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TEACHING PROBABILITY THROUGH USE OF AN APPLET

by

Melissa Gregory Jackson

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

MASTER OF MATHEMATICS

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Abstract

Teaching Probability through Use of an Applet

by

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Utah State University, 2009

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The use of technology in the classroom is an ongoing debate by educators. Many teachers consider it to be a valuable teaching tool. Despite the many advantages, there are also drawbacks in using technology. A Java applet is a particular kind of multimedia technology proven to be useful in education. Because of students’ struggles with learning basic probability in Statistics 1040, I have created a probability applet to reinforce the concept of probability. The applet was tested with two Statistics 1040 classes. The majority of students agreed that they learned more about probability from using the applet. Several of the students felt that learning using the applet was more enjoyable than learning out of a textbook. Corrections to the applet were made after suggestions from student evaluations. Overall, this applet seems to be a useful tool in teaching probability.
Teaching Probability through Use of an Applet

Seymour Papert, an MIT mathematician, computer scientist, and educator once said, “Indeed, the role I give to the computer is that of a carrier of cultural 'germs' or 'seeds' whose intellectual products will not need technological support once they take root in an actively growing mind.” (Papert, 1993, p. 9) Although technology should not be considered a replacement for teachers, it should be considered an important and highly valuable tool in our day. This paper will discuss the Java applet learning tool that was developed for the purpose of teaching the concept of basic probability, the testing that was performed on two classes of Statistics 1040 students, the improvements that were made, and how I believe it to be a useful tool in the teaching of basic probability. The applet is located at http://www.math.usu.edu/~schneit/CTIS/ProbabilityApplet/.

Literature Review

In a world filled with technology, questions arise in the field of education: “Should we use technology in education?” If so, “why should we use technology in education?” And, “how should we use technology in education?” The answers to these questions are still under debate. This is due largely to the fact that technology changes at such a rapid rate, that by the time research is finished, the corresponding technological innovation is already outdated. Despite this and other challenges, it seems that overall, technology is of great use in the field of education.

Why should we use technology in education? The technology we use in education today was obviously not used 100 years ago and schools did not have a problem functioning without it. But because technology has such an influence on the world today, it does not make sense that we would prepare students to enter the work
force without ever teaching with use of technology. Technology has changed the world, and education must change as well.

Although it seems necessary to teach students using technology in today's world, there are also many advantages of using computer-based technology to teach. First, the integration of technology into instruction can be very “hands-on.” Velleman and Moore (1996) claimed that, “... students learn best by their own activity, rather than by passively receiving information.” (p. 217) Moore (1997) stated, “It is ... important for teachers to remember that we overvalue lectures.” (p. 125) Because lectures worked for teachers when they were in school, teachers tend to believe that lectures will work for their students as well. (Moore, 1997, p. 125) Although lectures do work for many students, a vast number of students require additional learning tools. Multimedia technology is one such tool that can aid students by giving them a hands-on approach to learning.

Another advantage of using technology in education is that it is usually individualized. A student can work at his or her own pace. Students do not need to keep up or compete with other students. They move on from the concept only when they are ready to move on. This allows students to grasp concepts at a deeper level. Velleman and Moore (1996) stated, “Multimedia [technology] offers a highly interactive and individualized environment in which the learner is constantly invited to manipulate animations, asked to respond to questions, and encouraged to work independently to exercise newly learned concepts.” (p. 217)

Technology also increases learning by allowing students to take control of their education. Emerson (2000) claimed, “Successful learning takes place when students
have active responsibility for their own learning; The active engagement of new concepts is a key to student success, whereas passive involvement in the learning process at best gives lowered efficiency in learning." (p. 81) When students use interactive technology, their involvement is active and their learning increases.

The fact that technology allows students to receive instant feedback is another advantage. Students can immediately see errors made that come from fallacies in thought. These erroneous beliefs can be corrected instantly. Compare this to a book assignment where students do not receive feedback until they complete the assignment and hand it in for correction. A student may have had a mistaken idea from the start and worked all problems incorrectly. Not only did this student waste time doing problems incorrectly, but they have now trained themselves to do these problems with the same mistakes in the future. Technology improves this procedure by giving immediate feedback to the student.

Despite the many advantages of technology in education, there are some disadvantages and drawbacks we need to be aware of. Velleman and Moore (1996) pointed out that, "One weakness … is that the benefits of student-to-student communication and group work are lost." (p. 224) They suggest e-mail or course bulletin boards as tools to combat the loss of communication. (Velleman & Moore, 1996, p. 224) Students can still work together in a group or communicate with each other. It is simply a different kind of communication.

Another possible disadvantage is the loss of a motivating teacher. No technology can take the place of human touch. A teacher "encourages, prods, rewards, and in general increases student effort and accomplishment by personal interaction."
Also, a teacher is able to “inject well-chosen questions and comments into a group problem-solving session.” (Velleman & Moore, 1996, p. 224) Teachers can adapt to questions while computers follow a script. It is almost impossible to create code so detailed that it would account for every student’s question or concern. No technology has been invented (or will ever be invented) that can fully take the place of a human teacher. Educators need to remember that technology is a valuable tool, but it is just that, a tool. A teacher still needs to take an active part of student learning.

Another drawback to technology is the additional time and effort that goes into developing a lesson plan using technology. A teacher has to learn the technology and software before they are able to begin creating a lesson plan. Depending on the usability of the software, this can be a long process. Some teachers would prefer not to use technology since it seems the slower and harder route in many cases.

Finally, a disadvantage of technology is that it can fail to work properly. Software will always have bugs, the internet may crash, or the power may go out altogether. No matter how well-planned a lesson using technology is, it is not entirely infallible. A backup lesson plan is needed in case of technology failure. This takes extra time for the teacher, as they may have to create two lesson plans instead of their usual one.

We can see that technology does have a worthwhile place in education although there are some pitfalls that must be taken into account. The field of statistics education is no exception. Chance, Ben-Zvi, Garfield, and Medina (2007) stated, “The technology revolution has had a great impact on the teaching of statistics, perhaps more so than many other disciplines.” Cobb (2007) claimed, “In recent years, almost all teachers of
statistics who care about doing well by their students and doing well by their subject have recognized that computers are changing the teaching of our subject."

Technology has enabled teachers to concentrate more on concepts rather than computations. In the field of statistics, computations can become quite large and tedious. Software has been developed that performs such calculations for students. This allows the teacher and students to concentrate on why a procedure is used instead of how. According to Coppola (2004),

Statistics courses are vastly different now that standard deviations, coefficients, and $p$-values can be calculated by computers. With time saved on calculations, teachers and students can spend more time mastering statistical concepts, understanding what the statistics tell them and what they do not, and learning the many tools available to analyze naturally occurring numerical data. (p. 2)

Technology also allows teachers and student to ask “what if” questions. (Chance, Ben-Zvi, Garfield, & Medina, 2007) Technology can simulate many types of situations in seconds, situations that would take several minutes or hours to create by hand. For example, the outcome space to a certain probability question can be generated in seconds. This gives the student a chance to see a problem from several different angles, strengthening their understanding of a concept.

Biehler (1997) pointed out that educators need to be aware of the types of software they are using. According to him, “…the community of statics educators should take responsibility for the evaluation and improvement of software quality from the perspective of education.” (p. 169) Many software programs developed for statistics are useful tools for statistical calculations, but are not particularly effective in a
classroom setting. Meeker suggested, “Future technology will permit more improvements in the quality of education...” (Moore, Cobb, Garfield, & Meeker, 1995, p. 256)

Future research performed on the use of technology in statistics education will also aid teachers in the development of new lesson plans. Meletiou-Mavrotheris (2003) stated, “Despite the wide use of technology now observed in statistics classrooms, relatively little published research exists describing its impact on student learning.” (p. 266) As more studies are done, more information about the use of technology in statistics education will be revealed and methods of teaching using technology will improve.

As mentioned previously, a possible disadvantage of using technology in education is the amount of time and effort required to master it. This is possibly more true in the field of statistics than in many other fields. The learning curve of some software is quite high. Meeker declared, “... new technology requires large investments both in equipment and in faculty time and effort...” (Moore, Cobb, Garfield, & Meeker, 1995, p. 256) A teacher of statistics needs to be prepared to make this time commitment if technology is a goal in his or her classroom.

Another disadvantage of using technology in statistics is the possibility that the students will use programs without really knowing what they are doing. With just a few mouse clicks, calculations are performed, spreadsheets are created, and graphs appear. (Coppola, 2004, p. 4) If students were required to do such things by hand, would they know how? Technology does bring the added concern that students may use such software as a crutch rather than a learning tool.
Despite the drawbacks of using technology in statistics education, we can see that there are many advantages. This is especially true when using applets. Applets are a beneficial tool to use in education for several reasons. First of all, many applets can be accessed over the internet for free. They can be run off of a browser window so there is no need to download programs. This is advantageous since many people are hesitant to download programs due to the risk of viruses, malware, spyware, and the like.

Also, applets have many characteristics that give them an edge over physical manipulatives. Cangelosi (2003) stated,

Computer software is now available whereby activities with hands-on, physical manipulatives can be simulated on a computer just as you can play chess or solitaire on a computer without concrete hand-on chess pieces or playing cards. These electronic or virtual manipulatives are an extremely convenient and powerful supplement to hand-on manipulatives – not a complete replacement for the tactile real-world experiences that students need manipulating concrete objects and measurement instruments. But following up physical manipulatives with virtual ones has immense advantages. Besides emulating physical hands-on manipulatives, electronic manipulatives have pedagogical and mathematical features that are impossible with the physical variety. For example, virtual objects can instantaneously change color (e.g., to highlight a specific surface or edge that has been selected). (p. 346)

As stated, applets are not the only tool needed in education, but they do have abilities that other tools lack.
Studies have been done to show that applets are beneficial in teaching introductory statistics courses. (Aberson, Berger, Healy, & Romero, 2002; Anderson-Cook & Dorai-Raj, 2003; West & Ogden, 1998) Anderson-Cook and Dorai-Raj (2003) stated,

We have found that students in introductory statistics classes react very positively to the applets, both in terms of enjoying being able to experiment with them as well as being better able to discuss the concepts relating to power. Anecdotally, students’ performance on test questions ... has improved. On end-of-term evaluations, students frequently cite the use of the applets as one of their favorite parts of the course and comment that they found them very helpful.

Aberson, Berger, Healy, & Romero (2002) declared, “Student reactions to this tutorial and performances following tutorial use demonstrate that interactive computer-based tutorials integrated into introductory statistics courses can be accepted by students as useful supplements, or even replacements for, traditional statistics assignments.” These studies show that applets can be a useful teaching tool in a statistics course.

Although there have been studies done concerning the use of applets in teaching statistics, very little research has been done with probability in particular. Dinov and Sanchez (2006) stated, “Because of lack of access to technology for all students, or for other reasons, no testing of the effectiveness of using the applets in student performance or other outcome measures exists. Even less evidence exists on the effectiveness of applets in teaching probability courses.” More research is needed in all
aspects of technology and teaching. In particular, studies done with applets and statistics/probability are required.

Although more research is needed, we can see that technology in introductory statistics courses is beneficial to both students and teachers. It allows students a hands-on approach to learning that allows them to work at their own pace. It goes places that simple visual manipulatives cannot. It responds to user input immediately and further enforces their knowledge of a concept. It allows teachers to concentrate on concepts rather than mere calculations. The advantages far outweigh the disadvantages. Technology can and should be considered a useful tool in the teaching of statistics and probability.

**Project Goals & Methods**

While teaching Statistics 1040 at Utah State University, Fall Semester of 2008, I noticed that basic probability seemed to be a challenging subject for many of my students. Although some students could easily calculate probabilities using the multiplication and addition rules, I was concerned that they did not understand the concepts behind these rules. For example, when selecting (with replacement) a red fish and a blue fish in any order out of five different fish, there are two combinations of fish that fit this criterion out of 25 combinations total. I decided an applet that taught basic probability was needed.

I began this project with a simple draw-up. The students were to select a number of fish out of a total of five. They were to then figure out the probability of selecting those fish if chosen at random. Over time, I developed my applet into an eight-level applet that gets progressively more challenging.
Level 1 is intended to introduce the most simplistic probability. As seen in Figure 1, five different types of fish swim in an aquarium and the user is asked to select one fish. The fish they select goes into their fish bag and a question appears, “If chosen at random, what is the probability of selecting this type of fish?” The user can then submit their answer. In all levels, the user can either “Submit Answer” or “See Solution.” That way, they can always advance to the next level even if they cannot figure out an answer to a certain question.

![Level 1](image)

**Figure 1. An example of the first screen of Level 1.**

Once an answer is given, a new screen is presented, as seen in Figure 2. Not only will the user be given an explanation describing how to algebraically calculate the probability, they will also see a chart of fish with the fish they selected highlighted. This
chart describes the probability visually instead of algebraically. They will see that there are five fish and they chose one, thus the probability is 1/5.

Figure 2. An example of the second screen of Level 1.

The user can then advance to Level 2 or try Level 1 again if needed. Level 2 is similar to Level 1 in that the user still selects one fish. There are still five fish but now two fish are of one type and three are of another, as Figure 3 displays.

Figure 3. The aquarium on Level 2.

The second screen, as shown in Figure 4, gives the explanation for the probability: 2/5 or 3/5 depending on which type of fish was chosen. The five fish are shown in the chart and the cells are highlighted accordingly.
That's right! You chose one fish. Because there are five fish total and two fish of this type, the probability of choosing this type of fish is \[
\frac{2}{5}
\]

![Figure 4. An example of the second screen of Level 2.](image)

Level 3 once again has five different types of fish and asks the user to select two fish. The question is asked, "If chosen at random and without replacement, what is the probability of selecting 2 fish of these types in the order you picked them?" There are two phrases in this question that help determine what kind of probability to calculate: "without replacement" and "the order you picked them." The user can see that once a fish is chosen, it is not replaced in the aquarium. Also, the question is asking for the probability of fish chosen in a certain order. This simplifies the calculation of the probability since the user does not have to use the addition rule. However, the multiplication rule is now needed since there are two fish being chosen.

As seen in Figure 5, the second screen of Level 3 offers an algebraic explanation using the multiplication rule. The visual explanation is now more complex since there are 20 combinations of choosing two fish without replacement.
That's right!

You chose two fish without replacement.

The probability of choosing these two types of fish in the order you selected is found by using the multiplication rule. It is the probability of choosing the first fish multiplied by the probability of choosing the second fish:

\[
\frac{1}{5} \times \frac{1}{4} = \frac{1}{20}
\]

**Figure 5.** An example of the second screen of Level 3.

Level 4 differs from Level 3 in that there are now two fish of one type, two fish of another type, and one more of yet another type. The user is once again asked to choose two fish and a question appears similar to the question on Level 3. The question still asks for the probability of the fish being chosen in the order the user selected them. But in Level 4, the fish are drawn “with replacement.” As seen in Figure 6, when a fish is chosen, a net appears and drops a fish of the same type back into the aquarium, giving the user a visual cue that the fish are drawn with replacement. The user then has the option of selecting the same type of fish in the same position more than once.
Figure 6. An example of the first screen of Level 4.

Depending on which fish are chosen, the probability differs. The answer may either be $4/25$, $2/25$, or $1/25$, as seen in Figures 7, 8, and 9, respectively. This gives the user some options in choosing different fish to calculate different probabilities if they wish to try the level again.
NOTE: In the chart below, 1 denotes the first fish of that type, 2 denotes the second fish of that type, R1 denotes the first fish replaced, and R2 denotes the second fish replaced. You chose two fish with replacement. The probability of choosing these two types of fish in the order you selected is found by using the multiplication rule. It is the probability of choosing the first fish multiplied by the probability of choosing the second fish:

\[
\frac{2}{5} \times \frac{1}{5} = \frac{2}{25}
\]

\[\frac{2}{5} \times \frac{2}{5} = \frac{4}{25}\]

*Figure 7. An example of the second screen of Level 4 when the probability is 4/25.*

NOTE: In the chart below, 1 denotes the first fish of that type, 2 denotes the second fish of that type, R1 denotes the first fish replaced, and R2 denotes the second fish replaced. You chose two fish with replacement. The probability of choosing these two types of fish in the order you selected is found by using the multiplication rule. It is the probability of choosing the first fish multiplied by the probability of choosing the second fish:

\[
\frac{2}{5} \times \frac{1}{5} = \frac{2}{25}
\]

\[\frac{2}{5} \times \frac{2}{5} = \frac{4}{25}\]

*Figure 8. An example of the second screen of Level 4 when the probability is 2/25.*
NOTE: In the chart below, 1 denotes the first fish of that type, 2 denotes the second fish of that type, R1 denotes the first fish replaced, and R2 denotes the second fish replaced. You chose two fish with replacement. The probability of choosing these two types of fish in the order you selected is found by using the multiplication rule. It is the probability of choosing the first fish multiplied by the probability of choosing the second fish:

\[
\frac{1}{5} \times \frac{1}{5} = \frac{1}{25}
\]

Figure 9. An example of the second screen of Level 4 when the probability is 1/25.

Level 5 once again has five different types of fish and the user is asked to select two. This time, the question asks the user to calculate the probability of selecting those two with replacement in any order. "In any order" is essentially asking the user to apply the addition rule. There is still a 1/25 chance for the fish to be chosen with replacement, but now the user must add 1/25 and 1/25.

The second screen of Level 5, displayed in Figure 10, explains the need for the addition rule and shows the calculation algebraically. Visually, the user will see the two fish they selected highlighted in any order. The one exception to this is if the user selects the same fish twice. Then, the addition rule is not needed since the probability of choosing the same fish twice in any order is simply 1/25.
That's right!

You chose two fish with replacement.

The probability of choosing these two fish in the order you selected is found by using the multiplication rule. It is the probability of choosing the first fish multiplied by the probability of choosing the second fish.

\[
\frac{1}{5} \times \frac{1}{5} = \frac{1}{25}
\]

The probability of these two types of fish being chosen in any order is found by using the addition rule. There are two different ways to arrange the two fish (see below) and each combination has the probability calculated above. So the total probability of choosing these two fish in any order is:

\[
\frac{1}{25} + \frac{1}{25} = \frac{2}{25}
\]

Figure 10. An example of the second screen of Level 5 when the probability is 2/25.

Level 6 goes back to the format of Level 4 with two fish of one type, two of another type, and one of yet another type. The user still selects two fish, this time without replacement. The probability of selecting those two types of fish is to be calculated if the fish were chosen in any order.

The second screen shows the probability of selecting those fish, as seen in Figure 11. This probability is 2/20 if the same type of fish is chosen twice, in which case the addition rule is not used. Otherwise the probability is 4/20 or 8/20 with both probabilities using the addition rule.
NOTE: In the chart below, 1 denotes the first fish of that type, 2 denotes the second fish of that type.

The probability of choosing these two types of fish in the order you selected is found by using the multiplication rule. It is the probability of choosing the first fish multiplied by the probability of choosing the second fish.

\[
\frac{5}{20} \times \frac{4}{20} = \frac{20}{20} = \frac{1}{5}
\]

The probability of these two types of fish being chosen in any order is found by using the addition rule. There are eight different ways to arrange the two types of fish (see below) and each combination can be arranged in two different ways. So the total probability of choosing these two fish in any order is:

\[
\frac{4}{20} + \frac{4}{20} = \frac{8}{20} = \frac{2}{5}
\]

**Figure 11.** An example of the second screen of Level 6 when the probability is 8/20.

Level 7 is back to five fish, one of each type. The user is asked to select three fish and a question is asked, “If chosen at random and without replacement, what is the probability of selecting these 3 fish in the order you picked them?” The multiplication rule is needed again and this time, the user must multiply three probabilities instead of just two.

The second screen algebraically and visually explains the probability of selecting these three fish. Sixty combinations are displayed with one of the sixty combinations highlighted, as displayed in Figure 12.
That's right! You chose three fish without replacement.

The probability of choosing these three types of fish in the order you selected is found by using the multiplication rule. It is the probability of choosing the first fish multiplied by the probability of choosing the second fish multiplied by the probability of choosing the third fish.

$$\frac{1}{5} \times \frac{1}{4} \times \frac{1}{3} = \frac{1}{60}$$

Figure 12. An example of the second screen of Level 7.

Level 8 is most challenging for the majority of students. The five types of fish are displayed and the user is asked to select three fish. The user is then asked to calculate the probability of selecting those three fish with replacement in any order.

If three different types of fish are chosen, the probability is $6/125$, as seen in Figure 13. If the same type of fish is chosen twice, the probability is $3/125$. And if the same type of fish is chosen all three times, the probability is $1/125$. In the first two cases, the addition rule is needed to calculate the probability (as well as the multiplication rule). In the third case, the addition rule is not needed.
You chose three fish with replacement.
The probability of choosing these three types of fish in the order you selected is found by using the multiplication rule. It is the probability of choosing the first fish multiplied by the probability of choosing the second fish multiplied by the probability of choosing the third fish:
$$\frac{1}{5} \times \frac{1}{5} \times \frac{1}{5} = \frac{1}{125}$$

The probability of these three types of fish being chosen in any order is found by using the addition rule. There are six different ways to arrange the three fish (see below) and each combination has the probability calculated above. So the total probability of choosing these three fish in any order is:
$$\frac{1}{125} + \frac{1}{125} + \frac{1}{125} + \frac{1}{125} + \frac{1}{125} + \frac{1}{125} = \frac{6}{125}$$

Figure 13. An example of the second screen of Level 8 when the probability is $6/125$.

Student Response

Two instructors of Statistics 1040 at Utah State University, Spring Semester of 2009, agreed to give their students a homework assignment that included this applet. Eighty-four students total completed the homework assignment, which consisted of a worksheet and a survey. The students were given three to five days to finish the task.

The worksheet, see Appendix A, was intended to test the conceptual knowledge of the students as they worked through the applet. An example of this is Question 4 on the worksheet: “On Level 3 and Level 4, did you use the addition rule or the multiplication rule to compute the probability? Explain in your own words why this rule must be used.” The students must first of all, work through Level 3 and Level 4 to answer the question and be able to explain why the multiplication rule is needed in their
own words. This should help the students learn more about when and why the multiplication rule is needed, and how to use it. Other questions ask about calculating basic probability, the difference between with replacement and without replacement, the difference between finding the probability of fish in this order versus any order, and the multiplication and addition rules.

The survey, see Appendix B (Tuddenham, 2009), was given to students to obtain honest feedback about the worth of the applet. The survey contains five statements in which the students can mark “strongly disagree,” “disagree,” “agree,” or “strongly agree.” It also contains three statements that give the student the option to fill in the blank, such as: “If I could change the applet to make it more effective I would change...” Student responses to these statements can be found in Appendix C. Lastly, the survey asks for any other comments or suggestions.

Statement 1 of the survey is, “I understand more about the topic than I did before I used the applet.” As seen in Figure 14, the majority of students agreed or strongly agreed with this statement. Less than twenty percent disagreed or strongly disagreed with this statement. It can be concluded that most students felt that they learned more about basic probability after using this applet.
I understand more about the topic than I did before using the applet.

Figure 14. Student responses to Statement 1 of the survey.

Statement 2 is, "I did not learn very much about the topic from using the applet because I already knew what the applet was trying to teach me." Figure 15 shows that the majority of students disagreed or strongly disagreed with this statement according to the evaluations. Around twenty-five percent of the students agreed with this statement. We can see that some students felt that the applet did not teach very much because they already had knowledge of calculating probability. But the majority of students did not feel this way.

I did not learn very much about the topic from using the applet because I already knew what the applet was trying to teach me.

Figure 15. Student responses to Statement 2 of the survey.
Statement 3 reads, "Overall I enjoyed using the applet." Figure 16 shows that almost ninety percent of the students agreed or strongly agreed with this statement, a clear majority. This would indicate that most students found the applet to be an entertaining tool for learning. I believe this is an important quality for a teaching tool. If students find an activity fun, they will be more motivated to learn intrinsically.

![Overall I enjoyed using the applet.](image)

*Figure 16. Student responses to Statement 3 of the survey.*

Statement 4 from the survey is, "I would like to use other applets like this involving other concepts and subjects." The majority of students assert that they would like to use similar applets, as seen in Figure 17. Only fifteen percent of students disagreed or strongly disagreed. This indicates that in general, students found this to a fun and useful way to learn and would like to learn in similar ways in the future.
I would like to use other applets like this involving other concepts and subjects.

![Bar chart](image)

**Figure 17.** Student responses to Statement 4 of the survey.

Statement 5 reads, "The directions for the applet were easy to follow." A vast majority of students agreed or strongly agreed with this statement. Less than five percent of students disagreed or strongly disagreed with the statement, as we can see in Figure 18.

![Bar chart](image)

**Figure 18.** Student responses to Statement 5 of the survey.

The most common requests for changes to the applet from students were: 1. Add a hint button so that the user can get help without seeing a complete solution. 2. Make it easier to "catch" the fish. 3. Create a previous level button so students can go back
through the levels if needed. 4. Make the technology behind the applet work better. 5. Make the wording of the directions and suggestions clearer. 6. Add more questions and more variety in the manipulatives.

Besides suggestions, other student comments include, "It made me feel like I was playing a game instead of doing math." "I loved the explanations because I felt I learned a lot from them." "I am totally a hands-on person and this helped me grasp the concepts tons easier." "I LOVED doing this versus out of the books." "Something different and fun!"

Although several students commented on how enjoyable it was to do an interactive homework assignment rather than a book assignment, a few students were not as enthusiastic. One student said, "It's pretty childish. I would probably prefer a normal assignment." Although a few students seemed to feel this way, it was not the norm by any means. Most students seemed to enjoy an interactive assignment.

Response to Student Surveys

After reading the student surveys, I felt that a hint button was a very good idea. I created a hint button that activates a pop-up window. The pop-up window displays different hints, depending on the level and the fish chosen, that give the user a basic outline of how to calculate the probability. For example, if a starfish is chosen on the second level and a hint is needed, the pop-up window displays, "There are three fish of this type and five fish altogether." If three different types of fish are chosen on Level 8, the hint is more complex: "Use the multiplication rule. The probability of choosing the first fish is one out of five, the probability of choosing the second fish is one out of five, and the probability of choosing the third fish is also one out of five. There are six ways
to arrange the fish since they are all of different types. Use the addition rule and add the probability six times." Hopefully, these hints will allow the students receive the help they need to calculate the probability on their own. Giving them a hint but still requiring them to do the calculation will give them a sense of accomplishment they would not get otherwise.

The complaint that the fish were too hard to "catch" is easy to resolve. In reality, the user does not need to click directly on a fish to select it. It would seem that some students were having a difficult time choosing fish because the fish "moved too fast." Clicking anywhere in the area that the fish swims should select that fish. To resolve this problem, I simply added a statement above the aquarium: "NOTE: You do not have to click directly on a fish to select it."

The third suggestion, adding a back button to the applet, seemed like a beneficial idea. For example, if a student goes through a level, but then wishes to compare that level to the previous level, it would be useful if they could go back and try the previous level again. I added the button and it is now possible for the user to maneuver throughout the levels without restraint.

The fourth suggestion, to make the technology behind the applet work better, is beyond my control. For some reason, the applet does not work on certain types of computers. I made the applet as accessible as possible and technological problems are to be expected. Most of the computers on campus had no technological problems running the applet, so the students still could do their homework, even if the applet did not work on their home computer.
The fifth suggestion, to make the wording of the directions and solutions clearer, is difficult to resolve. Some students seemed to think the solutions were very helpful, while an almost equal number of students found them to be confusing. Students learn in a variety of ways and it is possible that the students who found the wording of the solutions and directions confusing are simply not visual learners.

The sixth suggestion, to add more variety to questions and manipulatives, are beyond the scope of this applet. Some students did not think eight levels were enough. They wanted more practice with probability. More practice should be done as a class and individually, in other homework assignments. This applet was not created to be a total lesson on probability. It is simply a supplemental tool. Students also felt that a variety of manipulatives would be useful, such as dice and cards. I agree that students should work with a variety of problems to learn probability, but these problems can be obtained from other sources.

Conclusion

We can see that technology is a useful tool in education in general. In particular, applets seem to be advantageous. The applet discussed in this paper was created to enforce the concepts of basic probability. A homework assignment, which included a worksheet and survey, was given to two Statistics 1040 classes at Utah State University. From the survey we can see that the majority of students found this applet enjoyable and still felt that they learned more about the subject. After making corrections based on student evaluations, I feel this applet is a useful tool in teaching basic probability.
References


Appendix A

BASIC PROBABILITY

NAME______________________________________

Applet address: http://www.math.usu.edu/~schneit/CTIS/ProbabilityApplet/

1. Which fish did you select on Level 1? Be specific. ________________________________
   Why is the correct probability 1/5? _____________________________________________

2. What answer did you get on Level 2? _____________________________________________
   What would be the probability if you had picked a different type of fish than you did? __

3. On Level 3, how would the probability change if the fish were drawn with replacement
   instead of without replacement? _________________________________________________

4. On Level 3 and Level 4, did you use the addition rule or the multiplication rule to
   compute the probability? Explain in your own words why this rule must be used.
   ________________________________________________________________

5. On Level 5, why must you double the probability after using the multiplication rule?
   ________________________________________________________________

6. On Level 6, did you use the Addition Rule? Why or why not? ___________________________
   ________________________________________________________________

7. What were the two differences between Level 7 and Level 8 which led you to get
   different probabilities? Explain. _____________________________________________
Appendix B

NAME ________________________________

Applet address: http://www.math.usu.edu/~schneit/CTIS/ProbabilityApplet/
Read each statement and indicate the degree to which you agree with the statement by selecting one and only one choice:

1. I understand more about the topic than I did before I used the applet.
   - strongly disagree - disagree - agree - strongly agree

2. I did not learn very much about the topic from using the applet because I already knew what the applet was trying to teach me.
   - strongly disagree - disagree - agree - strongly agree

3. Overall I enjoyed using the applet.
   - strongly disagree - disagree - agree - strongly agree

4. I would like to use other applets like this involving other concepts and subjects
   - strongly disagree - disagree - agree - strongly agree

5. The directions for the applet were easy to follow.
   - strongly disagree - disagree - agree - strongly agree

6. I used the applet to look at things besides those specifically asked for in the assignment.
   - not at all - a little bit - somewhat - a lot

Please complete the following statements:

7. If I could change the applet to make it more effective I would change

8. If I could change the applet to make it easier to use I would change:

9. I would have learned more about the topic if the applet had:

Other comments or suggestions:
Appendix C

Technological Problems

- "Maybe it was just my computer, but when I would click on a certain fish, a few times it would choose that fish for me twice instead of letting me choose my own second/third fish."
- "I had a hard time getting it to work on my Mac." (A similar comment was made two other times.)
- "I struggled downloading the plug-in to make it possible to use the applet."
- "Make it work on personal computers." (A similar comment was made one other time.)
- "So it would run easily and conveniently on Internet Explorer, and not just on Firefox."
- "The program should be available to those who use processors besides Windows/Microsoft."
- "The use of Java. Not all computers have it." (A similar comment was made one other time.)

Wording

- "Maybe use the terminology less like the book and more like you're talking to students."
- "Where and how the questions were asked. Put the question in bold or in a more noticeable place." (A similar comment was made two times.)
- "The directions. They were easy to follow but maybe make them a little more clear."
- "The wording of the questions, because they were a little confusing." (A similar comment was made four times.)
- "Have the directions (objectives in the right screen) incorporated directly into the questions themselves."
- "Use larger print and make questions more clear."
- "For some reason, when asked the probability of the same fish being chosen in any or same order a certain amount of times confused me."
- "Please say simplify in the directions."
- "Maybe not needing to simplify it because in class we don't do it." (A similar comment was made one other time.)
- "I wish it would have used the terminology that will be used on our tests."

Solutions

- "I like how the solutions give all the info." (A similar comment was made four other times.)
- "I thought it was very thorough in showing the solutions to the questions and I also liked the explanation and objective at each level listed on the right column."
- "It was great to visually have all of the possible outcomes highlighted for you." (A similar comment was made two other times.)
- "I like the objective and description for each level. Well done."
• “Gone into more detail about how the solution was found.” (A similar comment was made four other times.)
• “Maybe easier to understand solutions. They were sort of hard to follow.” (A similar comment was made five other times.)
• “Give longer descriptions & cleaner answers.”
• “Explaining everything through a table of outcomes because that got confusing and is not the way I’d always find probability.”
• “Explained why when it said to select the fish in any order requires first using the multiplication and then the addition rule.”
• “Someone explaining it to me. I started to get confused and the applet didn’t explain why / when to use what rule.”
• “Possibly put the explanations in your own words. More detailed directions on how the answer was figured out and possibly more complex problems.”
• “The addition part was still throwing me off so I’d try to explain it better or have more examples.” (A similar comment was made one other time.)

Graphics
• “Sometimes it was hard to click the fish.” (A similar comment was made seven other times.)
• “Don’t make the fish move so much.” (A similar comment was made one other time.)

Buttons
• “Add some helps instead of just Incorrect, then see the answer. Easier to learn more if one needs help along the way.” (A similar comment was made eight other times.)
• “A way to view previous answers if you get it wrong.” (A similar comment was made seven other times.)
• “I felt that if you didn’t understand something you could click help, and figure it out.” (A similar comment was made one other time.)
• “Well on some problems I just looked at the solution and figured it out after knowing the solution. I would have learned more if I didn’t have the solution sitting right there for me to look at before I tried it on my own.” (A similar comment was made two other times.)
• “Make is so you had to try a few (3) times before you could look at the solutions.”
• “It’s too easy to advance from level to level without learning anything. There needs to be a consequence for looking at the solution, or the situation should change so you’re working with new numbers. That way you’re tested on principle not memorization.”
• “Make me redo the ones I missed.”

Levels
• “I found question 5 & 7 to be somewhat confusing.”
• “Level 8 was hard to realize why there were 6 possibilities, more explanation maybe.” (A similar comment was made two other times.)
• “More problems like 7 & 8.” (A similar comment was made one other time.)
• "I would change level 7 & 8 (Make them a little bit easier.)
• "Add more levels, the more I do something the easier it gets." (A similar comment was made nine other times.)
• "Added more review questions."
• "Asked a greater variety of questions." (A similar comment was made one other time.)
• "A couple more levels dealing with a little bit more complicated probabilities." (A similar comment was made one other time.)
• "If you want to try a problem again it needs to be changed up some or else you don't learn it."

Usability
• "The applet is easy to use." (A similar comment was made 17 other times.)
• "Very simple." (A similar comment was made two other times.)

Background Knowledge
• "Have a brief tutorial before explaining how to do it." (A similar comment was made two other times.)
• "More background info on the topic."
• "I would tell what rule needs to be used for every level." (A similar comment was made four other times.)

Variation in Manipulatives
• "Different types of settings; maybe some aquarium, some cards, some dices." (A similar comment was made four other times.)
• "Maybe implementing more real world situations."

Positive Feedback
• "Great program!" (A similar comment was made three other times.)
• "Fun fish idea!" (A similar comment was made two other times.)
• "I LOVED doing this versus out of the books." (A similar comment was made one other time.)
• "Nothing, it was easy and great for me, so it will be that way for others."
• "Great work! I am totally a hand-on person and this helped me grasp the examples tons easier." (A similar comment was made two other times.)
• "I thought it was very effective." (A similar comment was made six other times.)
• "I really liked this. Something different and fun!" (A similar comment was made one other time.)
• "I loved it, keep this going and thanks!"
• "It was a good applet overall and was a fun way to learn probability." (A similar comment was made one other time.)
• "Overall I felt this was a great supplemental learning tool to the information presented in class."
• "It was a very cute and fun way to learn! It made me feel like I was playing a game instead of doing math."
• "I thought that it was very well made."
• “I really enjoyed doing the applet.”
• “I learned a lot and it taught me to stop and think about what it was asking. Good applet!”

Miscellaneous
• “When the probabilities are with replacement and I have chosen my fish to not keep those 2 in the aquarium and in my bag because it appears to me like there are 7 fish, when really there are only 5.” (A similar comment was made one other time.)
• “List what order I placed in the fish, because I forgot that order.”
• “Add sound to use more learning styles.”
• “Have answers to questions on this sheet submittable through the applet. Make applet blackboard available.”
• “The mouse clicker to look like a hand or a hook.”
• “More positive reinforcement when questions are answered correctly.”
• “Be able to type your work in so it can tell you where you were going wrong.”
• “Make everything fit so there are no scroll bars.”
• “Having a calculator on there would be nice!”
• “Not having to add everything into 1 fraction, it confused me!”
• “I learned better writing things down and going over the subject and so it didn’t really help me.”
• It’s pretty childish and I would probably prefer a normal assignment.”