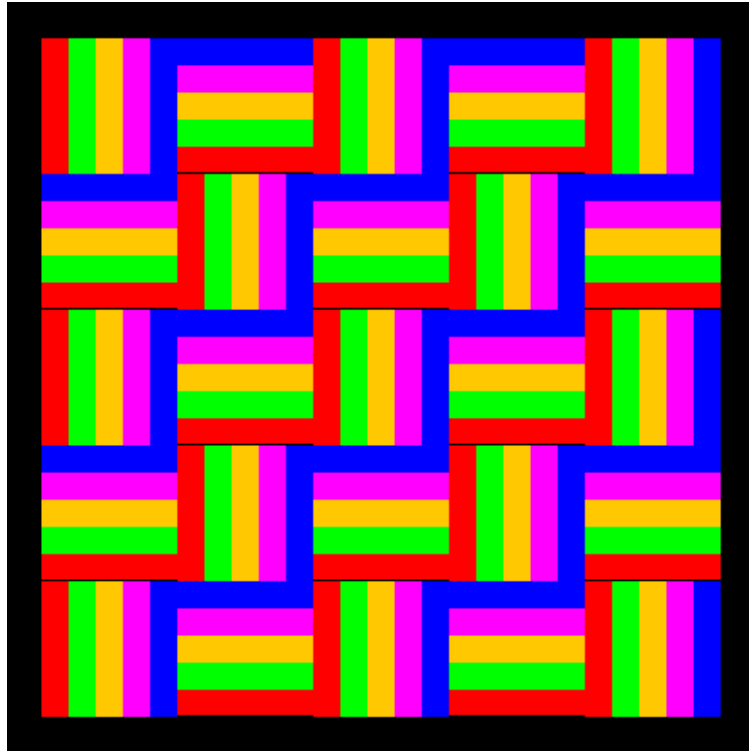


Figure 8. Loops ILM sample pattern 4.

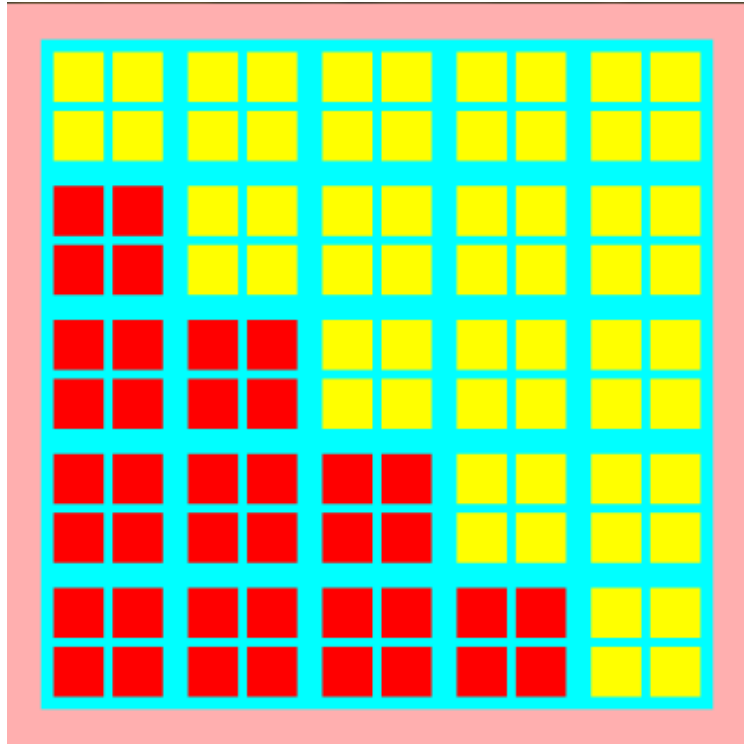


Figure 9. Loops ILM sample pattern 5.

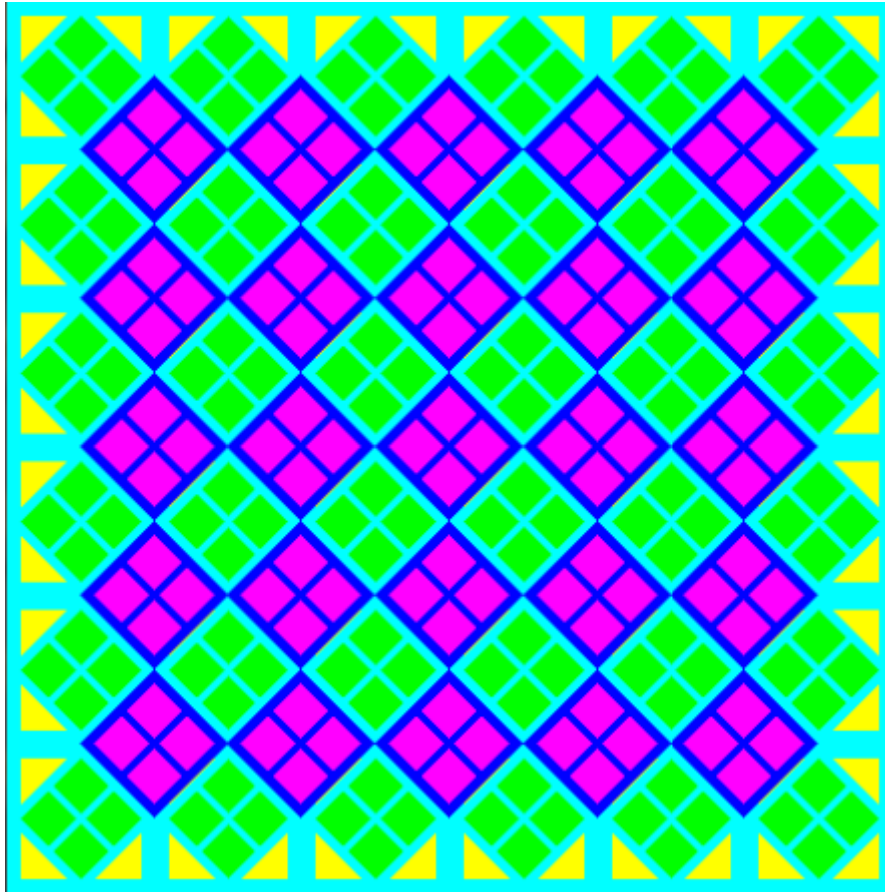


Figure 10. Loops ILM sample pattern 6.

To address students' tendency to ignore instructions, videos were prepared for each ILM. Each video is approximately 4 minutes long and gives basic information about the functioning of the ILM, but does not contain information motivating the topic.

In this session, initially, the students watched both the videos and then were free to try either or both ILMs. The students were given a sheet of paper for each ILM to direct their activities. One contained questions on Boolean logic involving simplifying the

expression, determining the output of an expression, and comparing two expressions to determine if they are logically equivalent. The other sheet was merely a check off list for the various sample patterns of the Loops ILM. Students had to get an instructor's signature after creating each sample pattern. There was no point value associated with producing a given pattern or any reward for progress. At the start, the students were almost equally distributed in the two groups of ILM users, but eventually nearly all the students started working on the Loops ILM. In the end, we received the survey response from eight students out of which one was for the Boolean ILM, six for the Loops ILM, and one student did not mention the ILM he used.

4.3 Third Session

Heersink and Moskal [2] state their findings for the reasons behind the decline of students' interest in computer science and information technology via an attitude survey. The attitude survey used in this research is an extension of the Heersink and Moskal survey.

The original survey used by the authors of [2] was used as designed, but a few questions on student accessibility to computers and student GPA were added. This survey is available at <http://csilm.usu.edu> under Computing Attitude Survey (Long). The survey used was based on the same five categories as those originally used by the authors of [2]. In this discussion, we replace professional category with a more precisely labeled "Stigma" category. The five categories for the survey are described in Table 1. Refer to Appendix C for the questions used in the survey.

Table 1. Five Main Categories Used in Formation of Attitude Survey.

Confidence Category	Students' confidence in their own ability to learn computing skills
Interest Category	Students' interest in computing
Gender Category	Students' concept of computing as a male field
Usefulness Category	Students' belief in usefulness of learning computing, &
Stigma Category	Students' belief about computing as a lonely field to work.

The motivation behind our study is to provide insight to the following questions:

1. What predicts whether a student will want to take more CS classes?
2. Do students believe that a computing career is appropriate for women?

4.4 Fourth Session

In order to test the usability of the ILMs, a few computer science graduate students were asked to use the ILMs and give their reviews. College students were chosen for this due to their perspective, which differs from that of high school students. For usability testing purposes, we chose the "Observation Approach" wherein the tester observes individual persons using the ILM either by taking a video or by making notes. The user is asked to say things aloud while s/he is using the product. The video seemed a great idea for observing various factors. A video was used for evaluating the ILM with two students, and the rest of the students were simply observed while using the ILMs.

CHAPTER 5

KEY FINDINGS

This chapter states the things learned from the surveys and some assumptions.

5.1 Students Do Not Read Instructions, and Video Seems to Work Well

In all, 22 surveys were collected on both the ILMs. On the first session survey, 14 out of 18 students filled out the survey and on the second session survey, eight out of twelve students filled out the survey. From observation and student's survey response, only four students out of twenty-two students said that they read the instructions before starting with the ILM. This clearly indicates that many students do not read instructions. Since students might feel uncomfortable navigating between pages if the instructions are given on a separate page from the one where the ILM is displayed, the instructions for the ILM are displayed on the right hand side pane of the ILM as depicted in Figure 11.

While having the instructions in the same view as the ILM is convenient, it is evidently not particularly effective. A reason for this could be "peer pressure." Our observations indicate that when a student sees neighboring peers progressing to a more active part of the activity, s/he quickly abandons the passive reading of instructions. On the first survey, four students out of fourteen mentioned that they did not understand the operators well, even though the instructions on the side bar explain all the operators.

Boolean Operators | **Objects**

Unselected | Swap Shapes | Selected

Instructions

[Click here to watch a demo](#)

1. A friend says: The opposite of "and" is "or". Is he/she right?
2. Simplify the following expression. Verify that the results are unchanged.
 $((\text{isSpotted} \ \& \ \text{isTall}) \ | \ (\text{isSpotted} \ \& \ \text{isTall}))$
3. Rewrite the following expression at least two different ways (by bringing the "!" inside the parentheses). Verify that the results are unchanged
 $!(\text{hasRed} \ \& \ \text{hasGreen})$

Operators:

() - inserts parentheses to control order of application of operators

& - inserts "&" at the cursor. Represents the boolean AND operator.

Boolean Logic applet was created by Kyle Feuz
 Source: USU Computer Science Interactive Learning Modules

Figure 11. Boolean logic ILM and its instruction on the right.

In our testing environment, the classroom is divided into two parts. One part has chairs arranged in rows facing a smart white board. The second part is a typical computer lab environment. Instructions and the video presentation were given in the classroom environment before moving to the lab environment. Thus, students were not able to start using the ILM until after the preliminary information was dispensed. While this situation is ideal, the same effect could be achieved by locking students out of using the computers during the presentation.

The video seemed to work quite well to quickly orient the students. One difference between printed instructions and the video is the organization. The video takes

a problem-oriented approach – taking the user from start to finish in solving a practical problem. The instructions take a functional approach, which describes every option. A second difference is that a video is more likely to be viewed in its entirety than are the instructions to be read. The ILMs are largely self-explanatory, which makes reading the instructions less compelling. Because of the reluctance to read instructions, it is important to provide tool tips on the ILM wherever possible. On the first survey, four students out of thirteen mentioned that they had problems understanding the Boolean operators and suggested including tool tips on the buttons (for Boolean operators and operands) for better understanding.

One of the comments from an instructor was that the demo video is too long to keep student interest in watching the video. When analyzing student responses with respect to her comment, it was found that two students complained about having difficulties in understanding “how to add loops over another” and “why a design flaw would result when adding a new loop over another” even though these two points were clearly mentioned in the video. However, one reason for this could be that the video told the students everything about the ILM before they had any experience, and it became hard for students to retain facts for which they had no immediate need. One solution to these problems could be to make both an introductory video and a video for the ILM that only covers more advanced features of the ILM. However, in a classroom environment, often individual computers do not have speakers, so having each student listen to the appropriate video as they needed additional instruction would not be possible.

Overall, the video works better than reading instructions. One student even watched the video after the demo was shown to all the students before he started working on the ILM.

5.2 Activities on the ILM Help Capture Students' Attention

In the first session, when students were asked to try things on their own using the Boolean logic ILM, it was observed that even though sufficient time was provided, most students had completed the ILM within fifteen minutes and were filling out the survey. By contrast, in the second session wherein both the Loops and Boolean ILMs were used, it was amazing to see students' interest in the Loops ILM. The activity of generating sample patterns on the Loops ILM turned out to be extremely engaging for students. Not only did it provide a way of learning "for loops" but also developed a sense of competition, although there was no reward for students who completed the exercise first. Generating prescribed patterns was engaging for students; even when the pizza was served, students did not get distracted by it and continued generating the patterns. Two students in the class that were unable to complete all the patterns were so engaged that even after many students left, they did not lose interest and were trying until the period ended and the computer automatically shut down. For this reason, they were unable to fill out the survey. Although there is no measure as to why students liked the Loops ILM over the Boolean logic ILM, we state several possible reasons for the difference in appeal.

1. The task of creating sample patterns was more challenging to the students than simply experimenting on their own. The Boolean logic worksheet was more like homework. Six students completed the survey for the Loops ILM, and each of

them mentioned at least once in their survey that they liked the activity of creating patterns. The results of the Loops ILM were additive; students could see that they were getting closer and closer to their goal.

2. In a group setting, students tend to be affected by what others are doing. Watching neighboring student generate patterns created interest in the student.
3. The Loops ILM had more play value. It was very creative and full of colors. In the present age, wherein student use the computer for gaming, the Loops ILM proved to be more game-like as compared to the Boolean logic ILM. Students were able to create something even if they were not able to produce a correct pattern.

Beyond than the above stated points, we created a list of differences between the two ILMs that might have affected the students to choose the Loops ILM over the Boolean logic ILM. The differences are categorized for each ILM under subheadings.

LOOPS ILM

1. Goal directed

The Loops ILM activity was goal directed.

2. Active feedback

The feedback was active, involving students in the feedback. Students found the difference between the pattern they generated and the pattern they were asked to develop. They had to decide where they were wrong and how to correct it.

3. Specific feedback

Since students compared their result and desired output visually, they were able to see even the subtle differences. For example, if the border color or rotation was improper, they were able to note it. There was a tendency to want it to be perfect, rather than say, "Close enough."

4. Problem conjures up ideas for the solution

When there was a problem, the problem was often stated using the language which indicated the solution. A student would say, "I don't have the right number of columns" or "I haven't rotated it enough," rather than, "Gee, it is wrong and I have no idea why."

5. Immediate feedback involving teacher approval

The immediate feedback by way of visual representation of the output saved time, but the fact that the instructor had to check off their completed solution allowed for praise from the teacher.

6. Controlled progression

The patterns were arranged in increasing order of difficulty. Starting with simple patterns helped students to build confidence to help them in moving to more complex patterns.

7. Solution encouraging cooperation

Students were able to help other students once they completed all the patterns. After finishing the patterns, some students were still engaged in creating patterns on their own, while still others helped classmates.

1. Not goal directed

The activity was not goal directed. We asked students to learn using the ILM, but the problems did not work together to accomplish sub-goals. There was no feeling of accomplishment.

2. Partially active feedback

Students were able to simplify a complex expression by checking that the results generated by the two expressions were the same or not. However, in other cases, this did not hold true. For example, on questions like “what is the type,” there was no active feedback.

3. No Specific feedback

The ILM indicated if the answer was correct or incorrect, but it gave no reason why the answer was incorrect. For the correct answer, a message as shown in Figure 12 popped up. For an incorrect answer, a message as shown in Figure 13 popped up.

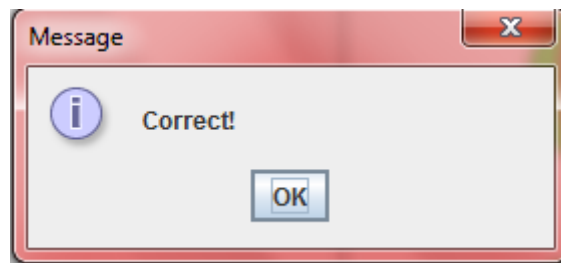


Figure 12. Boolean logic ILM "Correct" message.

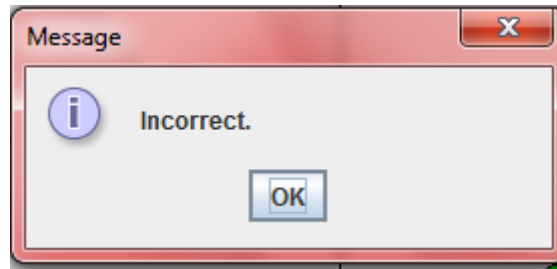


Figure 13. Boolean logic ILM "Incorrect" message.

4. Problem did not conjure up ideas for the solution

While the students knew that their answers were incorrect, that knowledge did not give them any indication of how to solve the problem. They could, however, click on "Apply Expression" to see what the correct answer should have been, but even then it is not always clear why their selection was wrong.

5. Partially immediate feedback

Although the students were prompted with a message indicating an incorrect answer, they often had to wait for their instructor to tell them why it was incorrect.

6. Controlled progression

Progression was partially controlled as students could select "Basic", "Normal", or "Advanced" Boolean operators, but most students appeared to jump quickly to the "Advanced" mode.

7. Solution encouraged cooperation

The solution did not encourage cooperation. Since the shapes were randomly generated for each student, problems were different between students.

5.3 Students Learn More if They Spend More Time with an ILM

The more a student likes an ILM, the more time he/she will spend with it. The National Education Commission on Time and Learning discovered that time is strongly correlated to learning. They conclude that we deceive ourselves when we expect our students to learn as much as their foreign counterparts in only half the time [13]. Increased time increases the ability to learn via the ILM. The Expanded Learning Time initiative of Massachusetts is more than just adding minutes to the day. Learning is integrated with instructional time, individual tutoring, homework time, and enrichment opportunities. In Massachusetts, some schools added 300 more hours per year to the curriculum. This resulted in improvement trends in all tested subjects. In English language arts with the increased time on task, students gained in proficiency at twice the rate of the rest of the state. In mathematics, the gains were nearly five times the state average gain [14]. In the second session, of eleven students that turned in the check off sheet for Loops ILM, three students were able to generate all six sample patterns, two students were able to complete the first five sample patterns, and the remaining five students completed the first four sample patterns. There was only one student who did not complete any of the patterns.

5.4 Students Responses on the Survey Depends on Their Achievement of the Task

On analyzing student responses for the number of patterns they were able to generate, it was found that students who completed most or all of the patterns on the Loops ILM tended to give a positive response on the survey as compared to the those who were able to generate few or no correct solutions. One interesting case is a student that gave negative response for all the questions on the survey. This student first tried the Boolean logic ILM for few minutes, gave up, and then started with the Loops ILM. On asking him if he needed any help, his response was that he does not know anything about either of the topics covered in the ILMs. However, even though he did not know anything, he liked to generate the patterns. His behavior indicates that having several possible tasks on the ILM keeps students engaged as compared to having them try things on their own. Students who completed all the patterns desired more sample patterns, while others mentioned their enjoyment of generating the patterns.

Achievement is frequently associated with positive feelings as is seen in cases wherein the students with higher expected grades tend to give more positive responses on student evaluation of teaching [10, 11]. Krautmann and Sander state that by lowering their teaching standards, faculty are able to increase teacher evaluation scores [10]. McPherson (2006) agrees [11]. From data collected in both upper and lower division economics courses, higher expected grades are correlated to significantly better student evaluation of teaching [11]. Nowell [12] states that the relationship between student

evaluation of teaching and expected grades by the students is a strong one. This research points out several interesting correlations:

1. Full time faculty receive higher evaluations than part time faculty.
2. Class size is inversely related to teacher evaluations.
3. Economics classes that are more quantitative score worse.
4. Age of student is positively correlated to higher evaluations.
5. Higher expected grades of students are correlated with higher teacher evaluation score.

5.5 Different Levels of Students Have Different Perspectives

From the data collected from high school students and computer science graduate students, it is observed that experienced students expect to have complex exercises on the ILMs. On the Loops ILM, high school students requested more sample patterns. On the Boolean logic ILM, however, it was not mentioned what kind of exercises students were expecting, but a few students did mention that they wanted the ILM to be more compelling. Novice students look for the ILMs' visual appearance and play value. From the responses of the high school students from the first session, it is observed that some students were expecting more interesting and difficult activities on the ILM. Some learned only about simple Boolean operators and mentioned their concerns about the shapes and graphics of the ILM. Others learned different Boolean operators without any complaint about graphics.

When computer science graduate students were using the ILM, it was observed that they were less interested in the graphical representation. Although they liked the

shapes and colorfulness of the Loops ILM and use of images in the Boolean logic ILM, they were most concerned about what they learned.

While the high school students were excited to generate patterns on the Loops ILM, none of the computer science graduate students willingly tried to generate sample patterns even when encouraged to do so. One reason for this could be that graduate students were using the ILM individually so there was no competition to generate patterns. Another reason could also be some reluctance to appear to fail in the task as an observer was watching each student directly, rather than having one observer for a handful of students. Most likely the reason is that they already knew what loops should be applied to get the desired pattern.

Overall, high school students were happy using the ILMs and enjoyed the experience. On the contrary, graduate students seemed disinterested in the content the ILM and concentrated mainly upon the GUI design. This is to be expected as the ILMs were not designed for them. However, their observations were useful and helped to improve both of the ILMs and also provided some suggestions for other ILMs.

5.6 Video-taping Students May Not Be Practical

A video-taping student while they used the ILM was attempted so that the video could be used for future analysis by the observer and others. The plan was implemented with two graduate students, but the recording made these students nervous and self-conscious in their actions. Some even refused to participate if a recording would be made. In addition, the extra time required to view the video tape may not be worth the small additional gain.

5.7 Know Your Goals

It is hard to satisfy everybody. One must learn to listen to the various suggestions given by participants while not losing sight of the goal. Several suggestions were received on both the ILMs. Some students wanted more play-value as compared to learning while others wanted to have more complex activities in order to learn more. Teachers have asked for a system that provides assessment and is integrated with grade book tools. Some have envisioned the system like a huge game with levels and various worlds to explore. Others have hoped the system could be a teacher replacement. As a developer, after going through a series of revisions and planned improvements to the ILMs, it is realized that the developer must decide what functions s/he wants in the ILMs as well as being sensitive to suggestions.

CHAPTER 6

CORRELATING SURVEY QUESTIONS

This chapter describes correlations between questions on the Attitude Survey and ILM Survey to analyze what drives a student to answer on a question based on his/her responses on other questions.

6.1 Attitude Survey

In order to determine students' attitudes towards computing, an attitude survey was conducted with Logan High School students to analyze what they think about computer science. Students were from technology courses or from a summer enrichment course entitled "When Math and Art Collide." The details of the survey are given in Section 4.3.

Student willingness to take computing classes is largely reflected in how they replied to all types of survey questions. For all positively phrased questions in each category (confidence, interest, stigma and career), with a sample size of 75 students, there is a positive correlation with student views about taking additional computing classes. Tables 2 through 6 depict the correlation of taking additional computer science classes with all positively phrased questions on confidence, interest, stigma and career questions, respectively. In addition, average responses for each question are included. All reported correlations in this section have a significance of at least 2.5%. An * indicates correlations are significant at the 1% level, while ** indicates significance at the .05% (.0005) level. Appendix B contains the list of all questions used for finding the correlations and its values.

Table 2 depicts a positive correlation between the confidence of a student in computing and his/her willingness to take more computing courses. This indicates that if a student is more confident with using and learning computing concepts, then s/he is more likely to take additional computing courses and vice-versa. On average, most student responses indicated they were confident about using and learning computing concepts.

Table 2. Correlation of "I would voluntarily take additional CS courses if I were given the opportunity" with Positively Phrased Confidence Category Questions.

	Correlation	Average
I can learn to understand computing concepts.	0.26*	3.99 (Agree)
I am comfortable with learning computing concepts	0.23	3.91 (Agree)
I am confident that I can solve problems by using computer applications.	0.34*	3.74 (Agree)
I can make the computer do what I want it to do.	0.50**	3.46 (Neither agree nor disagree)

Table 3 also depicts positive correlations between students' interest in computing and their willingness to take more computing courses. The correlation value is very high on these questions; however, the average student neither agreed nor disagreed with the statements that computer science is interesting, computer science concepts will be required for future career, or the challenge of solving problems appeals to them. Thus,

there is a need to increase student interest in computer science because students with a higher interest are more likely to take computer science classes.

Table 3. Correlation of "I would voluntarily take additional CS courses if I were given the opportunity" with Positively Phrased Interest Category Questions.

	Correlation	Average
I think computer science is interesting	0.66**	3.36 (Neither agree nor disagree)
I hope that my future career will require the use of computer science concepts.	0.72**	3.2 (Neither agree nor disagree)
I like to use computer science to solve problems.	0.58**	3.24 (Neither agree nor disagree)
The challenge of solving problems using computer science appeals to me.	0.72**	3.34 (Neither agree nor disagree)
Computers can allow me to do more interesting and imaginative work.	0.34*	3.86 (Agree)

Table 4. Correlation of "I would voluntarily take additional CS courses if I were given the opportunity" with Positively Phrased Stigma Category Questions.

	Correlation	Average
In the real world, computer scientists spend a lot of time working with others	0.38**	3.23 (Neither agree nor disagree)
A student who performs well in computer science is likely to have a life outside of computers.	0.24	3.01 (Neither agree nor disagree)

Table 4 illustrates a positive correlation between students' stereotypical thinking about computer science and its effect on taking further computing classes. When a student thinks that computer scientists spend a lot of time working with others, s/he is more likely to take more computing classes. When s/he thinks that a computer science student most likely has a life outside of computers, s/he also tends to be willing to take more computer science classes and vice-versa.

Table 5 depicts the correlation between students' thinking about "A student who performs well in computer science is likely to have a life outside computers." It shows that if a student thinks "A student who performs well in computer science is likely to have a life outside computers," s/he also feels they can make the computers do what they want it to do, thinks computer science is interesting, likes to use computer science for solving problems, and thinks computing to be useful for his/her future career and vice-versa. However, on average, apart from the career questions, students neither agreed nor disagreed with the above mentioned questions. Moreover, the perception of having a life outside of computers had no negative correlation with any of the questions on the survey.

On average, on all stigma category questions, students neither agreed nor disagreed. As observed before, students' decisions about taking more computer science classes have a positive correlation with all stigma category questions.

Table 5. Correlation of "A student who performs well in CS is likely to have a life outside of computers" with Interest, Confidence and Career Questions.

	Correlation	Average
I can make the computer do what I want it to do.	0.31*	3.46 (Neither agree nor disagree)
I think computer science is interesting	0.23	3.36 (Neither agree nor disagree)
I hope that my future career will require the use of computer science concepts.	0.27*	3.20 (Neither agree nor disagree)
I like to use computer science to solve problems.	0.27*	3.24 (Neither agree nor disagree)
In the real world, computer scientists spend a lot of time working with others.	0.39**	3.23 (Neither agree nor disagree)
I expect that learning to use computing skills will help me achieve my career goals.	0.21	3.94 (Agree)
Developing computing skills will be important to my career goals.	0.25	3.83 (Agree)

Table 6. Correlation of "I would voluntarily take additional computer science courses if I were given the opportunity" with Positively Phrased Career Category Questions.

	Correlation	Average
Knowledge of computing will allow me to secure a good job.	0.21	4.05 (Agree)
I expect that learning to use computing skills will help me achieve my career goals.	0.46**	3.94 (Agree)
Developing computing skills will be important to my career goals.	0.48**	3.83 (Agree)

Table 6 depicts a positive correlation with career-based questions. On average, students agreed that developing computer skills is important for their future careers. So, it can be said that students considering computer science as their career option is associated with taking computing classes.

It is also observed that using computers in school work and believing that computers help in organizing one's work better do not have any significant correlation to taking computing courses. Only a correlation of 0.12 and 0.16 is observed on questions "I often use computers in school work" and "Computers help me to organize my work better" with "I would voluntarily take additional computer science courses if I were given the opportunity." Students generally agreed that they often use computers in daily and school life. Perhaps computer usage is just too commonplace to be correlated to other factors.

Students believe that both men and women can learn computer science and excel in careers requiring computer science. Table 7 depicts students' average responses on gender-based questions.

Table 7. Students' Average Responses on Gender Category Questions.

Question	Average
Men produce higher quality work in computing than women	1.88 (Disagree)
Women produce the same quality work in computing as men.	4.08 (Agree)
I doubt that a woman could excel in computing courses.	1.75 (Disagree)
Men and women can both excel in computing courses.	4.36 (Agree)
Men are more likely to excel in careers that involve computing than women are.	1.96 (Disagree)
Women and men can both excel in careers that involve computing	4.28 (Agree)
Men and women are equally capable of solving computing problems	4.34 (Agree)
It is not appropriate for women to study computing	1.71 (Disagree)
Computing is an appropriate subject for both men and women to study.	4.23 (Agree)

6.2 ILM Survey

On the ILM surveys, to find similarity between the two groups of students and analyzing the ILMs, a correlation was calculated on each survey for each question with every other question. Seven students responded for the Loops ILM and fifteen students for the Boolean Logic ILM. Out of twenty questions, ten questions were multiple choice question and others were descriptive questions describing student positive reaction towards the ILM and problems they faced. For the ten multiple choice question, some responses were coded on scale of two and others were on scale on five. Response “Strongly agree” and “Extremely enjoyable” were coded to numeric value “5”, “Agree” and “Somewhat enjoyable” was coded to “4” and so on. Response “Yes” was coded to “2” and “No” to “1”. Appendix A contains a list of all questions used for finding correlation to analyze student general perception. With 22 participants, a correlation of .36 indicates statistical significance at the 5% level. A correlation of .49 indicates correlations are significant at the 1% level, while .65 indicates significance at the .05% (.0005) level. Described below are some interesting observations.

6.2.1. Learning from the ILM and Its Usefulness Depends on Prior Knowledge about the Topic

Table 8 shows the correlation between several questions with respect to “I found the activity useful in learning the material”

Table 8. Correlation with Question "I found the activity useful in learning the material".

Correlation between usefulness (5 is strongly agree)	I found the activity easy to use	How would you rate your experience with this ILM?	How well did the activity help you learn the material?	I felt experimenting with the activity was a good use of my time?	Before using this ILM did you have any prior knowledge of the topic?
Loops ILM Responses	-0.06	-0.12	0.60	0.48	0.42
Average responses from Loops	2.43 (Disagree)	4.29 (Agree)	4.14 (Somewhat enjoyable)	3.50 (Agree)	1.71 (Yes)
Boolean ILM Responses	-0.27	0.23	0.37	0.40	0.33
Average Responses from Boolean	2.47 (Disagree)	3.07 (Neither agree nor disagree)	2.87 (Not enjoyable or frustrating)	3 (Neither agree nor disagree)	1.79 (Yes)

From the correlation between questions on the ILM survey, there is a positive correlation between finding an activity useful in learning the material with how well the

activity helps in learning the material, students experience with the ILM and student thought about ILM being a good use of their time. This indicates that if students already has prior knowledge about a topic they are in a better state to decide if the ILM is of any use or not. Without any prior knowledge, a student might not understand what the ILM is trying to teach. Hence the correlation also directs us to first give some introduction about the topic and then ask students to use to ILMs to better understand the topic visually. However, some students using both the ILMs did not find it easy to use and ease of use has a negative correlation with finding the ILM useful in learning the material.

6.2.2. Facing technical difficulties and reading instructions may or may not determine ease of use of the ILM.

Table 9 shows the correlations that were calculated with respect to “I found the activity easy to use”

Table 9. Correlation of "I found the activity easy to use" with Other Questions.

Correlation with “I found the activity easy to use”	Did you have any technical difficulties?	Did you read the instructions before starting with the ILM?	Before using this ILM did you have any prior knowledge of the topic?	I found the activity useful in learning the material.
Loops ILM responses	0.42	0.35	-0.09	-0.06
Boolean Logic responses	-0.30	-0.25	0.25	-0.27

Since the ILM correlation values are opposite, it is hard to draw a generalized conclusion. Both ILMs have small negative correlation with finding the activity easy to use with thinking the activity being helpful in learning the material meaning that if a student thought the activity is easy to use then he/she did not find it helpful in learning the material. On both the groups, on average students “Neither Agree nor disagree” that the activity was useful in learning the material. One reason can be that the students did not use the ILMs much and hence did not discover all the options on the ILM and that’s why they found them to easy to use but not helpful in learning the material.

On Loops ILM, there was a negative correlation between the activity being easy to use with reading instructions, having prior knowledge and thinking the ILN being useful in learning the material.

A negative correlation is found on Boolean Logic ILM between “finding the ILM easy to use” and “reading instructions”. A possible explanation is that if students did not read the instructions on the Boolean Logic ILM, they used a subset of the operators which were easy to use, but if they read the instructions, they learned about a wide variety of unfamiliar operators which increased the difficulty. Appendix D and E contains the instructions used for both the ILMs. From the correlation value, it can be said that, on the Loops ILM, if students did not have any technical difficulty or read the instructions or have some prior knowledge about “for” loops, then they found the activity easy to use. However, as stated in previous observation, learning from the ILM does not show any significance relationship with its ease.

6.3 Teacher Survey

From the teacher survey, it was observed that the teachers were happy using the ILMs. Some teachers also mentioned that the ILM helped students clarify their logic about the topic. They also planned to use the ILMs in future classes. One teacher mentioned that he will be using a different version ILM to evaluate students' understanding about the topic. In general, all teachers liked the use of ILM in their classes. Teacher approval and motivation for students to use the ILMs helps achieving the project goals.

Table 10 shows the correlation between teacher responses for “I found the activity easy to use” with “Did you have any technical difficulties?” and “Before using this ILM, did students have any prior knowledge of the topic?”

Table 10. Correlation of “ILM easy to use” with “facing technical difficulties”

	With “Technical difficulties” “2” for Yes	
	Correlation	Average
Ease of Use	-0.41	1.55

From Table 10 is it observed that there is a negative correlation between finding an ILM easy to use with facing technical difficulties. On average, teachers “Agree” that the ILMs were easy to use.

In general, teachers liked the use of ILM in their class and plan to use more ILMs in their class. Teacher approval and motivation for students to use the ILMs helps achieving the project goals.

CHAPTER 7

CONCLUSION AND FUTURE WORK

Evaluation of interactive learning modules is necessary and important in order to meet the goals of providing educational tools in an engaging and interactive way. The contributions of this project are as follows: laid the foundation for future ILM developers, developed surveys to analyze results, and analyzed student attitudes towards computing.

Students felt that using ILMs was a good use of their time. Being easy to use did not correlate with being useful. We learned that students do not always read instructions so watching a video concerning ILM usage and appropriate teacher introduction are important.

Teachers were happy using the ILMs. They felt that the ILM helped students clarify their logic about the topic. They planned to use the ILMs in future classes.

Belief in common computer scientist stereotypes, such as working in isolation or having no life outside of computers, are still prevalent but not generally held true. Students rejected insinuations that computer scientists should be male. Taking future computer science classes is linked to seeing the computer as vital to their future career and to enjoying the challenge of computer science. It is also observed that using computers in school work and believing that computers help in organizing one's work better do not have any significant correlation to taking computing courses.

Use of the attitude survey helped us to redesign the attitude survey. For the next iteration of experiments, we have added fill in the blank questions about the student's future plans for their career, ways the students currently use computers, and computer

classes taken. It is also observed that a positively and a negatively worded question for the same topic are not needed to validate student responses, and cause the survey length to be prohibitive. Many of the questions are so closely correlated that having a positive and negative version of the same question is unnecessary. We include either a positive or negative version of each question, but not both. The gender bias questions were too plentiful to be helpful and were soundly rejected. We retained only a few of these questions. This new survey will need to be validated.

It is informally observed that attitude towards computing is correlated to students' attitude about using interactive learning modules. Future research will attempt to measure those factors.

We are also curious about whether a two-week intensive computer experience would have a positive effect on attitudes toward computing. We are currently conducting before and after surveys of students in the enrichment program, "When Math and Art Collide," to gather that information.

Finally, while students seem to have a strong belief that computing is a field for both men and women, the inclusion of gender as part of the attitude survey would allow us to see if gender plays a role in the strength of that belief.

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APPENDICES

Appendix A. ILM and Teacher Survey Questions

The ILM survey is provided at the end of all ILMs on csilm.usu.edu. The survey is optionally filled by the students using the ILMs. A few questions on the survey are to get student information like their school, class rank and gender, and other questions are based on reaction to the ILM. On the ILM based questions, some questions were descriptive while others were selective based on Likert scale with options such as

1. “Strongly agree”, “Agree”, “Neither agree nor disagree”, “Disagree” and “Strongly disagree”
2. “Extremely enjoyable”, “Somewhat enjoyable”, “Not enjoyable or frustrating”, “Somewhat frustrating” and “Extremely frustrating”.

For calculating correlation on student responses following questions were used from the survey.

Q1. Class Rank

Q2. Gender (“1” for Male and “2” for Female)

Q3. I found the activity useful in learning the material. (“5” for Strongly Agree)

Q4. I found the activity easy to use. (“5” for Strongly Agree)

Q5. How well did the activity help you learn the material? (“5” for Extremely Enjoyable)

Q6. How would you rate your experience with this ILM? (“5” for Extremely Enjoyable)

Q7. I felt experimenting with the activity was a good use of my time? (“5” for Strongly Agree)

Q8. Did you read the instructions before starting with the ILM? (“1” for No, “2” for Yes)

Q9. Did you have any technical difficulties? (“1” for No, “2” for Yes)

Q10. Before using this ILM did you have any prior knowledge of the topic? If 1, please clarify your previous knowledge. (“1” for No, “2” for Yes)

Apart from the above mentioned questions the Student survey also had other questions that required descriptive answers. The remaining questions are as follows:

Q11. Of the following activities, rank each activity in terms of the method you would like most to use to learn the material. First choice represents your most desirable method of learning, while Fifth choice represents your least desirable method of learning.

Table 11. Student Survey Question on Choosing Most Desired Learning Method.

	1 st Choice	2 nd Choice	3 rd Choice	4 th Choice	5 th Choice
Reading text					
Formal lecture by instructor					
Informal lecture by teaching assistant					
Doing written Homework					
Using Interactive Learning Modules					

Q12. Was there something you liked about this activity? If so, what did you like about this activity?

Q13. Was there something you disliked about this activity? If so, what did you dislike about this activity?

Q14. What suggestions do you have for improving the activity?

Q15. What made this activity interesting or not interesting?

Q16. What, if anything, made this activity frustrating?

Q17. What did you learn in today's activity that you had not understood before?

The complete survey can also be found at csilm.usu.edu under Student Survey.

Table 12 and 13 shows the correlation between first ten for Loops ILM and Boolean Logic ILM, respectively. Value in green represents positive statistically significant at 5% level correlation and values in red represents negative correlation.

Table 12. Correlation Between Survey Questions Based on Loops ILM responses.

	Q1.	Q2.	Q3.	Q4.	Q5.	Q6.	Q7.	Q8.	Q9.	Q10.
Q1.	1	N/A	-0.42	0.09	-0.08	-0.26	0.18	0.26	-0.55	-1
Q2.	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Q3.	-0.42	N/A	1	-0.06	0.6	-0.12	0.48	-0.46	0.35	0.42
Q4.	0.09	N/A	-0.06	1	-0.62	-0.35	-0.66	0.35	0.42	-0.09
Q5.	-0.08	N/A	0.6	-0.62	1	0.13	0.46	-0.31	-0.11	0.08
Q6.	-0.26	N/A	-0.12	-0.35	0.13	1	-0.1	0.17	0.06	0.26
Q7.	0.18	N/A	0.48	-0.66	0.46	-0.1	1	-0.53	-0.4	-0.18
Q8.	0.26	N/A	-0.46	0.35	-0.31	0.17	-0.53	1	-0.47	-0.26
Q9.	-0.55	N/A	0.35	0.42	-0.11	0.06	-0.4	-0.47	1	0.55
Q10.	-1	N/A	0.42	-0.09	0.08	0.26	-0.18	-0.26	0.55	1

Table 13. Correlation Between Survey Questions Based on Boolean logic ILM responses.

	Q1.	Q2.	Q3.	Q4.	Q5.	Q6.	Q.7	Q8.	Q9.	Q10.
Q1.	1	0.33	-0.26	-0.03	0.06	0.3	0.24	-0.08	-0.23	-0.08
Q2.	0.33	1	-0.11	0.09	-0.05	-0.04	0	-0.44	-0.05	0.33
Q3.	-0.26	-0.11	1	-0.27	0.37	0.23	0.4	-0.44	0.3	0.33
Q4.	-0.03	0.09	-0.27	1	-0.13	-0.26	-0.4	-0.25	-0.3	0.25
Q5.	0.06	-0.05	0.37	-0.13	1	0.7	0.52	-0.04	-0.42	-0.04
Q6.	0.3	-0.04	0.23	-0.26	0.7	1	0.85	0.07	-0.36	-0.4
Q7.	0.24	0	0.4	-0.4	0.52	0.85	1	0	-0.26	-0.15
Q8.	-0.08	-0.44	-0.44	-0.25	-0.04	0.07	0	1	-0.06	-0.27
Q9.	-0.23	-0.05	0.3	-0.3	-0.42	-0.36	-0.26	-0.06	1	-0.06
Q10.	-0.08	0.33	0.33	0.25	-0.04	-0.4	-0.15	-0.27	-0.06	1

The [Teacher Survey](#) on csilm.usu.edu is provided for teachers using the ILM to give their reviews about the ILMs they use in class. Some questions are selective questions based on the same Likert scale as used for the Student survey and some questions are descriptive. Following questions are used for determining the correlation between questions based on teachers' responses.

Q1. I found the activity useful in helping students to learn the material.

Q2. I plan to use the ILM again as a teaching technique.

Q3. The activity is easy to use

Q4. How would you rate student experience with this ILM?

Q5. I felt that the activity was a good use of student time.

Q6. Did you have any technical difficulties?

Q7. Before using this ILM, did students have any prior knowledge of the topic? If yes, please clarify the previous knowledge.

Apart from the above mentioned questions, questions 11 – 17 on Student survey are also on the Teacher Survey with following additional questions:

Q8. Class Rank of students you observed using the ILM

Q9. Which ILM was used?

Q10. How was the ILM used? (Options were: “Integrated with regular lecture material”, “Teach a concept required by the course”, “Reinforce a concept required by the course”, “Review the material already covered”, “As enrichment only”)

Q11. Which of the following activities occurred in conjunction with using the ILM? (Options were: “Introduction of the material in lecture.”, “Demonstration of how to use the ILM”, “Post test to evaluate learning that took place”, “Summary/Follow up – explanation of what should have been learned from the ILM”)

Table 14 represents the correlation between questions 1 -7 on Teacher Survey based on teacher responses.

Table 14. Correlation Between Teacher Survey Questions Based on Teachers Responses.

	Q1.	Q2.	Q3.	Q4.	Q5.	Q6.	Q7.
Q1.	1	N/A	-0.23	-0.62	-0.12	0.09	-0.36
Q2.	N/A	1	N/A	N/A	N/A	N/A	N/A
Q3.	-0.23	N/A	1	0.62	-0.09	-0.41	-0.48
Q4.	-0.62	N/A	0.62	1	0.04	-0.31	0.06
Q5.	-0.12	N/A	-0.09	0.04	1	0.61	0.49
Q6.	0.09	N/A	-0.41	-0.31	0.61	1	0.55
Q7.	-0.36	N/A	-0.48	0.06	0.49	0.55	1

Appendix B. ATTITUDE SURVEY

To analyze students' attitude towards computing, an attitude survey was employed. The survey was taken by seventy-five students of Logan High School, twenty students belonged to a math class and the rest were from the technology class. The following questions were used. The questions were divided into five groups, "Confidence", "Gender", "Interest", "Stigma", and "Career".

Confidence group questions

- Q1. I can learn to understand computing concepts.
- Q2. I do NOT think that I can learn to understand computing concepts.
- Q3. I am comfortable with learning computing concepts
- Q4. I am NOT comfortable with learning computing concepts.
- Q5. I am confident that I can solve problems by using computer applications.
- Q6. I doubt that I can solve problems by using computer applications.
- Q7. I can achieve good grades (C or better) in computing courses.
- Q8. I have little self-confidence when it comes to computing courses.
- Q9. I can make the computer do what I want it to do.
- Q10. I cannot learn computer science without a teacher to explain it.

Gender group questions

- Q11. Men produce higher quality work in computing than women.
- Q12. Women produce the same quality work in computing as men.

Q13. I doubt that a woman could excel in computing courses.

Q14. Men and women can both excel in computing courses.

Q15. Men are more likely to excel in careers that involve computing than women are.

Q16. Women and men can both excel in careers that involve computing.

Q17. Men and women are equally capable of solving computing problems.

Q18. It is not appropriate for women to study computing

Q19. Computing is an appropriate subject for both men and women to study.

Interest groups questions

Q20. I would NOT take additional computer science courses if I were given the opportunity

Q21. I would voluntarily take additional computer science courses if I were given the opportunity.

Q22. I think computer science is boring.

Q23. I think computer science is interesting

Q24. I hope that my future career will require the use of computer science concepts.

Q25. I hope that I can find a career that does NOT require the use of computer science concepts

Q26. I do NOT like using computer science to solve problems.

Q27. I like to use computer science to solve problems.

Q28. The challenge of solving problems using computer science does NOT appeal to me.

Q29. The challenge of solving problems using computer science appeals to me.

Q30. Computers can allow me to do more interesting and imaginative work.

Q31. Working on a computer is tedious and boring.

Stigma group questions

Q32. Students who are skilled at computer science are less popular than other students.

Q33. Students who are skilled at computer science are just as popular as other students.

Q34. In the real world, computer scientists spend a lot of time working with others.

Q35. In the real world, computer scientists spend a lot of time working alone.

Q36. A student who performs well in computer science is likely to have a life outside of computers.

Career group questions

Q37. Knowledge of computing will allow me to secure a good job.

Q38. Knowledge of computing skills will NOT help me secure a good job.

Q39. My career goals do NOT require that I learn computing skills.

Q40. I expect that learning to use computing skills will help me achieve my career goals.

Q41. I often use computers in school work.

Q42. I do NOT use computing skills in my daily life.

Q43. Developing computing skills will NOT play a role in helping me achieve my career goals.

Q44. Developing computing skills will be important to my career goals.

Q45. I avoid coming in contact with computers in school.

Q46. Computers help me to organize my work better.

Table 15 through 18 represents values with statistical significance of 2.5% level correlation between the above questions. Because of space constraints, correlation between only positively phrased questions is being shown in the table.

Table 15. Correlation between Positively Phrased Questions from 1 to 24 with Questions from 1 to 24.

	Q1.	Q3.	Q5.	Q7.	Q9.	Q12.	Q14.	Q16.	Q17.	Q19.	Q21.	Q23.	Q24.
Q1.	1	0.37	0.54	0.24	0.33	0.33	0.39	0.46	0.26	0.32	0.26	0.27	0.18
Q3.	0.37	1	0.64	0.42	0.25	0.18	0.27	0.3	0.28	0.43	0.23	0.34	0.3
Q5.	0.54	0.64	1	0.54	0.38	0.22	0.19	0.29	0.11	0.4	0.34	0.18	0.27
Q7.	0.24	0.42	0.54	1	0.23	0.08	0.22	0.29	0.14	0.35	0.05	0.15	0
Q9.	0.33	0.25	0.38	0.23	1	0.07	0.03	0.13	0.01	0.15	0.5	0.33	0.42
Q12.	0.33	0.18	0.22	0.08	0.07	1	0.52	0.58	0.56	0.28	-0.18	-0.06	0.01
Q14.	0.39	0.27	0.19	0.22	0.03	0.52	1	0.68	0.68	0.34	-0.13	0	-0.02
Q16.	0.46	0.3	0.29	0.29	0.13	0.58	0.68	1	0.63	0.44	-0.05	0.16	0.01
Q17.	0.26	0.28	0.11	0.14	0.01	0.56	0.68	0.63	1	0.49	-0.09	0.09	0.04
Q19.	0.32	0.43	0.4	0.35	0.15	0.28	0.34	0.44	0.49	1	0.05	0.19	0.12
Q21.	0.26	0.23	0.34	0.05	0.5	-0.18	-0.13	-0.05	-0.09	0.05	1	0.66	0.72
Q23.	0.27	0.34	0.18	0.15	0.33	-0.06	0	0.16	0.09	0.19	0.66	1	0.53
Q24.	0.18	0.3	0.27	0	0.42	0.01	-0.02	0.01	0.04	0.12	0.72	0.53	1

Table 16. Correlation between Positively Phrased Questions from 1 to 24 with Questions from 27 to 46.

	Q27.	Q29.	Q30.	Q33.	Q34.	Q37.	Q40.	Q41.	Q44.	Q46.
Q1.	0.22	0.38	0.47	0.15	0.18	0.57	0.33	0.18	0.34	0.12
Q3.	0.3	0.24	0.1	0.17	0.23	0.32	0.42	0.4	0.39	0.1
Q5.	0.34	0.43	0.14	0.19	0.22	0.38	0.33	0.22	0.36	0.1
Q7.	0.22	0.18	0.06	0.01	0.14	0.24	0.13	0.3	0.25	-0.04
Q9.	0.29	0.5	0.1	-0.08	0.06	0.21	0.4	0.25	0.24	0.13
Q12.	0.07	0	0.13	0.07	0.18	0.38	0.21	0.26	0.28	0.25
Q14.	-0.02	0.05	0.21	-0.04	0.2	0.33	0.12	0.26	0.14	0.09
Q16.	0.13	0.08	0.22	0.18	0.29	0.54	0.32	0.46	0.29	0.2
Q17.	0.08	-0.04	0.08	0.13	0.3	0.39	0.42	0.32	0.33	0.04
Q19.	0.23	0.11	0.09	0.23	0.2	0.31	0.46	0.31	0.25	-0.01
Q21.	0.58	0.72	0.34	0.12	0.38	0.21	0.46	0.12	0.48	0.16
Q23.	0.64	0.58	0.38	0.14	0.46	0.35	0.48	0.37	0.48	0.16
Q24.	0.62	0.5	0.27	0.09	0.3	0.17	0.48	0.17	0.44	0.26

Table 17. Correlation between Positively Phrased Questions from 27 to 46 with Questions from 1 to 24.

	Q1.	Q3.	Q5.	Q7.	Q9.	Q12.	Q14.	Q16.	Q17.	Q19.	Q21.	Q23.	Q24.
Q27.	0.22	0.3	0.34	0.22	0.29	0.07	-0.02	0.13	0.08	0.23	0.58	0.64	0.62
Q29.	0.38	0.24	0.43	0.18	0.5	0	0.05	0.08	-0.04	0.11	0.72	0.58	0.5
Q30.	0.47	0.1	0.14	0.06	0.1	0.13	0.21	0.22	0.08	0.09	0.34	0.38	0.27
Q33.	0.15	0.17	0.19	0.01	-0.08	0.07	-0.04	0.18	0.13	0.23	0.12	0.14	0.09
Q34.	0.18	0.23	0.22	0.14	0.06	0.18	0.2	0.29	0.3	0.2	0.38	0.46	0.3
Q37.	0.57	0.32	0.38	0.24	0.21	0.38	0.33	0.54	0.39	0.31	0.21	0.35	0.17
Q40.	0.33	0.42	0.33	0.13	0.4	0.21	0.12	0.32	0.42	0.46	0.46	0.48	0.48
Q41.	0.18	0.4	0.22	0.3	0.25	0.26	0.26	0.46	0.32	0.31	0.12	0.37	0.17
Q44.	0.34	0.39	0.36	0.25	0.24	0.28	0.14	0.29	0.33	0.25	0.48	0.48	0.44
Q46.	0.12	0.1	0.1	-0.04	0.13	0.25	0.09	0.2	0.04	-0.01	0.16	0.16	0.26

Table 18. Correlation between Positively Phrased Questions from 27 to 46 with Questions from 27 to 46.

	Q27.	Q29.	Q30.	Q33.	Q34.	Q37.	Q40.	Q41.	Q44.	Q46.
Q27.	1	0.54	0.27	0.24	0.3	0.26	0.42	0.27	0.5	0.26
Q29.	0.54	1	0.37	-0.06	0.24	0.34	0.43	0.14	0.41	0.11
Q30.	0.27	0.37	1	-0.1	0.28	0.27	0.21	0.28	0.34	0.29
Q33.	0.24	-0.06	-0.1	1	0.08	0.34	0.14	0.16	0.21	-0.01
Q34.	0.3	0.24	0.28	0.08	1	0.32	0.4	0.27	0.38	-0.04
Q37.	0.26	0.34	0.27	0.34	0.32	1	0.45	0.28	0.55	0.18
Q40.	0.42	0.43	0.21	0.14	0.4	0.45	1	0.19	0.6	-0.01
Q41.	0.27	0.14	0.28	0.16	0.27	0.28	0.19	1	0.3	0.28
Q44.	0.5	0.41	0.34	0.21	0.38	0.55	0.6	0.3	1	0.22
Q46.	0.26	0.11	0.29	-0.01	-0.04	0.18	-0.01	0.28	0.22	1

Appendix C. Usability Survey

The usability survey was based on Likert scale with options “Strongly agree”, “Agree”, “Neither agree nor disagree”, “Disagree” and “Strongly disagree” and consisted of the following questions:

Q1. Which ILM did you use?

Q2. A simple and natural dialogue was used making it intuitive to find and understand features. [Some examples of this include requiring minimal navigation, appropriate use of color, and intuitive graphics.]

Q3. The interface used only familiar terms. [This includes abbreviations, units, and metaphors that make sense to the user.]

Q4. A user is NOT required to remember too much at one time to use the interface. [For instance, if a specific format is required for the user to enter a date, this format should be communicated to the user.]

Q5. The ILM is consistent in providing commands, attributes, and actions that always have the same meaning used in other software package.

Q6. Users are provided with feedback when they are performing a task. [This includes communication such as status bars and message boxes that let the user know the status of their actions.]

Q7. Clearly marked exits make the user feel safe exiting a program without fears, such as: losing work or affecting other users in a negative way

Q8. Short cuts have been provided to expedite the process that a user needs to go through to perform their tasks.

Q9. Good error messages have been used which are easy to understand and helpful.

Q10. Errors were prevented by reducing ambiguity or confusion in the interface.

[Preventing errors includes problems that occur due to ambiguity or design problems that confuse the user. This may also include situations in which it would be appropriate to have special modes.]

Q11. Help and documentation are readily available to the user. [It is organized so that the user can quickly locate what they are searching for. Most users do not want to read manuals, so an interface should be intuitive enough for them to figure out how to use it; and help should be arranged in a manner that allows quick retrieval of information.]

Q12. Gender

Q13. Grade level

Q14. Race

Appendix D. Boolean logic ILM Instructions

This section contains the instructions presented on the Boolean Logic ILM.

Instructions on Page 1

1. A friend says: The opposite of "and" is "or". Is he/she right?
2. Simplify the following expression. Verify that the results are unchanged.

`((isSpotted & isTall) | (isSpotted & !isTall))`

3. Rewrite the following expression at least two different ways (by bringing the "!" inside the parentheses). Verify that the results are unchanged

`!(hasRed & hasGreen)`

Operators:

`()` - inserts parentheses to control order of application of operators

`&` - inserts "&" at the cursor. Represents the Boolean AND operator.

`!&` - inserts the Boolean NAND operator. It is true when both operands are not true.

`|` - inserts a "|" at the cursor. Represents the Boolean OR operator.

`!|` - inserts the Boolean NOR operator. It is true when neither of its operands are true.

`!` - inserts a "!" at the cursor. Represents the Boolean NOT operator.

XOR - inserts an "XOR" at the cursor. Represents the Boolean "exclusive or" operator. It is true when exactly one of the operands are true.

XNOR - inserts the Boolean XNOR operator or "not exclusive or". It is true when both arguments are true or both are false.

Expressions

TRUE - Inserts TRUE into the expression. If "TRUE" means always.

FALSE - Inserts FALSE into the expression. If "FALSE" means never.

The Striped button inserts the Boolean function isStriped. Evaluates to true for all shapes the are striped.


The Spotted button inserts the Boolean function isSpotted. Evaluates to true for all shapes that are spotted.


TALL - inserts the Boolean function isTall. Evaluates to true for all shapes that are taller than they are wide.


WIDE - inserts the Boolean function isWide. Evaluates to true for all shapes that are wider than they are tall.

The Square/Rectangle button inserts the Boolean function isRectangular. Evaluates to true for quadrilaterals with four right angles.

The Circle/Oval button inserts the Boolean function `isRound`. Evaluates to true for all shapes that are round or oval.

 - inserts the Boolean function `hasRed`. Evaluates to true for all shapes containing the color red.

 - inserts the Boolean function `hasGreen`. Evaluates to true for all shapes containing the color green.

 - inserts the Boolean function `hasBlue`. Evaluates to true for all shapes containing the color blue.

Controls

Apply Expression - evaluates the Boolean expression and selects the shapes for which the expression is true. If an error occurs while evaluating the expression, the offending part of the expression is highlighted in red.

Clear Expression - clears the expression.

Check - evaluates the Boolean expression and verifies that the shapes for which the expression is true are on the right side. If an error occurs while evaluating the expression, the offending part of the expression is highlighted in red.

New Shapes - Draws a new set of shapes.

Menus

Boolean Operators - Basic, Normal, or Advanced - the three levels of difficulty available.

They control which buttons are visible.

Objects - Select the number and or type of objects created.

Hover your mouse over the objects to see a list of the individual boolean expressions for each object.

Instructions on Page 2

Using Parenthesis to control precedence

As you may have noticed previously while creating expressions, sometimes you want to control the order in which the expression is evaluated. Just like in mathematics, boolean algebra can use parentheses to group expressions together. Expressions inclosed in parentheses will be evaluated first, but in the absence of parentheses, there is a precedence between the operators $\&$, $|$, and $!$. See if you can discover it.

#4 Is $(\text{hasRed} \ \& \ \text{hasGreen}) \ | \ \text{hasBlue}$, different from $\text{hasRed} \ \& \ \text{hasGreen} \ | \ \text{hasBlue}$? Why or Why not?

#5 Is $\text{hasRed} \ \& \ (\text{hasGreen} \ | \ \text{hasBlue})$, different from $\text{hasRed} \ \& \ \text{hasGreen} \ | \ \text{hasBlue}$? Why or Why not?

#6 What is the order of precedence for the AND, OR and NOT boolean operators?

#7 Add parentheses to the expression below to illustrate which operators apply to which operands.

`!hasRed | isTall & isRectangular`

Instructions on Page 3

Simplifying Expressions

Many expressions that look different are actually equivalent - they produce the same results for all objects. For example `hasRed & !hasRed` is actually the same as `FALSE`.

#8 Given the expression `(TRUE & hasGreen)` can you find an alternate expression that is equivalent?

#9 Given the starting expression `!hasBlue | hasGreen` can you find an alternate expression that is identical?

Try your hand at simplifying the complicated expressions available via the drop down menu

Instructions on Page 4

Practice with Fun Images.

Before trying more complex expressions, practice using expressions with "AND", "OR", and "NOT". Create an expression and then try dragging the shapes to the correct side. Press Check to check your answer.

Note that if you place the cursor over an object, a list of descriptors appears.

Here are a few possible expressions to try:

!(hasRed & hasGreen)

canMove & isLiving

(isCartoon | isLiving) & hasRed

Instructions on Page 5

XOR and Set Difference

Two other operators we will consider are exclusive or (XOR) and Set Difference(-). The XOR operator is called an *exclusive or* because it evaluates to true when one of the two operands is true, but it evaluates to false when both operands are true. Thus one operand being true excludes the other from being true.

Set Difference is the difference between two sets. In Set logic, it is everything that is in one set minus what is contained in the second set. For Boolean logic, this is the equivalent of replacing the Set Difference operator with AND NOT. So $X - Y$ can be evaluated as $X \& !Y$.

#1 Write an expression which selects objects which can move or are electronic but not both.

#2 Write an expression which selects objects which can move but are not human.

Appendix E: LOOPS ILM INSTRUCTIONS

This section consists of the instructions on Loops ILM.

Instructions on Page 1

Designing a Scarf

Designing a scarf consists of two steps, described below:

Color the pattern

Click on the colors you want and then click on a section of the pattern to apply the color to that segment.

Select a color below for: allow you to pick color for a pattern, background or border

More Colors allows you to pick from a bigger set of colors.

Pattern Operations

Rotate Image By Angle: If we rotate 90 degrees, the pattern will turn counter-clockwise a quarter turn. If we rotate -90, the pattern will turn clockwise a quarter turn. The rotated imaged will be scaled to fit in the horizontal and vertical dimensions indicated in image size.

Block Size (in Pixels): Computer screens are measured in picture elements (pixels). Your screen may be 1024 pixels wide and 768 pixels tall.

Repeat the pattern

Practice supplying values (we call them parameters) to the for loop to the left.

Seeing the result

You can see the result by pressing View Project.

Create own Palette: creates a randomly colored pattern for you.

Add to Existing Project: lets you add design over your previous pattern

If you want to start over, click New Project.

Instructions on Page 2

Designing a Scarf

Controlling the Loop Parameters

The patterns can be made to start at a location other than the first by changing the starting location.

The number of times the pattern repeats can also be changed by altering the end location.

The default increment (++) increments the iteration variable by one each time.

Other possibilities include

(+=2) to increment by two each time

(+=3) to increment by three each time

(+=1.5) to increment by one and a half patterns each time.

(--) to decrement by one each time

(-=2) to decrement by two each time.

Instructions on Page 3

Making a quilt

To create a quilt, you need two loops (one inside the other) to create a pattern in two dimensions. These are called nested loops.

The Loop Nesting should be 2. The row variable will control the rows. The col variable will control the columns.

The second loop can also be controlled by the first loop iteration variable. Thus, the starting or ending location of the iteration variable can be the variable row.

Instructions on Page 4

Try to create patterns

Click on the Sample Patterns button. It will pop up some patterns. Try to make a similar pattern. Next and Previous button helps you to switch between patterns.