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Qualitative Analysis of the Usage by Spanish-Speaking English Language Learners of Resources for Learning Probability

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QUALITATIVE ANALYSIS OF THE USAGE BY SPANISH-SPEAKING ENGLISH LANGUAGE LEARNERS OF RESOURCES FOR LEARNING PROBABILITY

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QUALITATIVE ANALYSIS OF THE USAGE BY SPANISH-SPEAKING
ENGLISH LANGUAGE LEARNERS OF RESOURCES
FOR LEARNING PROBABILITY

by

BERENICE SALAZAR, BS

THESIS

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Abstract

English language learners are a rapidly growing population in the United States colleges and schools. There have been research studies about accommodations and resources for Spanish-speaking English language learners in subjects such as reading, writing, and mathematics, but little has been researched on introductory statistics courses. Introductory statistics courses are challenging to students because aside of handling words that have lexical ambiguity, students also go into the classroom having misconceptions. Some of the misconceptions of probability occur because the students do not have prior knowledge of the mathematical rules of probability and other misconceptions of probability are psychological. The purpose of the study is to investigate how a bilingual applet might help (Spanish-speaking) English language learners with probability concepts in their introductory statistics courses. The results showed that English language learners say they benefit and appear to benefit from using a computer simulation applet in English and Spanish. The results also showed several instances where language plays a factor when English language learners explore probability concepts.
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Chapter 1: Introduction

The Census Bureau estimated that approximately 5.5 million students in the United States are English language learners (ELLs) of which 80% of those students speak Spanish (Cardenas-Hagan, 2010). Research studies have been conducted about accommodations and resources for ELLs in subjects such as reading, writing, and mathematics, but little research has been conducted on ELLs in statistics (Lesser & Winsor, 2009). Due to lexical ambiguity, statistics is a challenging course not only for English language learners but also for those whose first language is English (Lavy & Mashiach-Eizenberg, 2009; Kaplan, Fisher & Rogness, 2009; Lesser & Winsor, 2009; Kaplan, Fisher & Rogness, 2010; Kaplan, Rogness & Fisher, 2012). It is essential for statistics instructors to be able to communicate effectively with all students. These students must become adapted to new customs, culture, and a new language, while trying to learn a new course. In fact, many English language learners are not only faced with navigating through a first course in statistics, but also in having to adapt and learn how to succeed in a course being taught in a different language.

Lesser and Winsor (2009) illustrated how some English language learners have difficulties understanding the language and concepts utilized in introductory statistics classes. Due to the No Child Left Behind Act of 2001, the inclusion of limited English proficient students and the provision of reasonable accommodations was mandated (Abedi, 2009; Menken, 2010). Therefore there is a need of research to find accommodations and resources that truly help improve the performance of English language learners in their introductory statistics course (Garfield & Ben-Zvi, 2007).

The intention of the study is to investigate if a bilingual applet helps English language learners in learning probability in an introductory statistics course. There is a particular need for this study because as Lesser and Winsor (2009) noted:

“There have been some expository and didactic articles (e.g., Hubbard, 1991) specifically about ELL’s learning statistics, but not with a sustained and comprehensive research focus. There have
been a few studies about language issues in learning statistics (e.g., Kaplan, Fisher, & Rognness, 2009; Lavy & Mashiach-Eizenberg, 2009) or probability (e.g., Green, 1984), but these generally do not involve students learning in a second language. There have been a few research studies about the second language learners learning probability (Kazima, 2007; Phillip & Wrights, 1977), but these did not involve Spanish.” (pp. 6-7)

Kaplan, Fisher and Rogness (2009, 2010, 2011) have conducted a series of research studies designed to understand the effect of lexical ambiguities and to develop techniques for exploring them in the statistics classroom. The first two studies focused on the words association, average, confidence, random and spread, and the third study focused only on the word the word spread. Similarly Lavy and Mashiach-Eizenberg (2009) conducted a research study where they studied the influence of spoken language on the informal definition of some statistical concepts; the spoken language in this study was Hebrew. These studies focused on language issues in learning statistics but do not include learning in a second language.
Chapter 2: Literature Review

2.1 Introductory Statistics

Statistics education can be viewed as a new area of study when compared to math education (Sharma, 2006; Garfield & Ben-Zvi, 2007). Even though there has been an increase on the research done in this area, there is a need to continue researching (Garfield & Ben-Zvi, 2007). Research shows that many students find statistics and probability difficult to learn and understand in both formal and in everyday contexts due to lexical ambiguity (Sharma, 2006; Garfield & Ben-Zvi, 2007; Lesser & Winsor, 2009; Lavy & Mashia-Eizenberg, 2009; Kaplan, Fisher & Rognes, 2009; Kaplan, Fisher & Rognes, 2010; Kaplan, Rognes & Fisher, 2012). Some of these difficulties come from the fact that informal definitions of statistical concepts are language dependent. They are language dependent especially since terms have different or the same meaning in the spoken language (Lavy & Mashia-Eizenberg, 2009).

A research study that included second year college students from Emek Yezreel Valley College in Israel examined the influence of spoken language in that case Hebrew on the informal definition of some statistical concepts (Lavy & Mashia-Eizenberg, 2009). The results were that most of the definitions that students gave when the statistical meaning was similar to the meaning of the spoken language were correct for instance the concept of mode (Lavy & Mashia-Eizenberg, 2009). But when the statistical meaning was different from the spoken language, the students’ definitions were influenced by the everyday meaning and had the wrong idea. For example, the concepts of life expectancy and expected value were confused in this manner (Lavy & Mashia-Eizenberg, 2009). The third result was that when the statistical meaning was opposite from the spoken language, most students wrote the opposite meaning because they were using the meaning of the spoken language such as the concept of significance level (Lavy & Mashia-Eizenberg, 2009).
Another sequence of research dealing with lexical ambiguities in statistics was conducted by Kaplan, Fisher, and Rogness (2009) at a university in the Southeastern United States. The researchers had identified the words association, average, confidence, random and spread to have lexical ambiguities. Lexical ambiguities are homonymy words which are those words that share the same form but have different meanings, polysemy words which are those words that have two or more different but related meanings, homophones are words with different spelling and meaning but the same pronunciation, and shifts of applications words which are those words that can mean different things when considered from different perspectives (Kaplan, Fisher & Rogness, 2009). In the first study students were asked to define or to give a synonym of these words and to use them in a sentence. The results showed that students had difficulties with each of the words for different reasons. In the case of average many students used it to describe something in the middle. A word that students had more difficulties with was with the word spread, because there are many common uses for the word that are not related it with the statistical use (Kaplan, Fisher & Rogness, 2009). For example, students were associating the word spread with buttering toast evenly. Students who think of the word spread as creating an even layer believed that more variability or spread was present in a distribution when the bars of a histogram are equally spaced across the entire x-axis or when the histogram top was not smooth (even if the range was small) (Kaplan, Rogness & Fisher, 2012). For the words random, confidence and association students had similar understandings of the words (Kaplan, Fisher & Rogness, 2009).

In the second study the researchers also studied the words association, average, confidence, random and spread. For this study the students were asked to define or to give a synonym for the words as it is used in everyday English and as it is used in statistics (Kaplan, Fisher & Rogness, 2010). The findings showed that many students believe that an association to be a commonality or similarity between two things rather than a more general relationship (Kaplan, Fisher & Rogness, 2010). The
results for the word average showed that students tended to discuss one of the three measures of center (Kaplan, Fisher & Rogness, 2010). The results about the word confidence showed that more students recognize that in statistics confidence is a level of surety rather than being very sure of something (Kaplan, Fisher & Rogness, 2010). The findings about the word random were that students believe that random sampling means that the researchers started by arranging the population in order to force a representative sample rather than understanding that the probability structure underlying random sampling provides the theoretical lack of bias in a random sample (Kaplan, Fisher & Rogness, 2010). Finally, the results about the word spread were that some students used the term as a synonym for shape and others used it as a synonym for variability (Kaplan, Fisher & Rogness, 2010).

These two previous researches demonstrate that it is difficult for students in an introductory statistics course to clearly have an understanding of some of the statistical concepts because of those words that have lexical ambiguity. But they only talked about everyday language and statistical meaning. Another research was done that focused more on how English language learners encounter language when learning introductory statistics. This research consisted of semi-structured interviews with scenarios and open ended questions that gave the students the opportunity to describe what certain statistical words meant in their own words (Lesser & Winsor, 2009). The results of this research showed that there were instances where the translation of words would make little difference especially when the meaning of a term was more influenced by the everyday language. Another observation that was made was that the deficiencies students had in their native language could delay the students’ understanding of statistics. Also, it was found that the role of context is more important for English language learners learning statistics than learning mathematics because statistics inherently involves and requires more context than mathematics (Lesser & Winsor, 2009). Aside from having difficulties with the everyday language and the academic language while learning introductory statistics, students also have difficulties
learning and understanding probability (Sharma, 2006; Garfield & Ben-Zvi, 2007, Lesser & Winsor, 2009).

2.2 Probability

Probability is an important subject taught in an introductory statistics course. Decisions, conclusions, and explanations we make in our lives are based mostly on our judgments of the likelihood of uncertain events (Kahneman & Tversky, 1972). This is why it is beneficial to have an understanding of probability and statistical concepts, because if we lack such understandings we can make the wrong decisions in areas such as law, medicine, research, politics, and social policy making (Cox & Mouw, 1992). Even though probability is an important subject, research shows that students have difficulties learning these concepts (Kahneman & Tversky, 1972; Cox & Mouw, 1992; Sharma, 2006). Research shows that the primary source of students’ difficulties are misconceptions in learning and understanding statistical and probabilistic concepts (Shaughnessy, 1977; Cox & Mouw, 1992).

2.3 Misconceptions

Some misconceptions of probability may be mathematical because the students do not have prior knowledge of the mathematical law of probability. If it is the case, students can correct misconceptions by being familiar with concepts such as sample space, simple probability, counting principles, independent events, and uniform and non-uniform probability distributions (Shaughnessy, 1977). However, research shows that sometimes misconceptions about probability are psychological, and that the mathematical law of probability may not be sufficient to overcoming misconceptions (Shaughnessy, 1977). Some of these misconceptions are availability heuristic, representativeness heuristic, gambler’s fallacy, conjunction fallacy, law of small numbers, and equiprobability. For examples on these misconceptions refer to table 2.1.
Table 2.1: Examples of Misconceptions in Probability

<table>
<thead>
<tr>
<th>MISCONCEPTIONS</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability Heuristic</td>
<td>If a person is asked to estimate the probability of being involved in a car accident, the frequency of the personal contact with car accidents may influence the response (Kahneman &amp; Tversky, 1972; Shaughnessy, 1977).</td>
</tr>
<tr>
<td>Representativeness Heuristic</td>
<td>If a person tends to believe a long string of heads does not represent the random process of coin tossing (Kahneman &amp; Tversky, 1972; Shaughnessy, 1977).</td>
</tr>
<tr>
<td>Gambler’s Fallacy</td>
<td>If a person believes that after nine heads have appear in a coin tossing that the tenth toss is more likely to be tails (Cox &amp; Mouw, 1992).</td>
</tr>
<tr>
<td>Conjunction Fallacy</td>
<td>If a person believes that the statement Linda is a bank teller and active in the feminist movement has a greater probability of happening than the statement Linda is a bank teller (Costello, 2009).</td>
</tr>
<tr>
<td>Law of Small Numbers</td>
<td>If a person expects even short runs of coin flips to reflect the fairness of a coin (Kahneman &amp; Tversky, 1972; Shaughnessy, 1977).</td>
</tr>
<tr>
<td>Equiprobability</td>
<td>If a person believes that getting three fives or one five on three rolls of a die are equally likely by nature (Lecoutre, 1992).</td>
</tr>
</tbody>
</table>

Heuristic refers to strategies people who are combinatorially naive use to estimate the likelihood of a complex probabilistic event (Shaughnessy, 1977). Two types of heuristics are the availability heuristic and representativeness heuristic. The availability heuristic is when people make decisions about the likelihood of an event based on the belief that the outcomes that can be brought easily to mind are more likely to occur (Shaughnessy, 1977). For example, a person might believe that they can generate more sequences of 10 coin flips having only 2 heads than sequences having 8 heads. The second type of heuristic is representativeness heuristic. Representativeness heuristic is when people make decisions about the likelihood of an event based on how similar the event is to the population from which is being drawn or how similar the event is to the process by which the outcome is generated (Kahneman & Tversky, 1972; Shaughnessy, 1977; Cox & Mouw, 1992; Sharma, 2006). For example in a study students were asked the following question:

Which of the sequences would be least likely to occur?

a) HHHTT  b) THHTH  c) THTTT  d) HTHTH  e) All four sequences are equally likely
Only 38% of the students answered correctly that all four sequences are equally likely. The majority of the students selected c) as being the least likely basing their response on the representativeness heuristic because its distribution was furthest from 50-50 (Konold et al., 1993).

Another type of misunderstanding is the gambler’s fallacy. For example, people tend to believe that after nine heads have appear in a coin tossing that the tenth toss is more likely to be tails to even out the distribution (Shaughnessy, 1977; Cox & Mouw, 1992). People expect even short runs of coin flipping to reflect the fairness of the coin. This is referred to as the law of small numbers where people believe that the law of large numbers can be applied to the small numbers (Shaughnessy, 1977). The law of larger numbers ensures that much larger samples are highly representative of the population from which they are drawn (Kahneman & Tversky, 1972). The next misconception is conjunction fallacy. Conjunction fallacy occurs when people believe that a conjunction A and B is more probable than a constituent A (Costello, 2009). An example is when a person believes that HHT will appear before HH when tossing a coin. The last misconception is equiprobability. Equiprobability is when people tend to assume that random events are equiprobable by nature (Sharma, 2006; Gürbüz & Birgin, 2012). An example of this is when a person believes that in 10 coin tosses the probability of getting 5, 6 or 7 heads is equally likely. Once the researchers identified the misconceptions students’ have while learning probability they study the methods to overcome them.

2.4 Overcoming Misconceptions

In the effort to overcome misconceptions in probability research has been conducted on the difficulties students have in understanding concepts at different grade levels and on the common misconceptions (Garfield & Ben-Zvi, 2007). Psychologists have researched how people make judgments and decisions when faced with uncertainty, and have identified common faulty heuristics, biases, and misconceptions in college students and adults (Garfield & Ben-Zvi, 2007). Other researchers have focused on methods to reason more correctly.
One of the methods that have been studied is making predictions. Making predictions can be used to uncover students’ prior knowledge, schemes, misconceptions and intuitions (Lim, Buendia, Kim, Cordero & Kasmer, 2010). It provides the opportunity for students to be aware of their misconceptions and to address them, and to experience cognitive conflict (Lim, Buendia, Kim, Cordero & Kasmer, 2010). Dashley (2010) conducted a research study that addressed high school students’ overuse of the representativeness heuristic and how making predictions and voting could help correct probabilistic reasoning. The study consisted of three groups who took a pre-test and a post-test. In the first group student were taught a lesson of probability with the use of predictions and classroom voting. In the second group students were taught the same lesson but using only predictions. In the third group the students were taught the lesson without prediction or classroom voting (Dashley, 2010). The results showed that the three groups improved their use of the representativeness heuristic, but did not show a significant difference from the groups that used predictions and/or classroom voting and the group without the use of predictions and classroom voting (Dashley, 2010). The results also revealed that making predictions and classroom voting might foster deeper levels of thinking and improved judgment in students, because the group that was making predictions and voting was the only group that did not show a tendency to inappropriately answer equally likely to probabilistic problems (Dashley, 2010).

Another method to help students understand and to remedy misconceptions is using technology such as computer assisted learning environments (Garfield & Ben-Zvi, 2007; Gürbüz & Birgin, 2012). Gürbüz and Birgin (2012) conducted a quantitative research that studied the effect of computer assisted teaching on remedying misconceptions on probability. The results showed that both groups the experimental and the control improved students’ learning and reduced their misconceptions, but when compared to each other the experimental group was more effective (Gürbüz & Birgin, 2012). The experimental group consisted of computer assisted teaching where the teacher was an organizer,
facilitator, counselor, cooperator, and supervisor. In the control group the teacher taught the class in a traditional manner (Gürbüz & Birgin, 2012).

Meletiou-Mavrotheris, Lee and Founladi (2007) also conducted a research study on computer assisted teaching, but their research was a qualitative analysis on the impact of technology based instruction. The results showed that the technology-based group enjoyed learning probability and statistics and had a better understanding of the roles that technology plays (Meletiou-Mavrotheris, Lee & Founladi, 2007). The results also revealed that there was no difference between the technology-based and the non-technology-based instruction on students’ understanding of the fundamental statistical concepts (Meletiou-Mavrotheris, Lee & Founladi, 2007). In the technology-based instruction, students had projects and hands-on activities conducted cooperatively in a computer based classroom environment, and in the non-technology based instruction the students were taught traditionally (Meletiou-Mavrotheris, Lee & Founladi, 2007).

Research has been conducted but there is a need for more research on this area to better understand students’ difficulties with probability and statistics to improve learning environments (Meletiou-Mavrotheris, Lee & Founladi, 2007; Garfield & Ben-Zvi, 2007). Most of the studies have been conducted to help those that are English proficient but little has been done to investigate how to efficiently help English language learners. There are only a few studies as reviewed in chapter 1 that studied Spanish speaking English language learners learning probability (Lesser & Winsor, 2009). Even though the federal government mandated the inclusion of English language learners, the research to verify if the methods being used are in fact beneficial is limited (Menken, 2010).

2.5 Inclusion

The Bilingual Educational Act from 1968 required that schools provide language support services to English language learners to make sure that these students could learn academic content areas while simultaneously learning English (Menken, 2010). The goals of the act emphasized putting
structured and programming in place to promote language learning (Menken, 2010). Language was recognized as a source of educational unfairness in school, and this act focused on creating equitable opportunities for language learning (Menken, 2010). At the same time, in schools certain groups were excluded from large scale assessments that may have been well intentioned considering the fairness and validity, but it was diminishing opportunities for English learners (Hofstetter, 2003; Abedi, Hofstetter, & Lord, 2004; Willner, Rivera, & Acosta, 2009).

Federal and state legislation require inclusion of all students in an attempt to provide fair assessment and maintain instructional standards for every child in this country including English language learners. The No Child Left Behind Act of 2001 mandates inclusion of limited English proficient students (Abedi, 2009; Menken, 2010). The No Child Left Behind Act terminated the Bilingual Education Act emphasizing on English learning and removing the term bilingual from the federal law (Menken, 2010). The law also required that English language learners take standardized tests on English language proficiency and academic content areas (Menken, 2010). The only students that were exempt from state assessments were those who did not attend schools under a local educational agency for a full academic year (Abedi, Hofstetter, & Lord, 2004). The act also increased the accountability for educational agencies by mandating that all students reach proficiency in reading and math by 2014 (Mongiello, 2011; Menken, 2010). The No Child Left Behind Act also mandates provision of reasonable accommodations (Abedi, 2009; Menken, 2010). The accommodations should give accurate data on what English language learners know and can do in academic content areas (Abedi, Hofstetter, & Lord, 2004). The problem for educational practitioners and researchers is defining and identifying English language learners (Abedi, Hofstetter, & Lord, 2004).

2.6 Who are English Language Learners?

According to Hofstetter (2003), English language learners are those whose first language is not English, which include those who are beginning to learn English that could benefit from school
instruction and those who are proficient in English but may need additional assistance in social or academic situations (2003). English language learners also include those who actively use another language besides English in the home environment (Hofstetter, 2003). But there have been problems with definitions or guidelines for identifying which students are English language learners (Abedi, Hofstetter, & Lord, 2004). The federal government has provided definitions of students with limited English proficiency for purpose of funding, but specific guidelines are not available and this gives varying interpretations across school districts and states (Abedi, Hofstetter, & Lord, 2004). This means that a student that might be designated as a limited English proficiency student in one school district may not receive that designation in a nearby district.

There are some criteria that have been used to determine which students fall under English language learners. Some of the most common criteria are Home Language Survey (http://www.isbe.net/bilingual/TPETPILetters/English_Translation/hls_english.pdf) and scores from English proficiency tests such as Language Assessment Scales (Abedi, Hofstetter, & Lord, 2004). Even though these criteria are common, there are concerns about their validity. Using Home Language Surveys may not be valid because of parents’ concerns on certain issues such as fairness in the education of their children, parents’ citizenship, and communication problems (Abedi, Hofstetter, & Lord, 2004). The concerns about using English proficiency tests are that there is not enough evidence that the content of this tests are align with commonly accepted English language proficiency standards, such as standards by Teachers of English to Speakers of Other Languages (Abedi, Hofstetter, & Lord, 2004).

The population of English language learners are linguistically, culturally, and socioeconomically diverse and also increasing. The fraction of English language learners in the United States public schools K-12 has gone from 1 in 20 in 1990 to 1 in 9 in 2008, and it is expected to be 1 in 4 in 2028 (Goldenberg, 2008). More than half of English language learners reside in only four states: 32.9% in California, 12.4% in Texas, 5.6% in Florida, and 5.2% in New York (Abedi, Hofstetter, & Lord, 2004).
Reports have shown that English language learners in the United States come from over 400 different language backgrounds (Goldenberg, 2008). The most common languages are Korean which represents 1.6% of English language learners, Cambodian also with 1.6%, Cantonese with 1.7%, Hmong 1.8%, Vietnamese with 3.9%, and Spanish with 75% (Hofstetter, 2003). In order to include all of these English language learners into the state assessments accommodations need to be provided.

2.7 Accommodations and Resources

Accommodations for English language learners should address the unique linguistic and sociocultural needs of the students, but without altering the construct of the material being assessed (Willner, Rivera, & Acosta, 2009). When doing assessments, English language learners acquire language processing skills and knowledge of academic English to focus on the assignments. Some students may take longer to process the language of the assessment and may encounter difficulties due to unfamiliar language, cultural references, or format (Willner, Rivera, & Acosta, 2009). For example, in a study where ELL students were given the following problem:

Sam can purchase his lunch at school. Each day he wants to have juice that costs 50?, a sandwich that costs 90?, and fruit that costs 35?. His mother has only $1.00 bills. What is the least number of $1.00 bills that his mother should give him so he will have enough money to buy lunch for 5 days?

Some students understood the problem differently, especially on the third sentence ("His mother has only $1.00 bills") they interpreted it as if the mother had only one dollar instead of many bills of denomination 1. They also concluded that this might have been due to their cultural background and socioeconomic status (Solano-Flores & Trumbull, 2003). The intent of accommodations is to remove irrelevant difficulties such as this to get a more accurate picture of what English language learners actually know in that specific content area (Hofstetter, 2003).
In the Guidelines for Assessment and Instruction in Statistical Education (GAISE) in the College Report (ASA, 2010) there are six recommendations for teaching statistics that are intended to help non-English learners, but can also help English language learners. The recommendations are to emphasize statistical literacy and develop statistical thinking, to use real data, to stress conceptual understanding, rather than mere knowledge of procedures, to foster active learning in the classroom, to use technology for developing concepts and analyzing data, and to use assessments to improve and evaluate students learning (ASA, 2010). According to the GAISE using active learning methods in class is important way of promoting collaborative learning which allows students to leaner from each other (ASA, 2010). It also mentions that it is important for teachers not to underestimate the ability of lab activities such as physical and computer-based to teach the material (ASA, 2010).

The National Literacy Panel (NLP) and the Center for Research on Education, Diversity, and Excellence (CREDE) have major reviews on the research on educating English learners (Goldenberg, 2008). The NLP conducted a meta-analysis with 17 studies. The meta-analysis concluded that teaching ELLs to read in their first language and in their second language compared with teaching them to read in their second language only, increased their reading achievement in the second language (Goldenberg, 2008). Five of the most rigorous studies in elementary school, middle school and high school were reviewed by the NLP. The studies involved random assignment of Spanish-speaking students either to instruction only in English or to instruction that was in both English and Spanish (Goldenberg, 2008). All five studies found positive effects on bilingual education on students’ reading achievement on various measures of reading in English (Goldenberg, 2008). Some argued that how does learning reading skills in their first language can help students read in their second language? The CREDE and NLP suggest that literacy, knowledge and other skills are transfer across languages (Goldenberg, 2008).

Appropriate accommodations are those that improve the performance of English language learners but leaves the performance of non-English learners untouched (Hofstetter, 2003). The most
common accommodations are settings such as small groups, giving students more time to think, presentation format which include translations and linguistic modifications, responsive format such as responses in students’ native language and other such as bilingual word lists, dictionaries or glossaries such as the International Statistical Institute (http://isi.cbs.nl/glossary/index.htm), and applets (Abedi & Lord, 2001; Hofstetter, 2003; Garrison & Mora, 1999). Many accommodation strategies have been proposed and used with not enough knowledge of the actual effects. This is why it is important to look at research that involves the relevance of accurate, systematic and objective procedures to obtain reliable and valid knowledge relevant to the education activities and programs (Abedi, Hofstetter, & Lord, 2004). One of the areas where research has been conducted to help English language learners succeed academically is mathematics (Garrison & Mora, 1999; Abedi & Lord, 2001).

2.8 English Language Learners in Mathematics

A research study conducted by Abedi and Lord showed that proficient English speakers preformed significantly higher than English language learners in mathematics (Abedi & Lord, 2001). After this result, they studied whether making modifications to the test would affect students’ performance (Abedi & Lord, 2001). Simpler versions of the test were made keeping the math task the same but changing non-math vocabulary and linguistic structures without changing the math terminology (Abedi & Lord, 2001). Even though results showed that students improved their performance, English language learners benefited more than English proficient speakers (Abedi & Lord, 2001).

Researchers have also studied how to assess English language learners in the mathematics classroom. According to Moschkovich (2007, pp.352) “If the goal is to assess students’ mathematical content knowledge, it is important to listen past English fluency and focus on the content: only then is it possible to hear students’ mathematical ideas”. For example, after a lesson on determining the area of a triangle students were asked to explain their process in English (see fig. 2.1) and then to explain it again
in Spanish (see fig. 2.2) (Garrison & Mora, 1999). The response of one of the students’ was “because we count the square” (pp. 43). Since the student was a recent immigrant, her English was limited and her response provided little information about her understanding (Garrison & Mora, 1999). The students’ response in Spanish was:


What the students is saying here is that the area is 18. Her explanation is that they counted the whole squares and got 12. There were some incomplete squares left over; some were big and others were smaller. They joined the big ones with the small ones and got 6. Finally they added 12+6 and their result was 18 squares. The student was able explain herself better and the teacher was able to gain a better insight of the students’ grasp of the concept when the student explained her process in Spanish (Garrison & Mora, 1999).
Figure 2.1: Explanation of Finding the Area of the Triangle in English

Figure 2.2: Explanation of Finding the Area of the Triangle in Spanish
Chapter 3: Method

3.1 Purpose and Research Questions

The purpose of the study is to investigate how a certain resource might help English language learners learn probability concepts in their introductory statistics course. Research has shown that even non English language learners have a difficult time in their introductory statistics classes. Therefore it maybe even harder for English language learners to clearly understand the statistical and probabilistic concepts being taught. Due to the No Child Left Behind Act, English language learners should be provided with accommodations so that they can demonstrate what they really know about the introductory statistics. This study will help investigate how using a simulation applet may help ELLs in their introductory statistics course.

The questions that are intended to be answer at the end of the research are:

1a. How do Spanish-speaking English language learners appear to benefit from using a computer simulation applet in English or Spanish?

1b. How do Spanish-speaking English language learners say they benefit from using a computer simulation applet in English or Spanish?

2. When do English language learners indicate that language plays a factor when exploring probability with a computer simulation applet in English and Spanish?

3.2 Participants

The participants were recruited through flyers that were passed to five sections of the introductory statistics course STAT 1380 (Descriptive and Inferential Statistics) during the spring semester 2012 at The University of Texas at El Paso. The flyer which is included in Appendix A stated that the research focused on Spanish speaking English language learners who would like to participate in an interview study that could help us better understand how to teach probability and statistics more
effectively to students in the future. Even though the study called for males and females, only females contacted the investigator to make an appointment for an interview. This is not unusual given the predominantly female gender distribution in that course. The six females were over the age of 18, currently taking an introductory statistics course, and identified themselves as English language learners.

### 3.3 Research Plan

The day of the interview, the students met with the interviewer in one of the offices at Bell Hall (the mathematics building at UTEP). Before the interview, the students read and signed the consent form which is included in Appendix C where they agreed to take part of the study. The consent form informed the students that the interview would be videotaped and that it would take approximately from 25 to 40 minutes. Videotaping was necessary to record not just what was said but also how the interviewee was interacting with the applet on the computer screen and to record any non-verbal behavior and gestures. It also informed them that they would not be addressed by or asked for their name at any time throughout the interview, and in any case, a pseudonym would be used for the interview transcripts to maintain the confidentiality of the students. After they signed the consent form, the interviewer turned on the video camera and started the interview.

The interviews were conducted in the months of March and April 2012. The interview consisted of three parts the pre-applet questions, applet questions, and the post-applet questions which are included in the Appendix D. During the pre-applet questions, students were required to answer questions regarding their knowledge about probability specifically on coin tossing. They were also reminded that they were always welcome to ask for a question to be given to them in Spanish if it was not clear in English. The interviewer itself used to be an ELL student who is now fluent in both languages and could clarify questions throughout the interview.

During the applet questions, the interviewer showed the students a coin-tossing simulation applet in both English and Spanish. The applet had two different operations. In the first one the coin would...
flip as many times as the student would put in the applet, and in the second one the coin would continue flipping until it would have a longest run of heads as the student would type in the applet. For both operations the applet would record the number of tosses, number of heads, number of tails, longest run of heads, longest run of tails, percentage of heads, and the chance error. The applet used for this part is available in the National Library of Virtual Manipulatives (http://nlvm.usu.edu/en/nav/frames_asid_305_g_3_t_5.html?from=topic_t_5.html). The students were given the opportunity to choose what version of the applet they were more comfortable working with, and they also had the liberty and facility to switch or toggle the applet between the English and Spanish language (fig. 3.1 and fig. 3.2). The applet could also be switched to a French version and a Chinese version whose screenshots are included in Appendix F, but the study focused on the English and the Spanish versions. The students were allotted time to explore the applet and run some trials given specific instructions. Throughout the exploration phase, the students were prompted to answer a series of questions directly related to the applet being used. Finally, during the post-applet questions, the students were asked questions regarding the effectiveness of the applet.
Figure 3.1: English Version of the NLVM Coin-Tossing Applet

Figure 3.2: Spanish Version of the NLVM Coin-Tossing Applet
Chapter 4: Findings

Table 4.1: What Were the Research Questions Answered

<table>
<thead>
<tr>
<th>RESEARCH QUESTION</th>
<th>HOW WAS THE QUESTION ANSWERED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. How do Spanish-speaking English language learners appear to benefit from using a computer simulation applet in English or Spanish?</td>
<td>To answer this question, we compared responses interviewees gave before having contact with the applet and after being exposed to the applet.</td>
</tr>
<tr>
<td>1b. How do Spanish-speaking English language learners say they benefit from using a computer simulation applet in English or Spanish?</td>
<td>To answer this question, interviewees were asked if they thought that using applets like the one they had exposure to would or would not be helpful to them or other students.</td>
</tr>
<tr>
<td>2. When do English language learners indicate that language plays a factor when exploring probability with a computer simulation applet in English and Spanish?</td>
<td>To answer this question tables were created to look for patterns in language used and cross-case analysis was done.</td>
</tr>
</tbody>
</table>

The transcribing of the videos took place during the months of June and July 2012 (transcripts are included in Appendix E1-E6). After the transcripts were completed the analysis began and the researcher worked on it throughout the fall of 2012. During the fall 2012 while the researcher was analyzing the transcripts, professor Dr. Lesser gave excerpts on Monday October 15, 2012 of the transcripts to his graduate students in MATH 5360 (Introduction to Research in Math Education) to give them the opportunity to analyze real data and for them to give their opinion. The researcher selected the excerpts after identifying three questions where the interviewees had a difficult time answering. The questions were: If you flip 100 times, how different from 50 heads would you have to get to call that result surprising? What do you think is the probability if you flip 10 times to get between 40% and 60% heads – in other words, exactly 4, 5 or 6 heads? In your own words, what does the longest run mean to you? The thirteen graduate students were given time to look over the excerpts of the transcripts to analyze them. On Wednesday October 24, 2012 at 6:30pm the researcher attended a MATH 5360 class where the researcher and the students discussed the questions that were given to them by Dr. Lesser.
The students expressed their thoughts and insights on the transcripts which helped the researcher to complete the analysis of the study.

4.1 Findings for Research Question 1a

To answer how Spanish speaking English language learners appear to benefit from using a computer applet simulation in English or Spanish, the researcher compared the responses the interviewees gave before having any contact with the applet to the responses they gave after being exposed to the applet. During the pre-applet questions interviewees were asked “if you flip the coin 100 times, how many times do you expect to get heads?” Interviewees I2 and I4 had similar responds. Interviewee I2 said “hmmm I don’t get it, 1 out of 100, wait 2 heads out of 200.” The interviewer asked the question again and this time interviewee I2 said “oh, 1 out of 100” (Appendix E2, lines 22-25). Interviewee I4 said “2 out of 100, I mean 1 out of 100, just heads?” The interviewer answered just heads and interviewee I4 said “1 out of 100” (Appendix E4, lines 29-32). Interviewees were asked to the applet in the mode where it would simulate 100 coin flips and would record them. After running the applet a couple of times the interviewer asked “how does this change or confirm your prediction about how far off from 50 heads you would reasonably expect to get in a 100-flip sequence?” Interviewee I2 respond “hmm, it’s kind of a fifty fifty chance so the numbers aren’t that far off, there is not much a chance error or a difference” (Appendix E2, lines 166-171). Interviewee I4 said “ah six percent”, the interviewer then repeated the question and the interviewee I4 said “I said it would be 1 out of 2 so pretty much a little bit up” (Appendix E4, lines 130-135). Both interviewees said that in a 100-flip sequence they expected to see 1 head. Then after being exposed to the coin flipping applet, they said it was a fifty fifty chance and that it would be one out of two.

When interviewee I1 was asked the same questions she said that in a 100 flip sequence she would expect to see 100 heads (Appendix E1, lines 40-44). Later on after running the applet a couple of time when interviewer asked her “how does this change or confirm your prediction about how far off
from 50 heads you would reasonably expect to get in a 100-flip sequence?” she said “it’s like in forty to fifty, it’s the range?” (Appendix E1, lines 234-254). Interviewees I1, I2 and I4 changed their responses to a more correct one after having the opportunity to explore the applet. Table 4.1 shows the responses from all interviewees when they were asked “if you flip a coin 100 times, how many times do you expect heads?” before having the opportunity to explore the applet, and “does this change or confirm what you predicted about how far off from 50 heads you would reasonably expected to get in a 100 flip sequence?” after running the applet.

Table 4.2: Responses of Interviewees

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>I1</th>
<th>I2</th>
<th>I3</th>
<th>I4</th>
<th>I5</th>
<th>I6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Applet Question 7</td>
<td>100</td>
<td>1 out of 100</td>
<td>50</td>
<td>1 out of 100</td>
<td>50-50, 50% of chance</td>
<td>50 out of 100</td>
</tr>
<tr>
<td>If you flip a coin 100 times, how many times do you expect heads?</td>
<td>It’s like in 40 to 50 it’s the range</td>
<td>It’s kind of a 50-50 chance so the numbers aren’t that far off</td>
<td>It’s approximately the same but 2% off to how many the percentage to get gets</td>
<td>I said it would be 1 out of 2 so pretty much a little bit up</td>
<td>In all the trials we did is actually about 50%, so it’s almost what I predicted</td>
<td>Esto confirma [this confirms]</td>
</tr>
<tr>
<td>Applet Question10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does this change or confirm what you predicted about how far off from 50 heads you would reasonably expect to get in a 100 flip sequence?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Another example of questions asked during the pre-applet questions and then asked again during the exploration part of the interview was when the interviewees were asked to sketch a graph. The interviewer said “suppose there was a graph of the proportion of heads so far after the 100th flip, 200th
flip, 300th flip, etc. Make a sketch of what you imagine it might look like on this graph paper.” The interviewees were given time to think and to make a sketch on the paper provided. If the interviewees said they did not know or if they looked confused the interviewer showed them five premade graphs (fig. 4.2). The responses interviewee I2 had was “I’m not sure, it would go line graph, table or like a. I’m sorry I don’t know. Can you repeat it in Spanish like maybe I” (Appendix E2, lines 52-60). The interviewer repeated the question in Spanish, and showed interviewee I2 the five premade graphs. Looking at the graphs, interviewee I2 said “it’s more likely, is a fifty fifty chance” choosing graph D (fig. 4.2) (Appendix E2, lines 61-79). After having the opportunity to run the applet the interviewer asked “does exploring with the applet make you feel you want to keep of change your answer to the question about the graph of the proportion of heads”. Interviewee I2 was also reminded that she had previously chosen graph D. Interviewee I2 then changed her answer to graph C (fig. 4.2) (Appendix E2, lines 174-184). Similarly the interviewer showed the premade graphs to interviewee I3. After seeing the graphs interviewee I3 said “it should show like only fifty percent” while drawing a horizontal line on 0.5 (fig. 4.1).
Then she also said “I think it might be like very close to it” while drawing a wavy graph on the top of the previous line she had drawn (Appendix E3, lines 51-65). The interviewer asked “which one would you pick?” After a looking at the graphs she had drawn, she said “I’m going to say the straight line” (Appendix E3, lines 66-69). After exploring with the applet interviewee I3 said “I would change it to be a little more, like smaller and then bigger like that” while drawing in the paper a wavy graph (Appendix E3, lines 142-152). Both interviewees first selected graph D and after the applet they changed their answers to graph C and to a graph that was similar to C (fig. 4.2). The reason for their change might have been caused by the fact that when they were running the applet the number of heads was not always fifty.
During the pre-applet questions interviewees were also asked “for a 100 flip sequence, how long do you think is the longest run of either heads or tails?” Interviewee I1 answered 100 (Appendix E1, lines 198-203). After running the applet the interviewer said “You had predicted in a previous question that there would be a longest run of 100 in a 100 flip sequence. Do your results seem to confirm or conflict with your prediction?” Interviewee I1 said that the results were conflicting with her previous
response (Appendix E1, lines 285-288). Before being exposed to the applet, interviewee I3 said that the longest run in a 100 flip sequence would be of two (Appendix E3, lines 104-107). After running the applet and being reminded that her previous prediction was of two, interviewee I6 said that the results conflicted with her prediction (Appendix E3, lines 161-163). Interviewee I1 seemed to have realized after the applet that the longest run in 100 flips was smaller than 100 and Interviewee I3 realized that the longest was actually bigger than two. The table 4.2 shows the responses from the six interviewees.

Table 4.3: Responses of Interviewees

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>I1</th>
<th>I2</th>
<th>I3</th>
<th>I4</th>
<th>I5</th>
<th>I6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Applet Question 19 For a 100 flip sequence, how long do you think is the longest run?</td>
<td>100</td>
<td>5</td>
<td>maybe 2</td>
<td>I don’t know, it could be equal or random</td>
<td>I can’t just answer here actually you don’t know</td>
<td>5</td>
</tr>
<tr>
<td>Applet Question 5 Does your result seem to confirm or conflict with your prediction about the longest run in a 100 flip sequence?</td>
<td>Conflicts</td>
<td>I guess it’s not that different it said 6 and I said 5</td>
<td>Conflicts</td>
<td>As many times as you flip a coin is never constant, so I don’t know</td>
<td>puedes tener más caras sucesivas si tienes más lanzamientos [you can have more successive heads if you have more flips]</td>
<td>Confirma [Confirms]</td>
</tr>
</tbody>
</table>

There were some questions that were asked after the interviewees had the opportunity to explore the applet. Then the interviewees were asked to run the applet a couple of times to see if the results would confirm or conflict with their predictions. One of the questions that was asked to the interviewees was “how many tosses do you think it will take before we see a streak of 4 heads in a row?” After their prediction interviewees were asked to run the apple in mode where the applet would continue running.
until it hit the longest run of the number inserted in the applet. In this case the applet continued running until it had a four heads in a row. The interviewer then asked “does the result seem to confirm or conflict with your prediction?” Interviewee I1 said that it would take from 120 to 100 tosses to see a streak of 4 heads in a row, and after running the applet she said that the results conflicted with her prediction (Appendix E1, lines 289-314). Similarly interviewee I2 said that it would take 80 flips to see a streak of 4 heads in a row, and after running the applet she said that the results conflicted with her previous response because it took less flips to obtain 4 heads in a row (Appendix E2, lines 202-212). Both interviewees thought it would take longer to see to streak of 4 heads in a row, but after the applet they realized it would actually take less than expected. On the other had interviewee I6 predicted that it would take 4 flips to see a streak of four heads in a row, but after running the applet she realized it would take more flips to actually have 4 heads in a row (Appendix E6, lines 179-200). Table 4.3 illustrates the responses of the six interviewees.

Table 4.4: Responses of Interviewees

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>I1</th>
<th>I2</th>
<th>I3</th>
<th>I4</th>
<th>I5</th>
<th>I6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applet Question 6</td>
<td>120 to 100</td>
<td>maybe 80</td>
<td>I guess within the first 20</td>
<td>I don’t know at least 4, at least 5</td>
<td>I cannot predict like is that going to happen</td>
<td>4</td>
</tr>
<tr>
<td>How many tosses do you think it will take before we see a streak of 4 heads in a row?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Applet Question 7</td>
<td>Conflicts</td>
<td>Conflicts</td>
<td>well the average is close enough</td>
<td>well you can run it more than five times, I guess so</td>
<td>It confirms</td>
<td>It conflicts</td>
</tr>
<tr>
<td>Does your result seem to confirm or conflict with your prediction?</td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>
Another question that was asked during the exploration phase was “if we change the probability of heads from 0.5 to 0.7, do you think there would be a difference on how many tosses it takes to get a streak of 4 heads in a row?” After the interviewees made their predictions asked to change the probability of heads from 0.5 to 0.7 and to run the applet in the mode where the applet will continue until a streak of 4 heads in a row happens. Interviewee I4 said “it would probably take more” and after running the applet she said the results conflicted with her prediction (Appendix E4, lines 186-191). In the same manner interviewee I6 said “si, seria más difícil, más lanzamientos creo [it would be harder, it would take more flips].” After having the opportunity to run the applet a couple of times interviewee I6 said that the results conflicted with her prediction (Appendix E6, lines 201-225). Both interviewees thought that after changing the probability of heads form 0.5 to 0.7 that it would require more flips to actually see a streak of 4 heads in a row, but after running the applet they realized it would take less flips than what they expected. Table 4.4 gives the responses from the six interviewees.

Table 4.5: Responses of Interviewees

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>I1</th>
<th>I2</th>
<th>I3</th>
<th>I4</th>
<th>I5</th>
<th>I6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applet Question 8 If we change the probability of</td>
<td>[no answer]</td>
<td>I think there would be more probability like the flippings it would be less</td>
<td>it would be to a like small number hmm in the first 5 or first 7</td>
<td>It would probably take more</td>
<td>I don’t think there would be a difference cus it would depend on, 70% combine I don’t know</td>
<td>si, seria más difícil… más lanzamientos creo [yes it would be harder… more flips]</td>
</tr>
<tr>
<td>heads from .5 to .7 do you think there would be a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>difference on how many tosses it takes to get a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>streak of 4 heads in a row?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Applet Question 9 Does your result seem to confirm</td>
<td>[no answer]</td>
<td>Confirm</td>
<td>Conflict</td>
<td>Conflict</td>
<td>It confirms</td>
<td>conflicts</td>
</tr>
<tr>
<td>or conflict with your prediction?</td>
<td></td>
<td></td>
<td></td>
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</table>

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Interviewees were also asked “if we change the probability of heads from 0.5 to 0.7, what change, if any, do you think there would be on the number of heads? What change, if any, do you think there would be on the longest run of heads?” Once the interviewees made their predictions, they were asked to change the probability of heads from 0.5 to 0.7 and to run the applet in the mode where the coin would flip 100 times. Interviewee I5 said “there would be no change cus we are just putting 100 tosses, right?” and when asked about the longest run of heads she said “no change either cus you don’t know”. After running the apple she said “of course there would be more heads because you are changing the probability of having heads to seventy percent from fifty percent so it would be more. I think I would change my answer from before” (Appendix E5 lines 278-301). Interviewee I6 said “si, si va a cambiar [yes, it’s going to change]” when asked if there was going to be a change in the number of heads, and she said “ahmmm no precisamente [not precisely]” when she was asked if there was going to be a change in the longest run of heads. After running the applet she said “es diferente a mi predicción [it’s different to my prediction], si porque yo dije que no importaría el numero de caras y si importa [yes because I said that the number of heads did not matter and it does]” (Appendix E6, lines 226-244). After running the applet both interviewees were able to correct their previous predictions. The table 4.5 shows the answers from the six interviewees.

Table 4.6: Responses of Interviewees

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>I1</th>
<th>I2</th>
<th>I3</th>
<th>I4</th>
<th>I5</th>
<th>I6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applet Question 10a</td>
<td>We are going to have more faces</td>
<td>There probably equal</td>
<td>the heads will be more</td>
<td>there would probably be more heads</td>
<td>there would be no change</td>
<td>si, si va a cambiar [yes it’s going to change]</td>
</tr>
<tr>
<td>If we change the probability from .5 to .7 what change if any do you think there would be on the number of heads?</td>
<td></td>
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<td></td>
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</tbody>
</table>
4.2 Findings for Research Question 1b

To answer how Spanish speaking English language learners say that they benefit from using a computer applet simulation in English and Spanish, interviewees were asked questions after using the applet. One of the questions that were asked to the students was if they thought that using applets like the one they had exposure to would or would not be helpful to them or other students, and to explain their response. The six participants answered that using applets such as the one they used would be helpful to them and other students. When they were asked to explain why, I5 said “well as far as if you are having problems with the wording of certain terms it would be easier if you have the ability to change language, cus maybe you learned in Spanish like I did and then can you switch it to English it helps” (Appendix E5, lines 313-326). What I5 is saying here is that the applet was helpful because she was able to see the equivalent words in the English version and the Spanish version of the applet.
Another interviewee I2 said “I think it would be because to me I’m more of a visual person so that’s why I was having a hard time when you were asking me questions, because I was trying to visualize it. So I think this would be better because you can see what’s happening” (Appendix E2, lines 246-249). For this student the applet was helpful not only because she can easily navigate between the English version and the Spanish version, but also because she said she is a visual learner and the applet gave her the opportunity to see what was happening with the coin tossing. Interviewee I3 agreed that the applet is helpful because it illustrated the information of the coin tossing, she said “it would be helpful because in one it is very clear with the toss and two its showing you a lot of the different types of data for the coin toss like the actually number of toss that you get to play with it and figure out whatever kind of information you need and, and it has a lot of information just for that” (Appendix E3, lines 205-210). Similarly interviewee I6 said “yes it would because it explains you everything like the number of heads hmmm ósea te dice cuantas veces lo lanzaste o sin la necesidad de que tu lo estés haciendo [it tells you how many times you flipped without having you do it]” (Appendix E6, lines 260-265). She also said “well in my personal opinion Spanish is easier because my first language is Spanish and I’m not sure in English” (Appendix E, lines 256-257). According to what this interviewee said the applet was useful to her because the applet was keeping track of the information without her having to perform the flips and recording of the data.

4.3 Findings for Research Question 2

To answer this question tables were created to look for patters in language used and cross-case analysis was done. The interviewees were shown both versions of the applet the English version and the Spanish version. They were given the opportunity to choose what version of the applet they were more comfortable working with and they also had the liberty and facility to switch or toggle the applet between the English and the Spanish language. Five out of the six interviewees decided to work with the Spanish version of the applet throughout the interview. Interviewees I2 had decided to work with
the English version of the applet without even seeing the Spanish version of the applet. The interviewer explained to the student that she was only going to show her the Spanish version of the applet and that after seeing both versions she could decide which version she wanted to use. After the I2 had seen both versions she decided to use the Spanish version of the applet (Appendix E2, lines 148-156).

During the first part of the interview the interviewees were asked what did they call the sides of a coin in English. Two of the interviewees I1 and I5 referred to the sides of a coin in English as faces and the rest of the interviewees said heads and tails. Then they were asked what they called the sides of a coin in Spanish. Their answers varied; I1 and I6 said “cara o cello”, I5 and I6 said “águila o cello”, I3 said she didn’t know, I2 said “cara o letra”, and I4 said “cabeza”. The interviewees that correctly named the sides of the coin in Spanish I1, I5 and I6 talked more in Spanish throughout the interview than the interviewees I2, I4 who named the sides of a coin in Spanish mistakenly. Interviewee I3 who said she did not know how to call the sides of a coin in Spanish used English throughout the interview.

The researcher also noticed that three of the interviewees were thinking in one language while talking in the other. Interviewee I4 said “cabeza” which is heads in English when she was asked what she called the sides of a coin in Spanish. Similarly interviewee I1 said “faces” when she was asked what did she called the sides of a coin in English. In Spanish the sides of a coin are called cara y cello or cara y águila the literally translation to English are face and seal or face and eagle. Also in Spanish caras is used in las caras de las monedas which means the sides of the coin but literally it can be translated to the faces of the coin. For example in pre-applet question 15 (Appendix D) interviewee I1 was given two sequences and was asked what sequence had a higher probability of happening or were they equally likely. Her response was “hmmmm, in the B is more equally of the faces than this one [pointing to sequence A] because this one have more Ts” (Appendix E1, lines 103-114). In the peer debriefing, the researcher and the graduate students agreed that in this occasion interviewee I1 said faces referring to heads. Another instance when interviewee I1 said faces was when the interviewer asked
“what would you call the sides of the coin in English?” and she responded “faces?” The interviewer repeated the question again, the interviewee I1 said “face, hmmm, I don’t know” (Appendix E1, lines 15-24). In this case the researcher believes interviewee I1 said faces and face referring to the sides of the coin. For more examples look at Appendix E on pages on lines 20, 24, 113, 209, 333, 337 and 371. Similarly when interviewee I5 was asked “what would you call the sides of a coin in English?” she said “the faces, the face of the side, I don’t know” (Appendix E5, lines 10-13). The researcher also believes that interviewee I5 said faces and face referring to the sides of the coin. Table 4.6 illustrates the responses from all interviewees on how they call the sides of a coin in English and Spanish.

Table 4.7: Responses of Interviewees on How They Call the Sides of a Coin

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>How do you call the sides of a coin in</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English?</td>
<td>Faces</td>
<td>Heads and</td>
<td>Heads and</td>
<td>Heads and</td>
<td>Faces</td>
<td>Heads and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tails</td>
<td>tails</td>
<td>tails</td>
<td></td>
<td>tails</td>
</tr>
<tr>
<td>How do you call the sides of a coin in</td>
<td>Cara o</td>
<td>Cara o</td>
<td>I don’t</td>
<td>Cabeza</td>
<td>Cello o</td>
<td>Águila o</td>
</tr>
<tr>
<td>Spanish?</td>
<td>cello</td>
<td>letra</td>
<td>know</td>
<td></td>
<td>águila</td>
<td>cello</td>
</tr>
</tbody>
</table>

Throughout interviews there were occasions when the question was asked in English and the interviewees answered in Spanish. For example during the applet questions the interviewer asked interviewee I2 “now you had predicted in a previous question that there would be a longest run of 5 in 100 toss sequence, does the result seem to confirm or conflict with your prediction? Look at the longest
run. How many does it say?” Interviewee I2 answered “el mayor numero de caras sucesivas 9 [the number of successive heads 9]” (Appendix E2, lines 193-196). The researcher believes the interviewee answered in Spanish due to the fact that the interviewee was looking at the Spanish version of the applet and the longest run of heads in the Spanish version of the applet says mayor numero de caras sucesivas (fig. 3.2). Similarly interviewee I4 answered by saying “el mayor numero de caras sucesivas [the number of successive heads]” when asked if the result seem to confirm or conflict with her prediction about the longest run in a 100 toss sequence (Appendix E4, lines 155-160). Another interviewee who was asked the questions in English and answered in Spanish was interviewee I6. The question the interviewer asked her was “for 1000 flips do you think you would have a larger, smaller, or equal chance error compared to 100 flip sequence and why?” The interviewee I6 said equal, and when she was asked why she responded “porque sigue siendo la misma probabilidad [because it’s still the same probability]” (Appendix E6, lines 152-157). Interviewee I6 answered in Spanish not because the applet was in Spanish like interviewees I2 and I4 but because she seemed more comfortable answering in Spanish.

There were other occasions when the question was given in Spanish because the interviewees asked for the question to be given to them in Spanish, or because the interviewer felt the interviewee did not understood the question and asked the interviewees if they wanted to hear the question in Spanish. After listening to the question in Spanish the interviewees sometimes answered in English and others in Spanish. For example, when the interviewer asked “if you flip 100 times, how different from 50 heads would you have to get to call that result surprising?” interviewees I2 and I6 asked to have the question repeated in Spanish. The interviewer then asked “¿Si lanzas la moneda 100 veces, que tan diferente de 50 caras tendrías que obtener para que el resultado sea sorprendente?” Interviewee I6 took a short pause and then said “ah I would say 70” (Appendix E6, lines 34-39). After hearing the question in Spanish interviewee I6 seemed to understand the question and was able to answer correctly. Interviewee I2 responded “do I have to give a number? How different from 50 heads [short pause] 150” (Appendix E2,
Interviewee I2 gave an answer but even after hearing the question in Spanish it seemed like she still did not understand the question completely.

Another example when the question was asked in Spanish and answered in English was when the interviewer asked “now suppose there was a graph of the proportion of heads so far for 100 flips, 200 flips, 300 flips all the way to 1000 flips. Make a sketch of what you imagine it might look like on the graph paper”. Interviewees I2 and I5 asked if they could have the question in Spanish. Then the interviewer said “Supón que hay una grafica de la proporción de caras que han caído hasta el momento después de 100 lanzamientos, 200 lanzamientos hasta 1000 lanzamientos. Haz un dibujo de lo que imaginas que podría ser la grafica en esta papel.” Both interviewees were still unsure about what to draw. To help the interviewees the interviewer showed the students five premade graphs (fig. 4.2) and asked which one they thought was more likely to happen. Interviewee I2 said “it’s more likely is a fifty fifty chance” choosing the graph D (fig. 4.2). Similarly interviewee I5 said “if you’re asking me for the probability of the flips, the proportion of heads it’s a fifty chance. I would say this one” while pointing to the graph D (fig. 4.2). Both interviewees selected graph D having the believe that no matter how many times a coin is flipped that the number of times it would land on heads is one half the total flips.

An example of when the question was asked in Spanish and answered in Spanish was when the interviewer asked “in your own words, what does the longest run mean to you?” Interviewee I6 asked for the question to be given to her in Spanish. The interviewer asked “en tus propias palabras, ¿que significa la mayor racha o el mayor numero de caras sucesivas?” Interviewee I6 answered “cuan
dobtienes [short pause] ah bastante numero de caras continuamente [when you obtain a number of tails continuously]” (Appendix E6, lines 89-93). Interviewee I6 took a short pause to think about the answer and then answered correctly. When interviewee I5 was asked the same question in English she said she did not know. The interviewer then asked her the question in Spanish and she responded “las veces que más tuviste cello o eso significa [the times you had most heads or that’s what it means]” (Appendix E6,
lines 128-135). Interviewee I5 did not ask for the question to be given in Spanish but the interviewer felt that it might help her, and after hearing the question in Spanish the interviewee I5 was able to answer correctly.

There were other occasions when the interviewee was able to express herself better in Spanish than in English. For example the student who explained how she got the area of a triangle in English and then in Spanish. Her response in Spanish was more elaborated and had more insight than her response in English. Something similar happened during the interviews, there were instances where the interviewee was able to express her ideas better in Spanish. The excerpt below illustrates an occasion when this happened (fig. 4.3).

<table>
<thead>
<tr>
<th>In your own words, what does longest run mean to you?</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1- Longest run, hmmm [long pause] longest run, like [short pause] the more the most hmmm the fastest to flip the coin, like many times but so fast [nervous laugh]</td>
</tr>
<tr>
<td>So fast?</td>
</tr>
<tr>
<td>I1- I don’t know.</td>
</tr>
<tr>
<td>You don’t know?</td>
</tr>
<tr>
<td>I1- No, longest run?</td>
</tr>
<tr>
<td>Do you want me to read it in Spanish? May be it make more sense to you?</td>
</tr>
<tr>
<td>I1- Ok</td>
</tr>
<tr>
<td>It says, en tus propias palabras, ¿Que significa la mayor racha o el mayor numero de caras sucesivas?</td>
</tr>
<tr>
<td>I1- mm-hum, ósea, el lo las caras que pasaron más rápido, no que se repetieron [the heads that pasted faster, no, that repeated]</td>
</tr>
</tbody>
</table>
When interviewee I1 heard the question in English it seemed like she did not understand the question or what was being asked. It also seemed if she was having a difficult time communicating her thoughts.

After hearing the question in Spanish interviewee I1 said that the longest run were the heads that passed the fastest, but right after saying that she corrected herself and said that the longest run were the heads that repeated.

Another occasion when the interviewee expressed herself better in Spanish was when interviewee I5 was asked about her prediction of the longest run in a 100 flip sequence. When interviewee I5 was asked “how long do you think the longest run of either heads or tails would be?” she answered “I can’t just answer here, actually you don’t know cus it would be a fifty fifty chance” (Appendix E5, lines 151-154). After running the applet she was asked if the results confirm or conflict with her prediction. She said “it cus you can have more so there would be more flips, so I think it would be could have more” and after a long pause she then said “puedes tener más caras sucesivas si tienes más lanzamientos [you can have more successive heads if you have more flips]” (Appendix E5, lines 221-233). When interviewee I5 answered in English it is not very clear what she is trying to say but after a long pause she answered in Spanish and her response was clearer.
Chapter 5: Discussion

5.1 Summary

Spanish speaking English language learners have a difficult time learning probability concepts, and using applets such as the one used in this research study could be helpful for them. The results showed that in some cases, as mentioned in chapter 4, the applet seem to be beneficial to English language learners. There were instances where the interviewees had made an erroneous prediction and after having the opportunity to run the applet they were able to have a better understanding. For example when the interviewer asked “if you flip the coin 100 times, how many times do you expect to get heads?” interviewee I1 said 100 heads and interviewees I2 and I said 1 out of 100 (Appendix E1, lines 40-44; Appendix E2, lines 22-25). Then after running the applet the three interviewees realized that they were wrong and gave a better answer. English language learners also feel that they benefit from using a computer applet simulation in English or Spanish. At the end of the interview, interviewees were asked if they thought that using applets like the one used in the study would or would not be helpful to them or other students, and the six interviewees agreed that it would be beneficial.

The results also showed that language plays a factor when learning probability. There were occasions when the question was asked in English and the interviewees answered in Spanish. For example when interviewee I6 was asked “for 1000 flips do you think you would have a larger, smaller, or equal chance error compared to 100 flip sequence and why?” Interviewee I6 said that the chance error would be equal and when she was asked why she said “porque sigue siendo la misma probabilidad [because it’s still the same probability]” (Appendix E6, lines 152-157). There were also instances when the interviewee asked for a question to be given to then in Spanish, or the interviewer gave the question to the interviewees in Spanish because the interviewer felt the interviewee did not understood the question and asked the interviewees if they wanted to hear the question in Spanish. Then the interviewee either answered in English or in Spanish. For example when interviewee I5 was asked “in
your own words, what does the longest run mean to you?” she said she did not know. The interviewer asked if she wanted to hear the question in Spanish, and after hearing the question in Spanish she said “las veces que más tuviste cello o eso significa [the time you had most tails or that’s what it means]” (Appendix E5, lines 128-136).

5.2 Limitations

One of the limitations this research study had was that after transcribing the videos the researcher was not able to clarify some of the things what were unclear. Even though it was not specified in the consent forms, the researcher was give permission by the Institutional Review Board Administrator to contact the interviewees via email to ask for clarification in certain things that were said during the interview, but was not allowed to ask any other questions. This would have been very useful especially when analyzing the transcripts from interviewee I1 because it was the transcript that needed more verification. Interviewee I1 used the word face or faces seven times throughout the interview, and clarification would have been helpful to determine whether she used it to refer to cara in cara o cello [heads or tails] or to las caras de la moneda [the sides of the coin]. Another place where clarification was needed was when the interviewee was given two sequences of coin flips and was asked “if one of the sequences were made up and the other actually obtain from real coin flipping, which do you think was which and why?” Interviewee I1 responded that sequence A was more real, and when she was asked why she said “because is more normal for the probability” (Appendix I1, lines 119-137). It was not clear to the researcher what interviewee I1 meant by “is more normal for the probability”. There were four other occasions where clarifications from interviewee I1 were needed. From the other interviews clarifications was needed once from interviewee I2 and I4. During the interviews the researcher did not notice that some answers required more explanation. The researcher emailed the interviewees but none of the interviewees responded to the email.
5.3 Directions for Future Research

Qualitative and quantitative research can be done to further investigate how Spanish-speaking English language learners benefit from using a computer applet simulation in English and Spanish, and when do English language learners indicate that language plays a factor when exploring probability. This research study can be conducted again with modifications such as asking the interviewees about their background information such as since when did they started learning English and rewording some of the questions. During the peer debriefing, students in MATH 5360 pointed out that question “if you flip 100 times, how different from 50 heads would you have to get to call that result surprising?” and question “what do you think is the probability if you flip 10 times of getting between 40%-60% heads – in other words, exactly 4, 5, or 6 heads?” were unclear because having 40%-60% heads and then exactly 4, 5 or 6 heads in the same question was confusing. The graduate students in MATH 5360 also made some suggestions of how to rephrase the questions. They said that the first question could be written as “if you flip 100 times, how many heads would you have to get to call that result surprising?” To rephrase the second question they gave two possibilities. The first one as “what do you think is the probability if you flip 10 times of getting between 40%-60% heads?” and the other one as “what do you think is the probability if you flip 10 times of getting exactly 4, 5, or 6 heads?” Another question that caused discussion during the peer debriefing was “in your own words, what does the longest run mean to you?” The question in Spanish said “en tus propias palabras, que significa la “mayor racha” o el mayor numero de caras sucesivas?” The reason for the discussion was that in English if the student has not seen the term before they would not have a idea of the question is asking them. The Spanish version of the question says el mayor numero de caras sucesivas which can be translated into English as what is the largest number of successive heads. Even if the student does not have prior knowledge he or she could figure out what the question is asking them. The graduate students suggested that the question in English could be written as “in your own word, what does the longest run mean to you or what is the largest number of successive heads means to you?”

Quantitative research can also be conducted. The researcher can write questions relating to probability specially on coin tossing. The research can have an experimental and a control group where
they are given the same assessment. In the experimental group, the students would have access to the NLVM coin-tossing simulation applet in English and in Spanish while working on their assignment. In the control group, students would work on their assignment without having access to the applet. Then the researcher can compare the results of both groups and can investigate if having access to the applet has a significant difference. The researcher can also investigate if there is any significant difference among the experimental group with student who used only the English version of the applet, students who used only the Spanish version of the applet, and students who used both versions of the applet.

Similarly a quantitative research can be conducted using the NLVM coin-tossing simulation applet in English and Spanish and the ISI glossary of statistical terms. For this study three groups can be formed. The first group can have access to the applet in English and Spanish while working on their assignment. The second group can have access to the glossary while working on the assignment. The last group will not have access to the applet or the glossary while working on the assessment. After the students complete the assessment, the results can be compared to see these recourses are effective when English language learners are learning probability.

5.4 Implications for Teaching

Applets such as the NLVM coin tossing simulation applet can be used to help Spanish-speaking English language learners when learning probability. Students have the facility of switching from the English version of the applet to the Spanish version of the applet. If the classroom has computers in the classroom or has access to computers, the applet can be used during class. This way the students can explore probability concepts by themselves and the teacher can be a facilitator. If there is not enough computers available for all students, an assessment with directions on how to use the applet such as homework can be given them. Teachers can also make the students be aware of such applets, and can allow them to use such resource for labs, homework and even test.

Having resources in the student’s native language can also be helpful for English language learners. In schools the material is taught in English, and having resources in their native language available can be very useful. If the teacher knows the students native language he or she can be a resource for the students. Students can go after school or during the office hours get help.
mathematics and statistics sometimes it is not that the students do not know the content but does not understand what is being asked. If the teacher does not know the native language of the student then he or she can look for resources in the student’s native language on the material that will be cover. Teachers should also be aware of what students know and what they can do in their first language so they can help them apply it to tasks in English.

Another way of helping English language learners is by allowing them to work in groups. Before the groups are formed the teacher can say that students are allowed to speak their first language. If the teacher does not specified that students can express themselves in their first language then if they do the teacher should allow it. When students work in groups they express their thoughts and can exchange ideas. The teacher can allow the students to form their own groups or can be assigned to groups. It could be very helpful if within the group there is a student that is fluent and understands both languages, because when they are having their discussion the student that is more fluent in English can help those who are struggling. During regular lecture English language learners might not feel comfortable sharing their ideas, but in small groups they might feel more comfortable and can learn from each other.
References


Appendix A – Flyer

Interview Study In Statistics

- If you are a Spanish speaking English language learner who is taking or has taken statistics at UTEP since fall 2011.
- You would like to participate in an interview study that could help us better understand how to teach probability and statistics more effectively to students in the future.
- Conducted by a graduate student researcher able to listen and speak in English and Spanish.
- In our analysis reporting, we will not use your name or any other information that could identify you.
- The interview will take only 20 to 40 minutes of your time and a possible very brief email or phone follow-up later to clarify anything that was not clear.
- In appreciation for your time, we will give you the opportunity to enter a drawing for a $25 Visa gift card.

If you are interested contact Berenice Salazar to schedule an interview: bsalazar3@miners.utep.edu
Appendix B – Research Proposal

Topics to Address in the Research Proposal

Title:
Effectiveness of Resources for Spanish-Speaking English Language Learners learning introductory statistics

I. Investigators:
Berenice Salazar and Lawrence Lesser

II. Hypothesis:
The null hypothesis being investigated is that the language of the resources offered will make no difference to Spanish-speaking English language learners as they encounter and discuss probability concepts common to an introductory course.

III. Background and Significance:
According to the 2007 American Community Survey 80% of the population in El Paso is Hispanic and many will enroll in university level courses at some point. Statistics is a challenging course not only for English language learners but also for those students whose first language is English (Lesser & Winsor, 2009). This provides a challenging scenario for our population of Hispanics because for many English is not their first language. It is essential that statistics instructors be able to communicate effectively with all students. These students must become adapted to new customs and culture, a new language, while trying to learn a new course. In fact, many English language learners are faced with not only navigating through a first course in statistics but also adapting and learning how to succeed in a course taught in a different language.

In November 2009 Statistics Education Research Journal, Lesser and Winsor (2009) explored how English language learners can have difficulties understanding the language and
concepts utilized in introductory statistics classes. According to The No Child Left Behind Act of 2001 the inclusion of limited English proficient students and the provision of reasonable accommodations was mandated (Abedi, Hoftetter & Lord, 2004).

This study will help investigate how using a computer applet in English and Spanish and resources such as a word list that shows English and Spanish equivalents for probability terms may be beneficial to English language learners (ELLs) when learning probability.

There is a particular need for this study because as Lesser and Winsor (2009, pp. 6-7) note: “There have been some expository and didactic articles (e.g., Hubbard, 1991) specifically about ELLs learning statistics, but not with a sustained and comprehensive research focus. There have been a few studies about language issues in learning statistics (e.g., Kaplan, Fisher, & Rogness, 2009; Lavy & Mashiach-Eizenerg, 2009) or probability (e.g., Green, 1984), but these generally do not involve students learning in a second language. There have been a few research studies about the second language learners learning probability (Kazima, 2007; Phillip & Wright, 1977), but these did not involve Spanish.”

IV. **Research Method, Design, and Proposed Statistical Analysis:**

The student will take part in an interview study- which will be videotaped with the identity remaining anonymous. (Audio taping may be used as a backup, but the videotaping is necessary because we need to record not just what is said but also how the interviewee is interacting with the applet on the computer screen.) The initial part of the interview will require the student to answer questions regarding their knowledge about probability (i.e. Coin tossing). Next the student will be given access to a coin-tossing simulation applet ([http://nlvm.usu.edu/en/nav/frames_asid_305_g_4_t_5.html?from=topic_t_5.html](http://nlvm.usu.edu/en/nav/frames_asid_305_g_4_t_5.html)) in both English and Spanish. However, the applet will be open in the English language but the
student will be able to easily switch or toggle the applet between the English and Spanish language. They will also be provided with a word list that provides the translations of the most commonly used probability terms. The students will be allotted time to explore the applet and run some trials given specific instructions (see interview protocol upload as a separate document). Throughout the exploration phase, the student will be prompted to answer a series of questions directly related to the applet being used. As the allotted time comes to a close, the student will be given a few post-applet questions regarding its effectiveness. Upon completion of the interview, the videotapes will be transcribed and we will use grounded theory (e.g., Strauss and Corbin, 1990) to analyze the qualitative data for effectiveness in stimulating the students’ use of the applet and word list in one or both languages.

V. Human Subject Interactions

A. Sources of potential participants

The subject must have been registered for an introductory statistics class at UTEP during the spring 2012 or summer 2012 semesters or taken it during the fall 2011 semester. These students will be the source of participants for the study. The study includes male and female subjects. There are no exclusions associated with the age or sex of the subject, except that we will first verify that the student is at least 18 years old. The interviews will remain voluntary and confidential, and (once transcribed with a pseudonym) anonymous. There is no risk associated with this study. The subject is asked to be part of the study because he/she is taking a statistics class during the spring 2012 or the summer 2012 semester or has taken statistics during the fall 2011. The expected outcome of the study is to discover whether using applets and a word list in
English and Spanish will help English language learners in their introductory statistics course.

B. Procedures for the recruitment of the participants

The participants have been registered in an UTEP introductory statistics class during the spring 2012 or summer 2012 semesters. The investigator B. Salazar will go to the introductory statistics courses to explain the research and to pass out flyers. Those students who took an introductory statistics during fall 2011 will receive an email with the same information as in the flyer (assuming access to their email addresses is still available via goldmine). The flyer is included in a separate file. If the participants are interested, they will contact investigator Salazar via email or phone to schedule the interview (to take place in a standard location on campus, such as an office in Bell Hall).

C. Procedure for obtaining informed consent

At the scheduled time the participants will receive an explanation of the study and will have the opportunity to ask any questions while or after they read the consent form. Students will sign the consent form before participating in the study.

D. Research Protocol

Once the subject has displayed interest in the interview study, they must schedule a reasonable meeting time with the investigator Salazar. On the mutually agreed upon date, the subject will be presented with a consent form outlining the process and confidentiality of the study. If the subject agrees to continue with the study and signs the consent form, then the interview will proceed. The interview will last about 25 to 40 minutes, during which questions about probability will be asked before, during and after
use of the applet. A copy of the interview questions can be found in the separately uploaded file.

E. **Privacy and confidentiality of participants:**

   The participant will not be addressed by or asked for his or her name at any time throughout the interview and, in any case, a pseudonym will be used for the interview transcripts. Only the researchers will ever see the videotape. Any footage shared with others would have the interviewee’s face not visible or blurred out. In this manner, the researchers can maintain the confidentiality of the participants.

F. **Confidentiality of the research data.**

   The videotaped interviews and transcripts will be kept in a locked file cabinet in a locked office and seen only by the investigator and research advisors. Upon publication of a full research paper, the tapes may be destroyed.

G. **Research resources.**

   a) The students that will participate in the study.

   b) The interviews of the students.

   c) Video camera to video tape the interview.

   d) Audio recorder used as backup.

   e) The transcribed interviews.

VI. **Potential risks**

   There is no associated risk in participating in this interview.

VII. **Potential benefits**

   This research may assist us in gaining significant data as to how accommodations made for English language learners may aid their comprehension in an introductory statistics
course. If so, it will be essential information to share with statistics professors prior to their
teaching of introductory statistics courses.

In regards to student participation of this interview, he or she may gain a further
understanding of the concept of probability, as this particular applet or type of applet was
probably not part of the “regular instruction” he or she received in the class. In addition, the
student may become aware of (and start to address) some particular misconceptions of
probability (whether language related or not) he or she may have, such as those relating to
the law of large numbers.

VIII. Sites or agencies involved in the research project

N/A

IX. Review by another IRB

N/A
Appendix C – Consent Form

University of Texas at El Paso (UTEP) Institutional Review Board
Informed Consent Form for Research Involving Human Subjects

**Protocol Title:** Effectiveness of resources for Spanish-speaking English language learners learning introductory statistics

**Principal Investigator:** Berenice Salazar and Lawrence Lesser

**UTEP:** Mathematical Sciences Department

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1. Introduction

You are being asked to take part voluntarily in the research project described below. Before agreeing to take part in this research study, it is important that you read the consent form that describes the study. Please ask the study researcher or the study staff to explain any words or information that you do not clearly understand.

2. Why is this study being done?

You have been asked to take part in a research study of the use of English and Spanish resources for English language learners taking an introductory statistics course. The main purpose of the study is to discover how using applets and a word list in English and Spanish may help English language learners in their introductory statistics course. You are being asked to be in the study because you are an English language learner who took or is taking an introductory statistics course in spring 2012, summer 2012 or fall 2011. If you decide to participate in this study, your involvement will last about approximately 25-40 minutes.

3. What is involved in the study?

If you agree to take part in this study, you will be interviewed in an office on the UTEP campus by an interviewer who is bilingual. The interview will last about 25-40 minutes, during which questions about probability will be asked before, during and after the use of resources that will be provided. The
4. **What are the risks and discomforts of the study?**

There are no known risks associated with this research. However, there might be a minimal discomfort due to the recording of videotape and audiotape.

5. **What will happen if I am injured in this study?**

The University of Texas at El Paso and its affiliates do not offer to pay for or cover the cost of medical treatment for research related illness or injury. No funds have been set aside to pay or reimburse you in the event of such injury or illness. You will not give up any of your legal rights by signing this consent form. You should report any such injury to Berenice Salazar at (915-731-1478) or bsalazar3@miners.utep.edu and to the UTEP Institutional Review Board (IRB) at (915-747-8841) or irb.orsp@utep.edu.

6. **Are there benefits to taking part in this study?**

There will be no direct benefits to you for taking part in this study, but you may gain a further understanding of probability concepts. This research may assist us in gaining significant data as to how accommodations made for English language learners may aid their comprehension in an introductory statistics course, and this may be useful to students taught in the future.

7. **What other options are there?**

You have the option not to take part in this study. There will be no penalties involved if you choose not to take part in this study.

8. **Who is paying for this study?**

This study does not receive funding from any association.
9. What are my costs?

There are no costs to you beyond the time you spend in the interview.

11. What if I want to withdraw or am asked to withdraw from this study?

Taking part in this study is voluntary. You have the right to choose not to take part in this study. If you do not take part in the study, there will be no penalty.

If you choose to take part, you have the right to stop at any time. However, we encourage you to talk to a member of the research group so that they know why you are leaving the study. If there are any new findings during the study that may affect whether you want to continue to take part, you will be told about them.

12. Who do I call if I have questions or problems?

You may ask any questions you have now. If you have questions later, you may contact Dr. Lesser at (915-747-6845; lesser@utep.edu). If you have questions or concerns about your participation as a research subject, please contact the UTEP Institutional Review Board (IRB) at (915-747-8841) or irb.orsp@utep.edu.

13. What about confidentiality?

1. Your part in this study is confidential. You will not be addressed by or asked your name at any time throughout the interview and, in any case, a pseudonym will be used for the interview transcripts. No footage would ever be shown or shared with anyone outside the research team unless the excerpt has your face blurred out or not visible. The raw videotaped interviews will be kept in a locked file cabinet in a locked office and seen only by the investigator and the research advisors. Interview transcripts will not use your name or any identifying information.
2. Every effort will be made to keep your information confidential. Your personal information may be disclosed if required by law. Organizations that may inspect and/or copy your research records for quality assurance and data analysis include, but are not necessarily limited to:

- The sponsor or an agent for the sponsor
- Department of Health and Human Services
- UTEP Institutional Review Board

The results of this research study may be presented at professional meetings or in publications, but only in a way that does not reveal your identity.

14. Authorization Statement

I have read each page of this paper about the study (or it was read to me). I know that being in this study is voluntary and I choose to be in this study. I know I can stop being in this study without penalty. I will get a copy of this consent form now and can get information on results of the study later if I wish.

Participant Name: ___________________________ Date: ______________

Participant Signature: ________________________ Time: ______________

Consent form explained/witnessed by: ___________________________

Signature

Printed name: ____________________________

Date: ______________ Time: ______________
Appendix D – Interview Questions

Pre-Applet Questions

1. What do you already know about probability?
   ¿Qué es lo que ya sabes acerca de probabilidad?

2. What probability or stats courses have you taken, are you taking, and plan to take?
   [Give a penny to the student.]
   ¿Qué cursos de probabilidad o estadística has tomado, estás tomando, y planes tomar?

3. What would you call the sides of a coin in English?
   ¿Cómo le llamarías a los lados de una moneda en inglés?

4. What would you call the sides of a coin in Spanish?
   ¿Cómo le llamarías a los lados de una moneda en español?

Remember that you are always welcome to ask for a question to be given to you in Spanish if it is not clear in English. The English version will refer to coin sides as heads (H) and tails (T), and the Spanish version with cara (C) and escudo (E).

Recuerda que siempre está a tu disposición pedir que se te haga una pregunta en español si no entiendes en inglés. La versión en inglés se referirá a los lados de la moneda como heads (H) y tails (T), en la versión en español se les referirá como cara (C) y escudo (E).

5. If you flip the coin twice, what do you think is the probability you get exactly one head? Why?
   Si lanzas la moneda dos veces, ¿cual crees que sea la probabilidad de obtener una cara exactamente? ¿Por qué?

6. If you flip the coin four times, what do you think is the probability you get exactly 2 heads? Why?
   ¿Si lanzas la moneda cuatro veces, cual crees que sea la probabilidad de obtener dos caras exactamente? ¿Por qué?

7. If you flip the coin 100 times, how many times do you expect to get heads?
   Si lanzas la moneda 100 veces, cuantas veces anticipas que caiga en cara?

8. What do you think is the probability of getting exactly that many heads in 100 flips?
   ¿Cual crees que sea la probabilidad de obtener exactamente esa cantidad de caras en 100 lanzamientos?

9. If you flip 100 times, how different from 50 heads would you have to get to call that result surprising?
   ¿Si lanzas la moneda 100 veces, que tan diferente de 50 caras tendrías que obtener para que el resultado sea sorprendente?

10. If you flip 10 times, what do you think is the probability if you flip 10 times of getting between 40%-60% heads – in other words, exactly 4, 5, or 6 heads?
Si lanzas la moneda 10 veces ¿Cual crees que sea la probabilidad de obtener entre 40%-60% caras- en otras palabras, exactamente 4, 5, o 6 caras?

11. If you flip 100 times, what do you think is the probability of getting between 40%-60% heads – in other words, exactly 40, 41, 42…, 58, 59, or 60 heads?
Si lanzas la moneda 100 veces, ¿Cual crees que sea la probabilidad de obtener entre 40%-60% caras- en otras palabras, exactamente 40, 41, 42,… , 58, 59, 60 caras?

12. Why do you think your answers to the last 2 questions were [based on their answers to #10 and #11, choose the appropriate ending from: the same; different]?
¿Por qué piensas que tus respuestas a las últimas 2 preguntas son [basado en las respuestas de las preguntas 10 y 11, elije el final apropiado entre: igual, diferente]?

13. Suppose there was a graph of the proportion of heads so far after the 100th flip, 200th flip, 300th flip, etc. Make a sketch of what you imagine it might look like on this graph paper. [Provide interviewee a pen and sheet of graph paper with vertical axis going from 0 to 1 in jumps of 0.1 and the horizontal axis going from 0 to 1000 in jumps of 100.]
Supón que hay una grafica de la proporción de caras que han caído hasta el momento después de 100 lanzamientos, 200 lanzamientos, 300 lanzamientos, etc. Has un dibujo de lo que imaginas que podría ser la grafica en este papel.

[If the interviewee has “no idea”, show him/her these pre-made graphs and ask them which of these graphs below seems more likely and why?]
14. Suppose there was a graph of the absolute difference between the number of heads so far and number of tails so far after the 100th flip, 200th flip, 300th flip, etc. Make a sketch of what you imagine it might look like on this graph paper.

[Provide interviewee a pen and sheet of graph paper with vertical axis going from 0 to 50 in jumps of 5 and the horizontal axis going from 0 to 1000 in jumps of 100.]

Supón que hay una gráfica de la diferencia absoluta entre el número de caras y escudos hasta el momento después de 100 lanzamientos, 200 lanzamientos, 300 lanzamientos, etc. Has un dibujo de lo que imaginas que podría ser la gráfica en este papel para graficar.

![](image1.png)

[If the interviewee has “no idea”, show him/her these pre-made graphs and ask them which of these graphs below seems more likely and why?]

For the next couple of questions, consider these two sequences of coin flips:
Si una de las secuencias fue inventada y la otra realmente obtenida lanzando una moneda, ¿Cuál crees que fue cual y por qué?

17. In your own words, what does “longest run” mean to you?
En tus propias palabras, ¿Qué significa la “mayor racha” o el mayor numero de caras sucesivas?

18. In your own words, what does “in the long run” mean to you?
En tus propias palabras, ¿Qué significa “a largo plazo”?

19. In sequence A, what is the longest run? In sequence B, what is the longest run?
For a 100-flip sequence, how long do you think the longest run (of either all H’s or all T’s) would be?
En la secuencia A, ¿Cuál es la mayor racha o el mayor numero de caras sucesivas? En la secuencia B, ¿Cuál es la mayor racha o el mayor numero de caras sucesivas? Para una secuencia de 100-lanzamientos, ¿Qué tan larga crees que sea la racha más larga de número de caras o escudos?

20. If you saw a streak of 4 heads in a row for a fair coin, what do you think is the probability of heads for the next flip? [If they need choices, give them these 3 choices: less than 0.5, equal to 0.5, greater than 0.5] Why?
Si vez una racha de cuatro caras de una moneda justa, ¿Cuál crees que es la probabilidad de que el próximo lanzamiento sea cara? [Si necesitan opciones: menor que 0.5, igual a 0.5, mayor que 0.5]; ¿Por qué?

[Bring up http://nlvm.usu.edu/en/nav/frames_asid_305_g_3_t_5.html?from=topic_t_5.html on the computer screen (easy way: Google the words NVLM coin tossing), and show interviewee how he/she can toggle with the pull down menu to the Spanish version (briefly show it, and then toggle right back to the English version)]

Applet Questions

1. Run the applet (to do a 100-flip sequence) about 5 times. How does this change or confirm what you predicted about how far off (i.e., the “chance error” number) from 50 heads you would reasonably expect to get in a 100-flip sequence?
Ejecuta el programa (para realizar una secuencia de 100 lanzamientos) alrededor de 5 veces. Como cambia esto o confirma lo que predijiste sobre que tan lejos (i.e., el numero de “error casual”) de 50 caras se puede considerar razonable en una secuencia de 100-lanzamientos.

2. Do you think a 1000-flip sequence would have a larger, smaller, or equal “chance error” compared to a 100-flip sequence? Why?
¿Crees que una secuencia de 1000-lanzaminetos tendría un mayor, menor o igual “error casual” en comparación con una secuencia de 100-lanzamientos? ¿Por qué?

3. Does exploring with the applet make you feel that you want to keep your answer or change your answer to the pre-applet question #11? Explain.
Explorar el programa ¿Te hace que quieras conservar o cambiar tu respuesta a la pregunta #11 antes de usar el programa? Explica.

4. Does exploring with the applet make you feel that you want to keep your answer or change your answer to the pre-applet question #12? Explain.
Explorar el programa ¿Te hace que quieras conservar o cambiar tu respuesta a la pregunta #12 antes de usar el programa? Explica.

5. You had predicted in a previous question [pre-applet question #19] that there would be a longest run of ____ in a 100-toss sequence. Do your results seem to confirm or conflict with your prediction?
Habías predicho en la pregunta anterior que la mayor racha o el mayor numero de caras sucesivas es de ____ en una secuencia de 100-lanzamientos. ¿Tus resultados parecen confirmar o entran en conflicto con tu predicción?
[change the mode of the applet to “longest run of heads” and insert 4]

6. How many tosses do you think it will take before we see a streak of 4 heads in a row?
¿Cuántos lanzamientos crees que tomara para que veas una racha de cuatro caras consecutivas?
[after prediction is made, have the interviewee do the simulation 6 times]

7. Do your results seem to confirm or conflict with your prediction?
Tus resultados ¿Parecen confirmar o entran en conflicto con tu predicción?

8. If we change the probability of heads from .5 to .7, what change, if any, do you think there would be a difference on how many tosses it takes to get a streak of 4 heads in a row?
Si cambiamos la probabilidad de caras de .5 a .7, ¿Que fue lo que cambió, si es que hubo algún cambio?, ¿Crees que habrá una diferencia en cuantos lanzamientos se necesitan para obtener una racha de cuatro caras consecutivas?
[change the probability from .5 to .7 and have the interviewee simulate this 6 times]

9. Do your results seem to confirm or conflict with your prediction?
Tus resultados ¿Parecen confirmar o entran en conflicto con tu predicción?

[change the mode back to number of tosses, keep the probability at .7, and have interviewee run the applet 6 times]

10. If we change the probability of heads from .5 to .7……
What change, if any, do you think there would be on the number of heads?
What change, if any, do you think there would be on the longest run of heads?
Si cambiamos la probabilidad de caras de .5 a .7
¿Que cambios, si los hay, crees que habrá en el numero de caras?
¿Que cambios, si los hay, crees que habrá en la mayor racha de caras?
Post-Applet Questions

1. How did you decide when to use the English version and when to use the Spanish version of the applet?
   ¿Cómo decidiste cuando usar la versión en inglés y cuándo usar la versión en español del programa?

2. What difference between the two versions did you notice or experience?
   En tu experiencia, ¿Qué diferencias entre las dos versiones notaste o experimentaste?

3. Do you think that using applets like this would or would not be helpful to you or to other students? Why?
   ¿Crees que el uso de programás como este serían o no serían útiles para ti u otros estudiantes? ¿Por qué?

4. Do you think it would or would not be helpful to have a word list such as this one [Show list from EXCEL file] that shows English and Spanish equivalents for probability terms? Why?
   ¿Crees que sería o no útil tener una lista de palabras como esta [Mostrar lista de archivos EXCEL] que muestra términos equivalentes de probabilidad en inglés y español? ¿Por qué?
We are going to start the interview,

I1- mm-hum

I’m going to ask you some questions.

I1- mm-hum

So, what do you already know about probability?

I1- hmmm the definition or

Just whatever you know about probability.

I1- hmmm something like approximately of a number

Ok, now, what probability or stats courses have you taken, are you taking or plan to take?

I1-hmmm I am taking

You’re taking right now? Which one?

I1- is the study of statistics [nervous laugh]

Ok. Are you planning on taking more statistics or this is the only one you need to take?

I1- This is the only one I need to take.

Ok, what would you call the sides of a coin in English?

I1- The what?

The sides of a coin

I1- aha

Like you have a penny over there,

I1- Faces?

You have a penny over there right?

I1- aha

What do you call it? Like what would you call this side what would you call the other side, in English?

I1- Face, hmmm, I don’t know [nervous laugh]
You don’t know?
I1 - No
Ok. How would you call them in Spanish?
I1 - Cara y cello [nervous laugh]
Ok, ok now, remember that you are always welcome to ask for a question to be given to you in Spanish if it is not clear in English. The English version will refer to coin sides as heads and tails, and the Spanish version to cara and escudo.
I1 - ok
That’s how we are going to refer to it in the applet. Now, if you flip a coin twice, what do you think is going to be the probability you get exactly one head?
I1 - hmmm, 2
2, why?
I1 - Because is the same probability.
Ok, if you flip the coin four times, what do you think is the probability that you get exactly two heads?
I1 - hmmm half and half
Ok, if you flip 100 coins, if you flip a coin 100 times, I’m sorry, how many times do you expect to get heads? So you’re flipping 100 times,
I1 - 100 [nervous laugh]
So if you flip 100 times you expect 100 heads?
I1 - Yes
Ok. If you flip 100 times, how different from 50 heads would you have to get to call that result surprising?
I1 - hmmm, can you repeat it again [nervous laugh]
If you flip 100 times, how different from 50 heads would you have to get to call that result surprising? I1 - hmmm 50 and 50, like you have 50 probability to have [short pause] I don’t know [nervous laugh]
Do you want me to read it to you in Spanish? Read you that,
I1 - No
No?
68
I1- its fine

54
Its fine? Ok,

55
I1- Ok, Yes in Spanish [short pause] Yes in Spanish

56
¿Si lanzas la moneda 100 veces, que tan diferente de 50 caras tendrías que obtener para que el resultado
sea sorprendente?

58
I1- hmmm no se, pues [I don’t know, well]

59
Ok

60
I1- [nervous laugh] Ok.

61
No, esta bien [It’s ok]

62
If you flip 10 times, do you think is, what do you think is the probability if you flip 10 times to get
between 40 or 60 percent heads – in other words, exactly 4, 5, or 6?

64
I1- How times or?

65
It says, what is the probability if you flip 10 times to get between 40% and 60% heads, in other words,
exactly 4,5, or 6 heads?

67
I1- one percent of probability in each number

68
In each number, ok, now if you flip 100 times, do you think, what do you think is the probability of
getting 40 to 60% of heads, in other words exactly 40, 41, 42, 43 all the way to 60 heads?

70
I1- Ten percent of each number

71
Ok, why do you think your answer was different for both questions? So, for the first one you said one
percent and for the second one you said ten

73
I1-Because are more numbers that ten, ten, the other one is one to one

74
One hundred

75
I1- aha

76
Ok, ok now, suppose there was a graph of the proportion of heads so far after the 100 flips, 200 flips,
300 flips. So now I’m going to ask you to make a sketch of what you think the proportion would look
like. I’m going to give you a paper. You already have a pencil.

79
I1- mm-hum

80
And, suppose there was a graph of the proportion of heads so far for 100 flips, 200 flips, 300 flips all the
way to 1000 flips. How do you think the proportion would look like, would the graph look like?
I: hmmm, Like this [drawing in silence a line starting at (100, 0.1) with slope 1/100] Like that?

Ok, the next question says, suppose there was a graph of the absolute difference between the number of heads so far and number of tails so far after the 100 flips, 200 flips all the way to 1000 flips. [short pause] Ok I’m going to repeat the question again, suppose there was a graph of the absolute difference between the number of heads and number of tails after the 100 flips, 200 flips, 300 flips all the way to 1000 flips.

I: I need to draw it here? [Pointing to the part of the paper where it says cumulative absolute difference between number of heads and number of tail]

Yes, on that one.

I: hmmm it was like five and five? The heads and tails no? for here is five by five

Yes, yes.

I: [long pause] To one thousand?

Mm-hum [drawing in silence a line starting at (100,5) with slope 1/20]
Ok so we are done with the graph right. [Short pause] Ok. So now I’m going to give you a sequence. So for the next couple of questions, consider these two sequences of flips, of coin flips. [The interviewee was handed a paper with the sequences:]

A) H T T H T H T H T T H T T T H T T T H T T T H T T H T T H T T T T H T T T H T T T H T


I-aha

Ok, What sequence has a higher probability of happening or are they equally likely?

I- This one? [pointing to the paper]

Yes [short pause] A or B?

I- Oh [nervous laugh] Which sequence, which face?

It says what sequence has a higher probability of happening or are they equally likely? So which of these two sequence

I- It’s equal

Ok

I- No it’s not equal, its

We are looking at the probability of happening
I1 - hmmm, in the B is more equally of the faces than this one [pointing to sequence A] because this one have more T’s

Ok, so then what sequence has a higher probability of happening or are they equally likely?

I1 - The B

B, ok

I1 - I could circle or?

No that’s fine. If one of the sequences were made up and the other one was actually obtained from real coin flipping, what do you think was which and why? [short pause] So one of the sequence was made up and the other one was obtain by flipping a coin

I1 - mm-hum

Which one was real and which one was real and which one was made up?

I1 - hmmm

By looking at the sequences, which one do you think

I1 - More real?

Yeah, like one of the sequence, one of the sequences was, were made up and the other actually obtained from real coin flipping,

I1 - Oh ok

Which do you think was which and why?

I1 - hmmm, I think this is more real [nervous laugh, pointing to sequence A]

Letter

I1 - A

A

I1 - mm-hum

Why?

I1 - because is more normal for the probability.

Ok, ok now, in your own words what does it mean, what does long longest run mean to you?

I1 - Longest what?
I'm going to repeat it again, in your own words, what does longest run mean to you?

I don't know.

Do you want me to read it in Spanish? May be it make more sense to you?

It says, en tus propias palabras, ¿Que significa la mayor racha o el mayor numero de caras sucesivas?

mm-hum, osea, el lo las caras que pasaron más rápido, no que se repitieron [the heads that past faster, no that repeated]

Ok [short pause] ok, in your own words, what does in the long run mean to you?

In general?

Oh you're asking me a question?

Yes [nervous laugh]

I'm sorry, what does in the long run mean to you?

In the long run mean to you? In other words, in your own words what does in the long run mean to you?

long run, Ok in Spanish [nervous laugh]

En tus propias palabras, ¿Que significa a largo plazo?

Oh, tener determinado un plazo pero muy largo [nervous laugh]

Ok now, in sequence A, what is the longest run?

The A only?

Yeah on sequence A, what is the longest run?
I1 - Here? [pointing to 4 consecutive T’s]

mm-hum

I1 - This or circle it?

Just tell me like the number

I1 - the number of

What’s the longest run

I1 - hmmm I don’t understand which number, is in the letter A,

Ok

I1 - I think the longest run

Ok

I1 - is this one but

Ok is that one, ok

I1 - but which is the answer?

Ok so you can circle it

I1 - Oh ok, here [circled the 4 consecutive T’s]

Now in sequence B what is the longest run?

I1 - [long pause, staring at the paper] hmmm I don’t know it has equally like HH TT and

Ok, so for A you circle that one right?

I1 - Mm-hum

Because how many T’s is it repeating?

I1 - four

Its four

I1 - aha

So what would be the longest run on this one?

I1 - Two

Ok
I1- Oh ok I understand
Your circle
I1- four and two ok
You circled it correctly
I1- [nervous laugh] Oh ok
Ok now, for a 100-flip sequence, how long do you think would be the longest run?
I1- For 100 sequence?
For 100 flips
I1- aha
So for 100 flips, a sequence of 100 flips, how long do you think would be the longest run?
I1- 100, no?
Ok, so if you saw a streak of 4 heads in a row for a fair coin, what do you think is the probability of heads for the next flip? Ok I’m going to repeat the question, if you saw a streak of 4 heads in a row for a fair coin, what do you think is the probability of heads for the next flip?
I1- hmmm 4, no?
Why?
I1- because is the number of faces [nervous laugh]
Ok now we are going to look at the applet [the applet is in the English version]. I’m going to ask you to run the applet about 5 times. So I’m going to ask you to press
Start
Start, and what happens. Run it again.
I1- Start?
Yes just press start.
I1-Ok
Ok. How does this change or confirm what you predicted about how far off from 50 heads you would reasonably expect to get in a 100-flip sequence? So I don’t know if you notice here, it tells you how many number of tosses you made
I1-mm-hum
Number of heads, number of tails right?

And once you run it here, this is in English right? and you press start and you run it right? That what you did right now.

Here you can change it to Spanish and it would be the same applet just that the descriptions are in Spanish,

but it’s the same thing, you put iniciar [start] and it would do the same thing. [short pause] Ok, so you can use which ever you want the English or the Spanish version

They both do the same thing. So now after looking at this, after running it a couple of times how does this change or confirm your prediction about how far off from 50 heads you would reasonably expect to get in a 100-flips?

50 -50  55, yes?

Ok,

Again ok, how does this change or confirm what you predicted how far off from 50 heads you would reasonably expect to get in 100-flips? So you are flipping 100 times

I1- aha, and you said 55, you didn’t say 55?

[shake head to say no]

No

I just said, aaah it says how does this change or predict what you pre, how does this change or confirm what you predicted about how far off from 50 heads you would reasonably
reasonably expect to get in a 100-flips? You said 50-50, right?

I1 - 50-50

But looking at the, at the applet here you see how many heads we get. Let’s run it again and let’s see what happens. Now we got 53

I1 - It’s like in 40 to 50 it’s the range?

Ok. Ok now, what do you think a 1000-flip sequence would have a larger, smaller, or equal chance error compared to a 100-flips? Ok do you think a 1000-flip sequence would have a larger, smaller, or equal chance error compared to a 100-flips?

I1 - Smaller

Why?

I1 - because they don’t complete 100, it doesn’t

Ok, does exploring with the applet make you feel that you want to keep your answer or change your answer to question 11?

I1 - Ok

Let me read again question 11. If you flip 100 times, do you think that, what do you think is the probability of getting between 40% and 60% heads – in other words, exactly 40, 41, 42

I1 - aha

Yes, so looking at the applet does that make you want to change your answer or you want to keep your answer?

I1 - what was my answer? It was like 10, 10, and 10 right?

Yes

I1 - hmmm I want to change like it will be to 40 to 60

Ok

I1 - So 20 and 20, yes? No?

I didn’t say yes or no, I was reading the questions

I1 - Oh ok [nervous laugh]

Ok now I’m going to the next question. Ok. You had predicted in a previous questions that there would be a longest run of 100 in a 100 sequence, remember?

I1 - aha
Ok, do you want, do your results seem to confirm or conflict with your prediction? I don’t know if you notice in here it actually tells you the longest run [interviewer gets the mouse and points to the longest run]

I1 - Oh and it’s four,

If we run it again what happens?

I1 - It’s equally [point with her finger to the longest run]

Now we got the longest run is 6 right? Ok so, does this want to make your, you had predicted in a previous questions that you would have a longest run of 100 in 100 tosses. Do your results seem to confirm or conflict with your prediction?

I1 - Conflict

6. Conflict, ok. Ok how many tosses do you think it will take before we see a streak of 4 heads in a row?

I1 - how many times?

How many times you have to toss a coin to get four streaks in a row four heads in a row?

I1 - 120 to 100

100, ok so now we are going to change here, and we want it to get to four, so can you press it for me

I1 - four? [changed the longest run to 4]

Mm-hum, what this is going to do, is going to keep on flipping the coin until we get the longest run of four, can you put, can you run it? [Ok, can you run it again? Lets run it one more time. I want you to pay attention how many, do you remember how many it took right now?

I1 - [nervous laugh]

It took 77, so right now how many it took?

I1 - 12

Ok let’s see what happens if we run it again.

I1 - 32

32, let’s run it again

I1 - oh so it’s the same in two and two? But first one was no the second one was 12 and the fourth one was 13

Ok

I1 - No? [nervous laugh]
So, this one, does the result seem to confirm or conflict with your prediction? Before we run it I asked you how many times we had to flip it to get four

I1 - I put 100

Aha,

I1 - it conflicts?

It conflicts right?

I1 - Yes

I was less than 100, ok now if we change the probability of heads from .5 to .7

I1 - aha

What change if any do you think there would be in the difference of how many tosses it would take to get a streak of four heads in a row? So I’m going to read it again, in If we change the probability of heads from .5 to .7, what change, if any, do you think there would be in the difference on how many tosses it takes to get a streak of 4 heads in a row?

I1 - Can you can tell it in Spanish (laugh)

Si cambiamos la probabilidad de caras de .5 a .7, ¿Qué sería el cambio, si es que habría un cambio?, ¿Y crees que habrá una diferencia en cuantos lanzamientos se necesitan para obtener una racha de cuatro caras consecutivas?

I1 - [nervous laugh]

So what happens if we there going to be if theres. We are going to actually change it here, but don’t run it. I’m just going to tell you what we are going to do we are going to change the probability of heads from 5 to 7 .7 [the interviewer changed the probability from .5 to .7]

I1 - mm-hum

Is that going to change anything at all? Or is going to remain the same?

I1 - it will be to change

Its going to change, ok. How is going to change

I1 - hmmm we are going to have more faces

Ok lets run it, let see what happens.

I1 - oh no [laugh]

You see it took. Ok run it again. Let’s see. Run it again. Lest run it again.
I1- Oh it have more probability to have faces than the other one

Ok let’s run it again

I1- [laugh]

Ok does your result seem to confirm or conflict with your prediction?

I1- Which prediction?

The one I asked you before running it.

I1- oh ok, oh ok its hmmm [short pause] confirm

Ok now , if we change the probability of heads from .5 to .7. What change, if any, do you think there would be in the number of heads? [shot pause] What change, if any, do you think there would be on the longest run of heads? Here we have two questions.

I1- [sight] hmmm ok can you tell again?

Ok, if we change the probability of heads from .5 to .7

I1- mm-hum

What change, if any, do you think there would be in the number of heads?

I1- hmmm it will be to decrease the probability

Ok, now what do you think would be the longest run of heads? What change, if any, do you think there would be in the longest run of heads?

I1- 3

Ok so now what we are going to do, ok now we are going to change the mode and we are going to do 100 flips but we changed the probability from .5 to .7. Can you run it to see what happens?

I1- from .5 to .7

The probability of heads we changed it from .5 to .7

I1- aha, ok. Again?

mm-hum

I1- Again?

So what was the change? From having the probability at .5 and having the probability at .7

I1- But we never put .5
Yeah, ok let’s do that then.

I1-[laugh]

Let’s change it. We did it at the beginning in case you don’t remember.

I1- Oh ok ok I remember hmmm

If you want to run it again it fine, if you put five

I1- Ok [laugh]

Run it, and you also have a graph to the right so you can also.

I1- hmmm it’s more equally than difference between face [short pause] and the other

Ok, ok now it says here, how did you decide when to use the English version and when to use the Spanish version of the applet?

I1- Which one what?

It says How did you decide when to use the English version and when to use the Spanish version of the applet?

I1- How? How I decide?

Or just

I1- it doesn’t matter

It doesn’t matter ok. What difference between the two versions did you notice or experience? Or any difference between the two

I1-hmmm no

No ok. Do you think that using applets like this would or would not be helpful to you or to other students? And why?

I1- yes will be hmmm help us to know statistic or the probability in the come

And then, we didn’t really used it but I gave you a word list.

I1- [laugh]

It says. Excuse me. Do you think it would or would not be helpful to have a word list such as this one that shows English and Spanish equivalents for probability terms? But I think you

I1- I didn’t use it.

You didn’t really use it
That’s ok, but do you think it would be helpful to have a word list or it wouldn’t matter to you?

It doesn’t matter

Ok, and we are done with it.

[nervous laugh]
We are going to start the interview. Ok first question is what do you already know about probability?

I2- hmmm probability is [short pause] hmm I don’t know hmmm

When they ask you about the probability of something, what is that?

I2- the outcome or something

Ok, what probability or stat courses have you taken, are taking or plan to take?

I2- hmmm just the statistics 1380

Ok. Ok, I’m going to give you a penny. So what would you call the sides of a coin in English?

I2- heads and tails

Ok, what would you call the sides of a coin in Spanish?

I2- cara or [short pause] letra something I really don’t know in Spanish.

Ok, ok now remember that you are always welcome to ask for a question to be given to you in Spanish if it is not clear in English. The English version will refer to coin sides as heads and tails, and the Spanish version we’re going to refer to it as cara and escudo.

I2- Ok

Ok now, if you flip the coin twice, what do you think is the probability you get exactly one head?

I2- 1 out of 4

Why?

I2-Because there’s two sides and you flip it twice

Ok, if you flip the coin four times, what do you think is the probability of getting exactly 2 heads?

I2- one fourth because its there’s four times two sides, four times two and then I’m getting two heads, two out of eight and if you simplified it it’s 1 out of 4.

Ok now, if you flip the coin 100 times, how many times do you expect to get heads?

I2- hmmm I don’t get it, 1 out of 100 wait 2 heads out of 200

It says if you flip the coin 100 times, how many times do you expect to get heads?

I2- oh 1 out of 100
What do you think is the probability of getting exactly that many heads in 100 flips?

I2- can you repeat the question?

What do you think is the probability of getting exactly that many heads in 100 flips?

I2- you’re bound to get a head when you flip it 100 times

Ok

If you flip 100 times, how different from 50 heads would you have to get to call that result surprising?

I2- can you repeat it again

If you flip 100 times, how different from 50 heads would you have to get to call that result surprising?

I2-[short pause] can you read it in Spanish?

¿Si lanzas la moneda 100 veces, que tan diferente de 50 caras tendrías que obtener para que el resultado sea sorprendente?

I2- hmmm how many times does it have to be so that is has to be like surprising more than 50 I’m sorry it’s cus I’m

How different from 50 heads would you have to get to call that result surprising?

I2- do I have to give a number? how different from 50 heads [short pause] 150

Ok, if you flip 10 times, what do you think is the probability to get of getting between 40% and 60% heads – in other words, exactly 4, 5, or 6 heads?

I2- what is the probability? Well 4 out of 10 probability to find it

Ok, now if you flip 100 times, what do you think is the probability to get of getting between 40% and 60% heads, in other words exactly 40, 41, 42, all the way to 60 heads?

I2- Can you read it in Spanish?

Ok, si lanzas la moneda 100 veces, ¿cual crees que sea la probabilidad de obtener entre 40 por ciento y 60 por ciento de caras, en otras palabras exactamente 41, 42, hasta 60 caras?

I2- hmmm nose [I don’t know] eight

Ok, why do you think that your answers for the last 2 questions were different?

I2- hmmm it’s going to be a because this one was more specific than the other one

Ok. Ok now suppose there was a graph of the proportion of heads so far for 100 flips, 200 flips, 300 flips all the way to 1000 flips. Make a sketch of what you imagine it might look like on the graph paper.

I’m going to give you this graph paper and I’m going to repeat the question again.
It says suppose there was a graph of the proportion of heads so far for 100 flips, 200 flips, 300 flips all the way to 1000. Make a sketch of what you imagine it might look like on this graph paper.

I2- I’m not sure, it would go line graph table or like a, I’m sorry I don’t know

Ok. Ok, I’m going to show you.

I2- Can you repeat it in Spanish like maybe I

Supón que hay una grafica de la proporción de caras que han caído hasta el momento después de 100 lanzamientos, 200 lanzamientos hasta 1000 lanzamientos. Haz un dibujo de lo que imaginas que podría ser la grafica en este papel. Ok, this are graphs, premade graphs and I’m going to ask you which one do you think is more likely to happen? So, you were kind of confused on how to graph them so I’m going to show you. You have A, B, C, and D. I’m going to give them to you.

I2-[looking at the graphs] it’s more likely is a 50-50 chance

So, your answer is

I2- D [y=0.5]
this question says, suppose there was a graph of the absolute difference the number of heads so far and the number of tails.

I2- Is absolute difference like, it just means the difference?

Absolute difference is like it’s the absolute value, so even if it’s negative it’s still positive

I2- oh ok

That’s absolute value [long pause] Ok I have another set of graphs.

I2- ok [long pause] hmmm I don’t know

So this side says the difference between heads and tails

I2- mm-hmm

and here is the number of flips

I2- I guess I’ll go with B [short pause]

![Cumulative Absolute Difference Between Number of Heads and Number of Tails](image)

Ok, and why?

I2- hmm because it starts of at 0 and then like it goes to 10 it grows

Ok. Ok now for the next couple of questions I’m going to ask you to consider these sequences. I’m going to give you this paper with 2 sequences. Ok what sequence has a higher probability of happening or are they equally likely?

I2- hmmm [short pause] I think they are equally likely

Equally likely, ok. If one of the sequence were made up and the other one actually obtain from a real coin flipping, which do you think was which and why?
I2- I think A because
A is which one?
I2- the actual flipping
Ok
I2- because there’s more patter like, like in this one just has a pattern [pointing to sequence B]
Ok. In your own words, what does longest run mean to you?
I2- Longest run?
Yes
I2- [shot pause] longest run [laugh] hmm like which one has more consistent throughout the like which one had more like heads or tails or
Ok, now in your own words, what does in the long run mean to you?
I2- does it have to like relate to math?
Yeah
I2- In the long run, I don’t know
Or in everyday life
I2- In the long run like isn’t it’s [long pause] like ahmm in the long run I know what it means but I don’t know how to explain it to you. It’s kind of self explanatory, like you know something in the long run its like it happen, I don’t know how to explain it but I know what it means
Ok, now long at sequence A
I2- Mm-hmm
And what is the longest run?
I2- Hmm, the one that has the most T’s
Ok, which is?
I2- Well there’s 2, like this one
Ok,
I2-Cus it has the most T’s
The most T’s. How many T’s in that?
4, ok. So in sequence B, what is the longest run? [long pause]

There is no longest run. Well cus they are all like, well what I’m thinking longest run is is the one that has the most and

And what’s longest run going to be?

There’s 2 H’s and 2 T’s

Ok. Ok now, for 100 flip sequence how long do you think is the longest run of either heads or tails would be?

like percentage?

Like what do you think is the longest run, like here what is the longest run in A?

the 4 T’s

Ok 4, what was the longest run in B?

The 2 T’s and 2 H’s

Ok, so now for 100 flip sequence how long you do think is the longest run of either heads or tails would be?

Hmmm [short pause] hmm it would be of 5

Now if you saw a streak of 4 heads in a row for a fair coin, what do you think is the probability of heads for the next flip?

can you repeat the question again?

If you saw a streak of 4 heads in a row for a fair coin, what do you think is the probability of heads for the next flip?

3

Ok, now I’m going to bring up the applet and we are going to save this one right here. Ok, now I’m going to let you run the applet like about 5 times. So first I’m going to show you how it works, here we are going to flip it 100 times.

mm-hmm

And here is going to be counting, the probability of heads is .5 it’s a fair coin 50-50. And it’s going to be counting the number of tosses, number of heads, number of tails, the longest run of heads, the longest run of tails, the percentage of heads, and the chance error. And here you can change it to Spanish [changing the applet to Spanish]
152 English is fine

153 Ok, I’m just going to show you that they are exactly the same thing. Now everything is in Spanish

154 I2 - Ok

155 You can use which ever you want to use.

156 I2 - Ok, that one is fine [leave the Spanish version]. Do I just press it.

157 Ok, and do you see right here it gives you it’s a graph it’s a bar graph of the probability of heads and tails. Ok, run it again. I want you to look at the numbers. Run it again.

159 I2 - Ok

160 Ok, and then what is chance error? This is error aleatorio [chance error]

161 Mm-hmm

162 Like it’s 6, why? Because if we are saying 50-50 but it went over 6 so the error is 6.

163 I2 - Oh ok,

164 Yes, that’s what it’s doing

165 I2- what it means, ok

166 Now we are going to start with the questions. It says how does this change or confirm what you predicted about how far off from 50 heads would you reasonably expect to get in 100 flips?

168 I2- hmmm, it’s kind of a 50-50 chance so the numbers aren’t that far off, there is not much of a chance error or a difference

170 Ok, now what do you think 1000 flip sequence would have a larger, smaller or equal chance error compared to 100 flips?

172 I2- I think it would have a greater because there’s more like flipping, there would be more chances if you flip a coin

174 Ok, ok does exploring with the applet make you want to keep your answer or change your answer to the question 13 where we were using the graphs. Remember for this one you choose letter D. [interviewer shows the graphs again]

177 I2- Mm-hmm

178 When we were comparing, when we were doing the cumulative proportion of heads.

179 I2- Again this one is like more similar to this one [pointing to C]

180 Ok, so you would change it to?
I2-C maybe, I guess

C

I2- because the difference is kind of like the

Ok, ok now does exploring with the applet make you feel you want to keep or change your answer
question 14, where we [short pause], this other graphs over here, you choose B.

I2-[short pause] hmmm

Now this one, we are talking about the difference, the cumulative absolute difference between the
number of heads and the number of tails

I2- the chance error of the numbers

This is just the difference between the number of heads and the number of tails

I2- oh ok, I’ll keep it

Keep it, ok. Ok, now you had predicted in a previous question that there would be a longest run of 5 in
100 toss sequence, does the result seem to confirm or conflict with your prediction? Look at the longest
run. How many does it say? Successive

I2- el mayor numero de caras sucesivas 9 [the number of successive heads]

9 ok. Run it again. [long pause] Now that you had run it a couple of times like does it seem to confirm or
conflict with your prediction?

I2- the one I guess it conflicts

You said it would be 5

I2- 5, I guess it’s not that different it said 6 and I said 5.
Ok. Now how many tosses do you think it would take before we see a streak 4 heads in a row? So how many flips do you think we had to do to get 4 heads in a row?

I2- hmmm, maybe 80

80, ok. Now what we are going to do we are going to change the mode

I2-Mm-hmm

Now here I want you to put 4, so it’s going to keep on going it’s going to keep on flipping until we get 4 heads in a row.

I2-ok

I want you to run it. Do it again. Do it again. Let’s try it one more time. Ok how does this result seem to confirm or conflict with your prediction?

I2- it conflicts because it took less,

It took less ok. If we change the probability of heads form .5 to .7 what change if any do you think there would be in the difference of how many tosses it would take to get a streak of 4 heads in a row?

I2- Can you read it in Spanish?

Ok, si cambiamos la probabilidad de caras de .5 a .7 cuál sería el cambio, si es que habría un cambio, que crees que habría una diferencia de cuantos lanzamientos se necesitan para obtener una racha de 4 caras consecutivas?

I2- Ah-mm I think there would be more probability like the flippings it would be less

Ok, ok now we are going to change the probability to .7

I2- do I press it?

Run it, run it again. Let’s try it one more time. Let’s try it one more time.

I2- it’s the same thing

I2- yeah

Does the result seem to confirm or conflict with your prediction?

I2- it confirm it, because it took less

Ok, if we change the probability of heads from .5 to .7 what change if any do you think there would be in the number of heads?

I2- mm-hmm
So if we change the mode again to flipping 100 times and we leave the .7 what do you think is going to be the number of heads, what change there would be?

I2- hmmm there probably be equal

Ok. And what change if any do you there would be in the longest run of heads?

I2- hmmm

So we changed the probability, so now what would be the change in the longest run of heads?

I2- I guess there would be more heads because there’s more probability

Ok let’s see, let’s run it. Let’s run it one more time. Ok does the result seem to confirm or conflict with your prediction?

I2- it confirms it because there is more caras sucesivas [successive heads]

Ok, now how did you decide when to use the English version and the Spanish version of the applet?

I2- how did I decide? Ahmm I don’t k now, I guess like when in Spanish if I don’t recognize the words I would change it English.

Ok and what difference between the 2 versions did you noticed or experienced?

I2- hmm there’s no difference

Ok, do you think that using applets like this would or would not be helpful to you or other students?

I2- hmm I think it would be because to me I’m more of a visual person so that’s why I was having a hard time when you were asking me questions because I was trying to visualize it. So I think this would be better because you can see what’s happening

Ok, do you think it would or would not be helpful to use a word list such as this one that shows English and Spanish equivalent for probability terms? So using a word list like this one would be useful or not

I2- Yes, like some words seem more understandable in English I mean in Spanish than in English, like you see it in Spanish and you are like oh

Ok we are done with the interview. Thank you.
Appendix E3 – Transcripts from Interview I3

1. Ok what do you know, what do you already know about probability?

2. I3- probability is hmmm the chances of something happening

3. Ok what probability or stat courses have you taken, are taking, or you plan to take?

4. I3- a statistics class

5. You know which one?

6. I3- I don’t know, the introductory one

7. Ok

8. I3- is that good enough?

9. Yes, what do you call the side of this coin in English? Like of a coin

10. I3- the heads and tails

11. Ok, what do you call the sides of a coin in Spanish?

12. I3- hmmm I don’t know

13. You don’t know, ok. So Remember that you are always welcome to ask for a question to be given to you in Spanish if it is not clear in English. The English version will refer to coin sides as heads and tails, and the Spanish version with cara and escudo. So If you flip the coin twice, what do you think is the probability you get exactly one head?

14. I3- hmmm [short pause] one fourth

15. Why?

16. I3-because in one flip it is one half and then in another flip it is another one half so when you multiply it, it comes to one fourth

17. Ok, now if you flip the coin four times, what do you think is the probability you get exactly 2 heads?

18. I3- four times?

19. Yes

20. I3- [counting with the fingers] one sixteenth

21. One sixteenth, why?
I3- because the same when you flip it is one half each time that you flip it and then on and on to get the same thing again wait, you said four times to get heads how many times?

Two

I3- oh sorry, its one half

Ok

I3- sorry

So if you flip the coin 100 times, how many times do you expect to get heads?

I3- 50

What do you think is the probability of getting exactly that many heads in 100 flips?

I3- one half

If you flip 100 times, how different from 50 heads would you have to get to call that result surprising?

I3- I’m sorry can you repeat the question again?

If you flip 100 times, how different from 50 heads would you have to get to call that result surprising?

I3- hmmm may be alike one fifth of the times

Ok, if you flip 10 times, what do you think is the probability of getting between 40% and 60% heads – in other words, exactly 4, 5, and 6 heads or 6 heads?

I3- approximately hmmm [long pause] 40 that well its cus [short pause] its 40 to 60 percent that’s what it is to get 40 to 60 percent

Ok, so if you flip 100 times, what do you think is the probability of getting between 40% and 60% – in other words, 40, 41, 42 all the way to 60 heads?

I3- hmmm the same 40 to 60 percent

Ok, now why do you think your answers to the last 2 questions were the same?

I3- because the values of are both in tenths

Ok

I3- 4 to 6 and from 1 to 10 and then 40 to 60 between 1 to 100

Ok, now suppose there was a graph of the proportion of heads so far for 100 flips, 200 flips, 300 flips. Make a sketch of what you imagine it might look like on this graph paper. So I’m going to give you graph paper. So I’m going to repeated again now suppose there was a graph of the proportion of heads
so far for 100 flips, 200 flips, 300 all the way to 1000. Make a sketch of what you imagine it might look like on this graph paper.

I3-[looking at the paper] this proportion of heads the is that the chances of happening? [flips the penny] Ok, ok hmm

I3- I’m just trying to think about the question I just totally didn’t get

Ok, hmm

I3- is only part on it is showing? like I don’t get that part

Ok, so I’m going to show you some graphs [show the graphs]. So you can select which one

I3- it should show like only 50% [draw a straight line y=0.5]

Ok

I3- I think it might be like very close to it [draw a wavy graph on top of the previous one]

Ok, so which one would you pick?

I3- hmm

The one with the straight line or the other one?
Ok, straight line, ok. So now suppose there was a graph of the absolute difference between the number of heads and the number of tails so far for 100 flips, 200 flips, 300 flips. Now make a sketch of what you can imagine it might look like on this graph paper. Now suppose there was a graph of the absolute difference between the number of heads and the number of tails.

I3- hmm I think it would be like would be closer to zero cus it should be the same [draw a straight line y=0]

Ok, now I’m going to give you two sequence of heads or flips

I3- Ok

For the next couple of questions. Ok. What sequence has a higher probability of happening or are they equally likely?

I3- [looking at the paper] they are equally likely

Ok, If one of the sequences were made up and the other actually obtained from real coin flipping, what do you which do you think was which and why?

I3- Hmm I think that the second one was the because

The second one was what?
I3- actually the

Oh

I3- just that the first one was made up hmm because the chances to pick there’s like more tails in the first one

Ok, in your own words, what does longest run mean to you?

I3- the longest run?

Yes

I3- Like it’s the longest time one like tails went 1, 2, 3, 4 times and you keep flipping it, it kept coming to 4 times

Ok, in your own words, what does in the long run mean to you?

I3- the final outcome

Ok, the final outcome,

I3- in the long run it should be that this was 100 50 is tails and 50 is heads even though some might be hmm consecutive like tails might be consecutive

Ok, in sequence A, what is the longest run?

I3- [Looking at the paper and counting] 4 tails

In sequence B, what is the longest run?

I3- 2

For a 100-flips sequence, how long do you think the longest run of either heads or tails?

I3- hmmm may be [short pause] 2

2

I3-Mm-hmm

Ok, if you saw a streak of 4 heads in a row for a fair coin, what do you think is the probability of heads for the next flip? So if you saw a streak of 4 heads in a row,

I3- the

For a fair coin, what do you think is the probability of heads of the next flip?

I3- it’s still 50% cus you still have both sides
Ok, ok now I’m going to show you the applet here we can have it in English or we can change it to Spanish [change it from English to Spanish]

I3-ok

And the both do the same thing

I3- mm-hmm[she changed it back to the English version of the applet]

Here they keep record of what’s going to happen, so you see the tosses heads and tails and everything so you could use, you could use which ever you want, it doesn’t really matter which one you use. Ok run it lets see what happens.

I3-Press start?

Press start. So that one what that does if flipping 100 times the coin keeping record of what happens.

I3- Jesus that’s a lot heads

Ok now run it again

I3- Oh my God look it

Ok, ok now how does this change or confirm what you predicted about how far off from 50 heads would you reasonably expect to get in a 100-flips?

I3- it’s approximately the same but 2% off to how many the percentage to get heads

Ok, do you think a 1000-flip sequence would have a larger, smaller, or equal “chance error” compared to a 100-flip sequence? Like here it says chance error because this is 48 right, you said it was 50 right the it should be 50 50, so the error here

I3- it’s going to be 2

This is 2 yes, so if we do it again. It might change a little,

I3-hmmm

So see now it’s what?

I3-so the

Its it went its 55 it went over 5, so that’s the chance error, so the question is do you think a 1000-flip sequence would have a larger, smaller, or equal “chance error” compared to a 100-flips?

I3- hmm greater, more [raising her hand at the same time as saying greater]

Greater, why?

I3- hmm because we’re adding like there’s more chance for it to, to be different
Ok, ok now does exploring with the applet make you feel that you want to keep your answer or change your answer to the question about the

I3-change it

About the graph, about the first graph you made in which said suppose there was a graph of the proportion of heads so far for 100, 200, 300 flips.

I3- I would change it to be a little more

Ok, ok you would change it?

I3- like smaller and then get bigger like that [drawing in the paper a wavy graph]

Ok, you would change it to be smaller and then bigger

I3- like the squiggles small and big

Ok, what about for, ok now does exploring with the applet make you feel make you you want to keep or change your answer to number 14. That one was like suppose there was a graph of the absolute difference between the number of heads so far and the number of tails for 100, 200, 300. So now, we are looking at the difference

I3- Oh ok, so you have this one and just keep it like that, and this one like that
Ok, so the first one you would keep it like squiggly, ok and this one, and this one too.

Ok, so now you had predicted in a previous question that there would be a longest run of 5, no of 2, you said of 2 in 100-toss sequence. Does the result seem to confirm or conflict with your prediction?

I3- it conflicts

It conflicts, how many tosses do you think it will take before we see a streak of 4 heads in a row? [short pause] So how many tosses do you think it will take before we see a streak of 4 heads in a row?

I3- hmm may be like hmm it could happens any time, I guess with in the first 20

20, ok. Ok so now we are going to change the mode of the applet for longest run and then we said 4 heads. So let’s press 4, and it’s going to keep on flipping until we get 4 heads in a row. Ok try it again. Ok try one more time. One more time. Ok let’s try one more time. Ok, does your result seem to be confirm or conflict with your prediction?

I3- its, well the average is probably close enough

Ok. If we change the probability of heads from .5 to .7, what change, if any, do you think there would be in the difference on how many tosses it takes to get a streak of 4 heads in a row?

I3- it would be to a like small number hmm in the first 5 or first 7
Ok, let’s see what happens, now we change the probability to .7 and lets run it a couple of times.

I3- like that, I don’t think, I think it’s a little bit more

So does the results seem to conform confirm or conflict with your prediction?

I3- conflict

Why?

I3- ah cuz it took a little bit longer than before average like 12

Ok, now if we change the probability of heads from .5 to .7. What change, if any, do you think there would be in the number of heads? So now if we run it like 100 times

I3- mm-hmm the heads will be more

Ok, what change, if any, do you think there would be on the longest run of heads?

I3- [long pause, looking at the screen] 7

Ok, let see, let

I3- 100

Now click on the number of head tosses, ok now start. Let’s run it one more time. Ok does the result seem to confirm or conflict with your prediction?

I3- I think it’s very close

Ok, ok how did you decide when to use the English version or when to use the Spanish version of the applet? Like why did you decided to use the English version

I3-mmmm [raising a shoulder to signal I don’t know] I don’t know

You don’t know, ok. What difference

I3- force of habit

The what?

I3- force of habit, force of habit

Ok,

I3- ok

And what difference between the two versions did you notice or experience or

I3- what what?
What difference between the two versions the English and the Spanish version did you noticed or experienced?

I3- I didn’t experienced the Spanish version

Ok, do you think that using applets like this would or would not be helpful to you or to other students?

I3- it would be helpful

Why?

I3- because in one it is very clear with the toss and two its showing you a lot of the different types of ah data for the coin toss like the actually number of toss that you get to play with it and figure out what ever kind of information you need and, and it has like a lot of information just for that

Ok, do you think it would or would not be helpful to have a word list such as this one to show English and Spanish equivalents for probability terms?

I3- yes

Why?

I3- because a lot of people it’s like hmm kinesthetic learners and visual learners and I think that something like this covers all grounds of different types of learning styles

Ok. Thank you for your time we are done
Appendix E4 – Transcripts from Interview I4

1. Ok, what do you already know about probability?
2. I4- probability is [short pause] in like in math terms, it would be like the probability like like in a number, like what is the probability of I haven’t done that in a while [laugh] ah-mm probability like in what way.
3. Just probability, what does it mean to you. What does it mean?
4. I4- it means something I don’t understand in math
5. Ok, what probability or stats courses have you taken, are you taking, and plan to take?
6. I4- I’m taking stats 1320 right now
7. Ok, what do you call the sides of a coin in English? [interviewer gives a penny to the interviewee]
8. I4- in English, ah like that one a penny
9. Like the sides,
10. I4- The sides, heads or tails
11. Ok. What would you call the sides of a coin in Spanish?
12. I4- ah [short pause] like cabeza [head] or I’m not sure, I’ve never thought of that
13. Ok, remember that you are always welcome to ask for a question to be given to you in Spanish if it is not clear in English. The English version will refer to coin sides as heads and tails, and the Spanish version as cara and escudo. If you flip the coin twice, what do you think is the probability you get exactly one head?
14. I4- twice it would be 2 out of 1 , like 1 out of 2, I’m sorry
15. 1 out of 2, why?
16. I4- ahm because there’s only two sides, there’s two different sides so
17. Ok,
18. I4- one or the other
19. Ok, if you flip the coin four times, what do you think is the probability of getting 2 heads?
20. I4- it would still be 1 out of 4 right? Well if you flip it four times and there’s still just 2 sides it would be 2 out of four.
Ok, why?

I4- Because it can be there the one of the other sides could be flipped four times

Ok, if you flip the coin 100 times, how many times do you expect to get heads?

I4- 2 out of 100, I mean 1 out of 100, just heads?

Just heads

I4- 1 out of 100

Ok, if you flip 100 times, how different from 50 heads would you have to get to call that result surprising?

I4- what do you mean?

Ok, if you flip 100 times, how different from 50 heads would you have to get to call that result surprising?

I4- 50 out of 50 I am not sure

Ok, so if you flip 10 times, what do you think is the probability of getting between 40% and 60% heads – in other words, exactly 4, 5, or 6 heads?

I4- what is the probability? Or what is

Yes, what do you think is the probability if you flip 10 times of getting between 40% and 60% heads, in other words, getting exactly 4, 5, or 6?

I4- 4 out of 10 or 4 out of 6

Ok,

I4- not sure of that one [laugh]

Ok now if you flip 100 times, what do you think is the probability of getting between 40 and 60% of heads, in other words exactly 40, 41m 42 all the way to 60 heads?

I4- it would be the pro probability well if you want to get lets say 40 it would be 40 out of 100, wouldn’t it?

Ok, now what do think yours answers for the last two questions were different?

I4- because they were phrased differently

Ok now

I4- cus I’m just guessing
Ok, suppose there was a graph of the proportion of heads so far for 100 flips, 200 flips, 300 flips, all the way to 1000.

I4- mm-hmm

Your going, hmm make a sketch of what you imagine it might look like on this graph paper. I’m going to give you some graph paper. I’m going to read the question again. It says suppose there was a graph of the proportion of heads so far after 100 flips, 200 flips, 300 flips, all the way to 1000.

I4- does it have to be a bar graph or a line graph?

It’s that working [the interviewee was having problems with the mechanical pencil]

I4- there you go

Ah ok.

I4-[graphing] I don’t know if that’s right

Ok, now suppose there was a graph of the absolute difference between the number of heads and the number of tails so far after 100, 200, 300, flips all the way to 1000. Make a sketch of what you imagine it might look like on this graph paper.

I4- like how many times you get heads?
Ok let me read it. Suppose there was a graph of the absolute difference between the number of heads so far and the number of tails so far after 100, 200, 300, flips all the way to 1000.

I4- I have no idea how that would look like

Ok. I’m going to show you some graphs. You can pick which one do you think [show the graphs]. So we are looking at the absolute difference between the number of heads and the number of tails for 100, 200, 300, all the way to 1000 flips.

I4- hmmm

So we are looking at the difference between heads and tails

I4- yeah, if anything I would probability pick the one that goes up and down,

Ok, so which one would that be?

I4- B

B, ok. Ok so now I’m going to give you 2 sequences. Ok for the next couple of questions, consider these two sequences of coin flips.

I4-ok

What sequence has a higher probability of happening or are they equally likely?

I4- they’re equally likely

If one of the sequences was made up and the other actually obtained from real coin flipping, which do you think was which and why?

I4- you really couldn’t figured it out because it is random

Ok. In your own words, what does longest run mean to you?
hmmm, in math nothing

Ok, in your own words, what does in the long run mean to you?

in the long run would be like let’s say in the long run after you flip the coin so many times how many times you think heads would show up.

Ok. Ok, in sequence A what is the longest run? [looking at the paper]

heads.

In sequence B what is the longest run? [looking at the paper]

heads

Ok, for 100 flips sequence, how long do you think the longest run either for heads or tails would be?

repeat that

For 100 flips sequence, how long do you think the longest run of either for heads or tails would be?

hmmm out of this 2 or?

I’m sorry.

out of this 2?

No, just out of 100 flip sequence.

ahm I don’t know it could be equal or random, I never thought about it

Ok, if you saw a streak of 4 heads in a row for a fair coin, what do you think is the probability of heads for the next flip?

ahmm 1 out of 2

Ok, so now I’m going to show you an applet. I’m going to put here in the computer. Is about coin tossing, here is the number of tosses is going to flip it, and then the probability, and its going to keep record of what happens, the number of tosses of heads, number of tosses, number of heads tails, the longest run, the longest run its like how much it repeats like constantly

mm-hmm

Right? Like in this case, the longest run in this case. Ok well I’ll tell you right now. Like we are going to run it right now and you’ll see what the numbers are

ok

Doing. And then right here we have the option to change it to Spanish and its exactly the same thing just that in Spanish
Ok, now I want you to run it so that we can see what happens, so that you can see what happens.

I- it just did it ah 51 percent

Ok, let’s run it again, let’s see what happens again.

I- borra y iniciar? [delete and start]

Just, you can just press iniciar and it would do it again.

I- it just flipped them around

Ok, let’s do it again.

I- ahmm [short pause] this time yeah

Ok, so how does this change or confirm what you predicted about how far off 50 heads you would reasonably expect to get in 100 flip sequence?

I- ah 6 percent

Like how does this change or confirm what you predicted about how far off from 50 heads you would reasonably expect to get in 100 flip sequence?

I- I said it would be 1 out of 2 so pretty much a little bit up,

Ok, a little bit up. Do you think a 1000-flip sequence would have a larger, smaller, or equal chance error compared to a 100-flip sequence?

I- there will be more of like a difference I think

Why?

I- because it’s a lot more flips [moving hand forward as she says a lot more]

Ok, does exploring with the applet make you feel that you want to keep your answer or change your answer to the previous question about, about the proportion of heads for 100, 200, 300 all the way to 1000, in other words your graph right here.

I- yeah, yeah I will probably like make it go up and down

How would you make it like, like how would you change it. You don’t have to erase it you can just draw the other one on top of it.

I- [draws the new graph] this time I’ll make it largest randomize it just like, it’s broken down
Ok, now does exploring with the applet make you feel that you want to keep or change your answer to the question about the absolute difference between the number of heads and the number of tails, so previously

I4- B

So you want to keep B?

I4-B

Ok, you had predicted in a previous question that there would be a longest run actually you said you didn’t know for 100 toss sequence,

I4- mm-hmm

Does the result seem to confirm or conflict with our prediction? Like here it keeps track of the longest run here in Spanish says

I4- el numero de caras sucesivas [the number of successive heads]

Yes, and then if we do it in the English it say longest run of heads. So does that want to make you change your prediction or keep your prediction

I4- keep it still

So it doesn’t
I- well no because like even as many times as you flip a coin is never constant so I don’t know if I understand that question or not

It says, [short pause] let me read the question

I- I’m exhausted from the whole day

It’s ok [short pause] it says for 100 flips how long do you think the longest run would be?

I- like how many times or, well yeah it would be random so it wouldn’t be constant so I wouldn’t change it

Ok, how many tosses do you think it will take before we will see a streak of 4 heads in a row?

I- ahmm [long pause] like if its, I don’t know. For it to get like 4 streaks in a row the same

4 streaks of heads in a row

I- we are doing it out of 1000

Like how many tosses do you think it will take before we see a streak of 4 heads in a row?

I- at least, at least 4, at least 5

At least 5 ok. Lest see, so now we are doing to run it. Now we are going to change here, and we are going to change how many heads we want, we are looking for 4 heads

I- yeah

It’s going to keep on going until we hit 4 heads, so let’s see run it. Ok run it again. Let’s run it one more time.

I- one more time?

Mm-hmm, ok does the result seem to confirm or conflict with your prediction?

I- well you can run it more than five times I guess so

Ok, what if we change the probability of heads from .5 to .7, what change, if any, do you think there would be in the difference on how many tosses it takes to get a streak of 4 heads in a row?

I- it would probably take more, I’m just guessing

More. Well let see what happens, change the probability to .7, let’s run it again. One more time. Ok so does it seem to confirm or conflict with your prediction?

I- conflict

Ok, now if we change the probability of heads from .5 to .7, what change, if any, do you think there would be on the number of heads?
I4- repeat it again

Ok so if we change it back to running like tossing it 100 times

I4- yeah

If we change the probability of heads from .5 to .7, what change, if any, do you think there would be on the number of heads?

I4- there would probably be more heads

Ok

I4- more caras [referring to heads]

What change, if any, do you think there would be on the longest run of heads?

I4- I’m not sure, it would show more caras sucesivas [moving hand forward as she’s saying cara sucesivas; successive heads]

Ok, now let’s change it, let’s run it.

I4- just to iniciar?

No, we need to change the mode. Select the one on the top.

I4- this one? Oh

That one, yes. Ok does the result seem to confirm your prediction or, confirm or conflict with your prediction?

I4- conflict, I thought it would take less time to get more caras

Ok. Ok how did you decide when to use the English version and when to use the Spanish version of the applet?

I4- when I read it on the screen in Spanish, I preferred it using in Spanish

Ok. What difference between the two versions did you notice or experience?

I4- hmmm [long pause, looking at the screen] not really, in particular

Ok, do you think that using applets like this would help or would help, ok let me read it again, do you think that using this applet would or would not be helpful to you or other students?

I4- it could be helpful if we do the probability of coin tossing

Ok, do think it would or would not be helpful to have a word list such as this one, the one I gave you

I4- ok
That shows English and Spanish equivalents for probability terms?

It could be helpful for bilingual students

Why?

I4- because some time even though we do nominate both languages hmm it is a tendency to understand one language in certain time than in others, I sometimes find myself in having to goggle words in from English to Spanish or, even though Spanish was my first language so I am more dominate in Spanish

Thank you.
Appendix E5 – Transcripts from Interview I5

1. How much do you already know about probability?
2. I5- how much do I know about probability, average, not too much
3. What’s probability?
4. I5- what is it?
5. Yes, what is it?
6. I5- what is the probability of something happening, like what is it hmmm, how can I explain it, [short pause] what is the most probable outcome of something going to happen
7. Ok, what probability or stats courses have you taken, are taking, or plan to take?
8. I5- well just a statistics course basically
9. Ok, what would you call the sides of a coin in English? [interviewer gives a penny to the interviewee]
10. I5- what would I call the side, the sides?
11. Yes like this side or this side
12. I5- the faces, the face of the side, I don’t know
13. Ok, what would you call the sides of a coin in Spanish?
14. I5- hmmm la cara de la moneda [she is saying it as she flips the penny, the face of the coin] depends.
15. Like if you’re flipping a coin
16. I5- aha
17. you know what would you call it like it’s going to land on
18. I5- on cello o aguila o I don’t know
19. Ok, remember that you are always welcome to ask for a question to be given to you in Spanish if it is not clear in English.
20. I5- mm-hmm
21. The English version will refer to coin sides as heads and tails,
22. I5-mm-hmm
23. and the Spanish version with cara and escudo.
If you flip the coin twice, what do you think is the probability you get exactly one head?

- mm-hmm

If you flip the coin twice, that I get the 4 times the head?

- aha

What do you think is the probability you get exactly one head?

- 50, 50 percent

Ok, why?

- because if you are flipping it twice and you have 2 options so

Ok, if you flip the coin four times, what do you think is the probability you get exactly 2 heads?

- 50 as well

Why?

- cus, you’re flipping it 4 times and then you only have 2 options, is the same thing

Ok, if you flip the coin 100 times, how many times do you expect to get heads?

- depends, it could be a 50-50, 50 percent of chance

Ok, if you flip 100 times, how different from 50 heads would you have to get to call that result surprising?

- can you repeat the question again?

If you flip 100 times, how different from 50 heads would you have to get to call that result surprising?

- I don’t know,[short pause] well if you get the 100 times the whole you always get heads that would be surprising [laugh]

Ok, if you flip 10 times, what do you think is the probability of getting between 40% and 60% heads, in other words, exactly 4, 5, or 6 heads?

- you’re asking for what is the probability

Yes.

To get 60 percent, I don’t know, ah it depends, it depends on your look. I really don’t know

Ok
So, if you flip 100 times what do you think is the probability of getting between 40 and 60 percent heads – in other words, getting exactly 40, 41, 42 all the way to 60 heads.

I5- hmmm [long pause] it’s more than 50 percent, it’s a 50-50 chance, you just can’t know

Ok.

I5- this are tricky questions [laugh]

Ok, why do you think the answers for the last 2 questions were different?

I5- what do you, the difference?

Why do you think your answers for the last 2 questions were different?

I5- why do I think,[short pause] the second question is more like like they’re giving you a specific

Ok

I5- and the other one they’re just giving you it could be this, this and this [moving the hands forward when saying this, this and this]

Ok

I5- so they are giving you 3 options I think this is more specific

So now, suppose there was a graph of the proportion of heads so far for 100 flips, 200 flips, 300 flips all the way to 1000. Make a sketch of what you imagine it might look like on this graph paper. I’m going to give you graph paper, you can use the pencil if you want.

Ok- ok, what is it?

Ok question it says suppose there was a graph of the proportion of heads so far for 100 flips, 200 flips, 300 flips etcetera.

I5-[short pause] a ver házmelo en español [let me see in Spanish]

Ok, Supón que hay una grafica de la proporción de caras que han caído hasta el momento después de 100 lanzamientos, 200 lanzamientos, 300 lanzamientos, etc. Has un dibujo de lo que imaginas que podría ser la grafica en este papel.

I5- ah-mm, if you’re asking me for the probability of the flips, the proportion of heads. It’s a 50 chance, I don’t know

You don’t know, ok. I’m going to show you some graphs for here, which one do you think you would pick?
I5- [looking at the paper] I would say this one [pointing to the graph D]

Which of this graphs seems more likely?

I5- this one [pointing to graph D]

D, why?

I5- cus is, you only have two options there’s 50 chance even like if you throw 1000 times you always would have 50 percent chance of getting heads or tails, it doesn’t really matter

Ok, now suppose there was a graph of the absolute difference between the number of heads and the number of tails after 100, 200, 300 all the way to 1000 flips. So that’s another question.

I5- ok, what is it again?

Suppose there was a graph of the absolute difference between the number of heads so far and number of tails so far after 100 flip, 200 flip, 300 flip etcetera.

I5- [looking at the graph paper, while thinking] I don’t know

Ok, I’m going to show you another set of graphs

I5- ok, the absolute number you’re asking right?

We are actually asking for the absolute difference

I5- difference

Between the number of heads and the number of tails
D

Cumulative Absolute Difference Between Number of Heads and Number of Tails

Number of Flips

D, why?

I5- I don’t think there’s a difference

Ok

I5- I mean, it’s just, it’s cus is simple, it’s a 50 percent chance. [laugh] I keep saying the same thing, I don’t know, maybe I’m wrong

That is fine. Ok now I’m going to give you 2 sequences right here

I5- mm-hmm

For the next couple of questions, consider these two sequences of coin flips. What sequence has a higher probability of happening or are they equally likely?

I5- [looking at the paper] they’re, they’re equally likely to have them because you don’t know if you are going to get more tails and heads like in this one [pointing to sequence A]

Ok, if one of the sequences were made up and the other actually obtained from real coin flipping, which do you think was which and why?

I5- which do I think would be the one that would be more likely to happen?

It says if one of the sequences were made up and the other actually obtained from real coin flipping, which do you think was which and why?

I5- this one [pointing to sequences B]

B was
I5- B would be the one more, the actual one

The real one or the made up

I5- yeah, the real one

Ok, why?

I5- because I think it’s more [pointing to the paper] you see here there’s heads tails heads tails tails head head and it’s like a 50 heads and then 50 it’s just a 50 percent chance right here

Ok,

I5 – it looks like you see it and then you start seeing the thing all crossed out [laugh]

Ok, in your own words, what does longest run mean to you?

I5- longest run [short pause] Hmmm like in the long in the long period like

The longest run, what does the longest run mean to you?

I5- longest run [short pause] I don’t know

Ok, en tus propias palabras, ¿Que significa la mayor racha o el mayor numero de caras sucesivas?

I5- mayor mayor racha el mayor porcentaje [greater longest streak the highest percentage]

O el mayor numero de caras sucesivas.

I5- las las veces que más tuviste cello o eso significa [the times you had most heads or that’s what it means]

Ok, in your own words, what does in the long run mean to you?

I5- ok in the [moving the hands forward]

In the long run

I5- in the long run, si [yes] like in ah in a certain time [moving the right hand forward] or at a certain period of time you would get this answer or whatever

Ok, in sequences A what is the longest run?

I5- in sequence A [looking at the paper] T tails

And what number is it like

I5- what is the number of tails that we have or?
Ok it would be, ¿Cuál es la mayor racha o cual es el numero de caras sucesivas? Cual es el mayor numero de caras sucesivas?

I5- hmmm [looking at sequence A] 4

Ok, what is the longest run for sequence B?

I5- the longest run [looking at sequence B] 2

Ok, for a 100-flip sequence, how long do you think the longest run of either heads or tails would be?

I5- can you repeat the question?

Ok, for a 100-flip sequence, how long do you think the longest run of either heads or tails would be?

I5- I can’t just answer here actually you don’t know cus it would be a 50-50 chance

Ok, if you saw a streak of 4 heads in a row for a fair coin, what do you think is the probability of heads for the next flip?

I5-[short pause] a 50 percent chance

Why?

I5-Because it doesn’t matter if you had it already heads 4 times the next time still a 50-50 chance of getting heads or getting tails

Ok, ok so now we are going to work with an applet. Ok here we have the English version

I5- mm-hmm

And it’s going to keep tracking, it’s going to keep track of the tosses

I5-mm-hmm

And the number of tosses, number of heads, number of tail, the longest run, the error chance and we could also change it to Spanish.

I5- ok

It’s the same thing it keeps record, la cantidad de lanzamietos, numero de caras, numero de escudos, mayor numero de caras sucesivas, numero de escudos sucesivos, it’s going to, it’s the same

I5- ok.

The same applet just that English

I5- and Spanish

I5- And Spanish
Ok now I want you to run the applet [the applet is in the Spanish version]

I5- do I push ini iniciar [start]?

Mm-hmm I want you to notice what is happening.

I5-ok

Ok run it one more time,

I5- ok

Ok one more. Let’s try one more. Ok. How does this change or confirm what you predicted about how far off from 50 heads you would reasonably expect to get in a 100 flip sequence?

I5-[looking and pointing at the screen] in all of the trials that we did is actually about 50 percent so it’s almost what I predicted, some of them were 40% the others were 50 52%

Ok, do you think a 1000 flip sequence would have a larger, smaller, or equal chance error compared to a 100 flip sequence?

I5- there would be no difference because there would be 1000 for

But like in this case the chance error is 2

I5- aha

So, let’s run it again

I5- in this one is 5

It’s going to keep changing right

I5- yeah

So do you think 1000 flip sequence may have a larger, smaller, or equal chance error compared to a 100 flip sequence?

I5-you would have a a larger

Why?

I5- cus if you do if you flip a coin more [laughs] then it would give you more error in case of whatever or it could be almost the same well it depends, I don’t know, it depends

Ok, ok does exploring with the applet make you feel that you want to keep or change your answer to the question about this one, about the proportion of heads. You choose this one do you want to keep your answer for it? [pointing to D]
I5- yeah cus it’s a 50-50, this one is for the cumulative right or?

This is the proportion of flips that are heads

I5- yeah

The question for this question was suppose there was a graph of the proportion of heads so far after 100 flips, 200 flips, 300 flips etcetera.

I5- hmm [short pause looking at the graphs] it’s cus it depends I don’t know. I still go with the 50% chance

Ok, now does exploring with the applet make you want to keep or change your answer to the other question about the absolute difference between the number of heads and the number of tails after 100, 200, 300 etcetera

I5-[short pause] the absolute difference, can you say the question in Spanish?

Ok, the question to this question was, supón que hay una grafica de la diferencia absoluta entre el número de caras y escudos hasta el momento después de 100 lanzamientos, 200 lanzamientos, 300 lanzamientos, etcetera.

I5- diferencia absoluta [short pause] I don’t think there’s a difference [shaking her head from side to side]

Ok

I5- no, so I’ll keep the same one. Tell me if I’m wrong [nervous laugh]

Ok, now you have predicted in a previous question that there would be a longest run of you said it would depend the longest run of in 100 tosses.

I5- mm-hmm

So do you seem to confirm or conflict with your prediction

I5- well [short pause] it’s cus there’s not too much error like as far as

But know we are talking about the longest run

I5- mm-hmm

El numero de caras sucesivas

I5-mm-hmm

You said that it would depend
Yeah, it could be 1 after doesn’t
So how many tosses do I have to do in order to get 4 heads after so 4 heads in a row
I- yeah yeah [shaking her head up and down] I understand the question the only thing is that I still
don’t [short pause] I don’t, I can not predict like is that going to happen how many times after you start
flipping the coin it just depends a lot
It just depends ok well let’s see what happens, so we are going to change the mode here and it’s going to
keep on flipping until we get 4 heads in a row
I- ok
So let’s see what happens. In this case it’s 27, let’s try it again, lest try it again
I- 16
Let’s try again.
I- 39
Ok, does the result seem to confirm or conflict with your prediction?
I- I think it confirms it cus you actually don’t know cus they were difference numbers like the first one
was 27, the second one was 16, the other one was 39 and this was 10 [pointing to the screen every time
she said a number]
Ok, so if we change the probability of heads from .5 to .7 what change, if any, do you think there would
be in the difference of how many tosses it would take to get a streak of 4 heads in a row? Ok, so if we
change the probability of heads
I- mm-hmm I don’t get it
From .5 to .7 what change if any do you think there would be on how many tosses it would take to get a
streak of 4 heads in a row?
I- if we change it from .5 to .7
Mm-hmm if we change the probability of heads from .5 to .7
I5- instead of 50% chance you’re going to start in 30
But do you think there would be a difference on how many tosses it would take to get a 4, 4 heads in a row
I5- hmm I don’t think there would be a difference cus it would depend on [long pause, as she points to the screen with her right hand] 70% combine, I don’t know
Change the probability to .7 and lets run it, let see what happens,
I5- 14
Let’s do it one more times
I5- 5, 8
Ok, let’s do it one more time
I5- 16
So does the result seem to confirm of conflict with your prediction?
I5- I think it confirms it cus you don’t it doesn’t make a difference ah unless you put it 100% probability to get a certain face I mean
Ok,
I5- unless you change it back to the different yeah it could be it could give you a different answer but no [shaking her head from side to side]
Ok, if we change the probability of heads from .5 to .7 what change, if any, do you think there would be on the number of heads? So now if we change the mode back to flipping 100 time
I5- mm-hmm
And we change the probability to .5 from .5 to .7 what change, if any, do you think there would be on the number of heads?
I5- there would be no change cus we are just putting 100 tosses right?
Yeah we are flipping 100 times
I5- and then
And the probability is changed from .5 to .7
I5- aha
What change do you think,
Do you think there would be any change if you think there would be in the number of heads?

I- I doesn’t really matter it’s the same thing.

Ok, what change if any do you think there would be in the longest run of heads?

I- longest run of heads [in a low voice] no change either cus you don’t know.

Ok, let’s see what happens can you change the mode?

I- to 100 [pointing to the screen]

Yes, lest try it again, one more time ok does the result seem to confirm or conflict with your prediction?

I- what was the question again?

It says, the question was if we change the probability of heads from .5 to .7 what change if any do you think there would be in the number of heads?

I- of course there would be more heads because you are changing the probability of having heads to 70% from 50% so it would be more.

Ok,

I- I think I would change my answer from before [laugh]

And then what change if any do you think there would be in the longest run of heads?

I- it would be larger percentage.

Ok, ok now how did you decide when to use the English version and when to use the Spanish version of the applet?

I- hmmm there’s no difference.

Ok, what difference between the two versions did you notice or experience?

I- well I experienced the Spanish only so I don’t know.

Ok,

I- but I think it would be the same thing.

Do you think that using applets like this would or would not be helpful to you or to other students?

I- well as far as if you are having problems with the wording of certain I don’t know terms it would be easier if you have the ability to change the language.
Ok

I5- cus may be you learned in Spanish like I did and then can you switch it to English it helps the average different you call average then you call probability it’s just different

Ok, do you think it would or would not be helpful to have a word list such as this the, one I gave you I5- mm-hmm

That shows English and Spanish equivalents for probability terms?

I5- yeah it would be good because that way you could like oh ok they’re talking about like graphic bars and so on like the histogram I had a hard time like knowing what it was una grafica de barras [a bar graph] because you call it here bar graphs and the professor is calling it differently so I kind of have to Google it and know what it was about and so on, so yeah it would be helpful at least for the first course and after that I think you probably get use to the wording and stuff

Ok, thank you.
Appendix E6 – Transcripts from Interview I6

1 Ok, what do you already know about probability?
2 I6- hmmm probability is the study of how likely is an event happen
3 Ok, what probability or stats courses have you taken, are you taking, and plan to take?
4 I6- I’m taking statatis statistics 1380 and that’s it
5 That’s it
6 I6- I took some statistics as in high school in Mexico
7 Ok, I’m going to give you a coin [interviewer give a penny to the interviewee] what would you call the
8 sides of a coin in English?
9 I5- heads and tails
10 What would you call the side of a coin in Spanish?
11 I6- aguila o cello o cara o cello
12 Ok, Remember that you are always welcome to ask for a question to be given to you in Spanish if it is
13 not clear in English. The English version will refer to coin sides as heads and tails, and the Spanish
14 version with cara and escudo. If you flip the coin twice, what do you think is the probability you get
15 exactly one head?
16 I6- if I flip it twice? Two fourths (2/4)
17 Why?
18 I6- because [short pause] can I say it in Spanish?
19 Yes
20 I6- porque si la aviento una vez ah tengo la probabi 50 por ciento de probabilidad de agarrarlo y pues
21 dos veces el doble [because if flip it one time I have 50 percent probability of getting it and twice the
22 double]
23 Ok, if you flip the coin four times, what do you think is the probability you get exactly 2 heads?
24 I6- 4, four eights (4/8) if I flip it 4 times
25 4 times and you get exactly 2 heads
26 Ok, if you flip the coin four times, what do you think is the probability you get exactly 2 heads?
If you flip the coin 100 times, how many times do you expect to get heads?

I6- [short pause] 50 out of 100

Ok, what do you think is the probability of getting exactly that many heads in 100 flips?

I6- can you repeat the question?

What do you think is the probability of getting exactly that many heads in 100 flips? So what is the probability of getting exactly 100 heads in, no 50 heads in 100 flips?

I6- 50 percent probability

Ok, if you flip 100 times, how different from 50 heads would you have to get to call that result surprising?

I6- can you repeat it in Spanish please?

¿Si lanzas la moneda 100 veces, que tan diferente de 50 caras tendrías que obtener para que el resultado sea sorprendente?

I6-[short pause] ah I would say 70 times

If you flip 10 times, what do you think is the probability if you to get it between 40% and 60% heads – in other words, exactly 4, 5, or 6 heads?

I6- ahmm sesenta, setenta o ochenta por ciento [sixty, seventy, or eighty percent]

Ok, if you flip 100 times, what do you think is the probability of getting between 40%-60% heads – in other words, exactly 40, 41, 42…, 58, 59, or 60 heads?

I6- hmmm cuarenta o sesenta por ciento [fourty or sixty percent]

Ok, why do you think your answers to the last 2 questions were different?

I6- hmm I’m not sure [shaking her head some side to side]

Ok, suppose there was a graph of the proportion of heads so far after 100 flip, 200 flip, 300 flip all the way to 1000. Make a sketch of what you imagine it might look like on this graph paper. I’m going to give you graph paper and you can use the pencil. Ok, suppose there was a graph of the proportion of heads so far after 100 flip, 200 flip, 300 flip all the way to 1000.

I6- [short pause] can you say it in Spanish please?

Supón que hay una grafica de la proporción de caras que han caído hasta el momento después de 100 lanzamientos, 200 lanzamientos, 300 lanzamientos, hasta 1000 lanzamientos. Has un dibuje de lo que imaginas que podría ser la grafica en este papel.

I6- [making a bar graph on the paper provided]
Ok, suppose there was a graph of the absolute difference between the number of heads so far and the number of tails so far after 100 flips, 200 flips, 300 flips all the way to 1000.

I6- can you say it in Spanish please?

Supón que hay una grafica de la diferencia absoluta entre el número de caras y escudos hasta el momento des pues de 100 lanzamientos, 200 lanzamientos, 300 lanzamientos hasta 1000 lanzamientos.
Ok, now for the next couple of questions consider these 2 sequences of coins flip. Now I’m going to ask you some questions. What sequence has a higher probability of happening or are they equally likely?

I6- can I count them? [looking at the sequences and counting. On the paper she wrote next to sequence A 12H T28 and next to sequence B 19]

Yes.

I6- can you repeat the question please?

What sequence has a higher probability of happening or are they likely equally likely?

I6- hmmm of happening, hmm me la dices en Español? [can you say it in Spanish?]

¿Que secuencia tiene una mayor probabilidad de ocurrir o son iguales probabilidades, igualmente probable?

I6- como que secuencia [like what sequence] you mean like A or B? [pointing at sequence A then at sequence B]

Yes

I6- or they are equally likely

Ok, If one of the sequence were made up and the other actually obtain from a real coin flipping, what do you think was which and why?
I6-[looking at the sequences] I would say B because
B is which one? The made up or the actually
I6- the actually, the actual
The actual?
I6- mm-hmm
Why?
I6- because it’s like it has [short pause] like tiene más variedad y no esta como, como la A parece como
un patrón [it has more variety and it is not like, like A with a pattern]
Ok, in your own words what does the longest run mean to you?
I6- longest run [short pause] can you say it in Spanish?
En tus propias palabras ¿que significa la mayor racha o el mayor numero de caras sucesivas?
I6- cuando eh obtienes [short pause] ah bastantes numero de caras continuamente [when you get a
number of heads continuously]
Ok,
I6- sin obtener un cello [without obtaining any tails]
In your own word what does in the long run mean to you?
I6- hmmm en Español [In Spanish]
En tus propias palabras ¿que significa a largo plazo?
I6- no se [I don’t know]
Ok, in sequence A what is the longest run?
I6- in sequences A, I’m guessing is T
Ok, en secuencia A ¿cual es el mayor, la mayor racha o el mayor numero de caras sucesivas?
I6- oh [looks at sequence A and starts counting] hmmm dos [two]
En secuencia A
I6-En secuencia A el mayor sucesivas es 2 [in sequence A the longest run is 2]
Ok,
I6- caras [heads]
En secuencia B ¿Cuál es el mayor racha o el mayor número de caras sucesivas?

Ok, en secuencia A ¿cual es el mayor número de escudos sucesivos?

Ok, ¿y en secuencia B?

Ok, para una secuencia de 100 lanzamientos ¿que tan larga crees que sea la racha más larga de caras o escudos?

Ok, if you saw a streak of 4 heads in a row for a fair coin, what do you think is the probability of heads for the next flip?

Si vez una racha de 4 caras de una moneda justa ¿Cuál crees que sea la probabilidad de que el próximo lanzamiento sea cara?

Por que?

Ok, now we are going to go to the applet. You see here we have the number of tosses, the probability of head, and then it keep record of the number tosses, number of heads, number of tails, the longest run of heads, the longest run of tails, and change error and then we can change it to Spanish. And it would do exactly the same thing but just that it would be in Spanish. You can work with which ever applet you want in Spanish or in English. Ok, now I want you run the applet a couple of times and I want you to keep track of what you are looking at. Like I want you to run it and see what happens.

Press iniciar. Ok, run it again. Ok let’s run it again. Let’s run it one more time. Ok now how does this change or confirm what you predicted about how far of from 50 heads you would reasonably expect in 100 flip sequence?

Ahmm, como cambia esto o confirma lo que predijiste sobre que tan lejos de 50 caras se puede considerar razonable en una secuencia de 100 lanzamientos. Tu habías dicho 50
tu habías dicho 50, te pregunté cuántas cara obtendrías de 100 lanzamientos y dijiste que 50-50

Esto confirma, esto cambia o confirma lo que habías dicho

¿Confirmás?

Ok, do you think a 1000 flip sequence would have larger, smaller or equal chance error compared to a 100 flip sequence and why?

What do you think a 1000 flip sequence would have larger, smaller or equal chance error compared to a 100 flip sequence and why? Like the chance error el error aleatorio en este caso es 0 because we got exactly 50 heads, if we do it again now the error is 3 because it is not exactly 50 it went over 3

I6- igual [equal] can you read it again

So for 1000 flips do you think you would have a larger, smaller, or equal chance error compared to 100 flip sequence and why?

I6- I would say equal

Equal, and why?

porque sigue siendo la misma probabilidad [because it’s still the same probability] you never know what you’re getting

Ok, does exploring with the applet make you feel that you want to keep or change your answer to the question about the proportion of heads? [showing the bar graph she had previously made]

I6- [looking at the bar graph] yea

Yes? You don’t have to erase it, you can just do it over it.

I6- [change the graph to a line y= 0.5]
Ok. Does exploring with the applet make you feel that you want to keep or change your answer to the question about the difference between heads and tails? Like for the other graph,

I6- [looking at the second bar graph] difference between heads and tails,

So what’s the difference?

I6-hmmm [long pause]

Do you want to change it or keep it is up to you

I6- I think like that I’m not sure [making a line y= 25]
Ok, ok you had predicted in a previous question that there will be a longest run of 5 in 100 toss sequence, does your result seem to confirm or conflict with your prediction?

I6- I would like it in Spanish

Ok, habías predicho en la pregunta anterior que el mayor la mayor racha o el mayor numero de caras sucesivas es de 5 en una secuencia de 100 lanzamientos. ¿Tu resultado para confirmar o entra en conflicto con tu predicción?

I6- confirma [confirm]

Confirma [confirm] ok, how many tosses do you think it would take before we see a streak of 4 heads in a row?

I6- in Spanish

¿Cuántos lanzamientos crees te tomará para que veas una racha de 4 caras consecutivas?

I6-[short pause] cuantos lanzamientos [how many tosses]

¿Cuántas veces tienes que lanzar la moneda?

I6-four

Four?

I6- yeah
Ok, o now we are going to change the mode instead of flipping 100 times it’s going to flip until you get this number of heads. Can you put there 4?

I6- here 4?

Mm-hmm and let run it.

I6- until I get 5?

No, it’s going to keep flipping until you get until the computer gets 4 heads

I6- here? oh ok

It took 12 this time and this time it took 11, let’s try it again

I6- ok

Ok does the result seem to confirm or conflict with your prediction? [short pause] You said it would take 4.

I6- aha

So it conflicts

Ok, if we change the probability of heads from .5 to .7 what change if any do you think there would be in the difference of how many tosses it would take to get a streak of 4 heads in a row?

I6- in Spanish please

Ok, si cambiamos la probabilidad de caras de .5 a .7 ¿como seria el cambio si es que habría un cambio crees que habrá una diferencia en cuantos lanzamientos se necesitan para obtener una racha de 4 caras consecutivas?

I6- hmmm [short pause] si cambio a .7 la probabilidad de caras [if I change it to .7 the probability of heds] hmmm disminuyiría la probabilidad. [the probability would decrease]

Mande [excuse me]

I6- ¿cual es la pregunta que me estas preguntando? [what is the question you are asking me?] 

Si cambiamos la probabilidad de caras de .5 a .7

I6- aha

Que seria el cambio si, si habría un cambio?

I6- si, seria más dificil

Si crees que habría una diferencia en cuantos lanzamientos se necesitan para obtener una racha de 4 caras consecutivas?
Las tendríamos más rápido, igual, igual de lanzamientos, más lanzamientos

Necesitaríamos más lanzamientos? [we would need more flips?]

Ok, let’s change the probability to .7, and let run it, let’s see what happens. Let’s run it again. Ok let’s run it again. Let’s run it again. Ok run it one more time. Ok one more. Ok does the result seem to confirm or contradict with your prediction?

Ok, now if we change the probability of heads from .5 to .7 so we go back to flipping 100 times. What change if any do you think there would be in the number of heads?

Si cambiamos la probabilidad de caras de .5 a .7 que cambio si los habría crees que habría en el numero de caras y que cambios si los ahí crees que habrá en le mayor racha de caras? Si cambiamos el modo para que lancé 100 veces

Crees que habría una diferencia en el numero de caras?

Mm-hmm en vez de tener la probabilidad en .5 porque dijiste tu que en .5 la probabilidad de obtener caras era 50, si le cambiamos a .7 crees que esa el numero de caras cambie o no cambie?

si, si va a cambiar [yes, it’s going to change]

Si va a cambiar y también crees que también va a ver un cambio en el mayor numero de caras sucesivas?

ahmm no precisamente [not precisely]

No, ok. Vamos a [let’s go] ok una vez más [one more time] Ok una vez más [one more time] Ok does the result seem to confirm or confliction with your prediction?

Ok, hmm es diferente a mi predicción [it’s different to my prediction]
I6- si porque yo dije que no importaría el número de caras y si importa [yes because I said that the number of heads did not matter and it does]

Ok, how did you decide when to use the English version and when to use the Spanish version of the applet?

I6- how would I what?

How did you decide when to use the English version and when to use the Spanish version of the applet?

Because there are some words I do not understand in English

Ok, what difference between the two versions did you notice or experienced?

I6- what version what do you mean?

What difference between the two versions did you notice or experience?

I6- well in personal opinion the Spanish is easier because my my first language is Spanish and I I’m not sure in English so

Ok

I6- I know more vocabulary

Ok, do you think that using applets like this would or would not be helpful to you or other students?

I6- yes it would

Why?

I6- because it explains you everything like the number of heads hmm osea te dice cuantas veces lo lanzastes o sin la necesidad de que tu lo estes haciendo [it tell you how many times you flipped without having you do it]

Ok, do you think it would or would not be helpful to have a word list such as this one, that shows English and Spanish equivalent probability terms and why?

I6- can you repeat the question again?

Ok, do you think it would or would not be helpful to have a word list such as this one that shows English and Spanish equivalent for probability terms and why?

I6-yeah it would help someone you may translate them and they might sound the same and they have different meanings in Spanish.

That completes the interview
Appendix F – French and Chinese Versions of the NLVM Coin-Tossing Applet

**Pile ou face**

- Nombre de tirages: 100
- Maximum de tirages « face » successifs: 5
- Probabilité de tirages « face » = 0.5

Nombre de tirages = 100
Nombre de tirages « face » = 49
Nombre de tirages « pile » = 51
Maximum de tirages « face » successifs = 6
Maximum de tirages « pile » successifs = 5
Pourcentage de tirages « face » = 49 %
Erreur aléatoire = -1
(nombre de tirages « face » - prévision du nombre de tirages « face »)

**掷硬币**

- 抛的次数: 100
- 最长的连续正面数: 
- 正面的概率 = 0.5

抛的次数 = 100
正面的数目 = 46
反面的数目 = 54
最长的连续正面数 = 6
最长的连续反面数 = 10
正面的百分比 = 46%
随机误差 = -4
(正面的数目 - 预计的正面数目)
Curriculum Vita

Berenice Salazar was born in Juarez, Chihuahua Mexico but has been a resident of El Paso, Texas for fifteen years. Daughter of Raymundo Salazar and Maria Salazar, she graduated from Americas High School, El Paso, Texas, in the spring of 2006 and entered The University of Texas at El Paso in the fall. While pursuing a bachelor’s degree in science, she worked for the university throughout her degree, first she was a math tutor, later she became a supplement instructor (SI) for Pre-Calculus, and during the summers of 2008, 2009, and 2010 she worked on the Enhanced New Students Orientation (ENSO) where workshops were given to the new incoming freshmen to help them place higher in the math portion of the Accuplacer. She received her bachelor’s degree in the fall of 2010, and entered the Graduate School at the University of Texas at El Paso in the spring of 2011. While pursuing a master in the Arts of Teaching Mathematics, she worked as a teaching assistant (TA) in the mathematics department at the university, co-authored papers presented at the 2012 Bilingual Education Emphasizing Multicultural Settings and Joint Statistical Meetings, and during her last semester she also taught three remedial courses at El Paso Community College. During the Pre-Commencement ceremony of the College of Science Fall 2012 she received an award of the Outstanding Graduate Student MAT Mathematics.

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