GAMES OF CHANCE: TOOLS THAT HELP ENHANCE PROSPECTIVE TEACHERS' NOTIONS OF STATISTICS AND PROBABILITY

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Research reported in this paper is part of a larger study that focused on curriculum development and on prospective teachers' content and pedagogical knowledge of probability. To address the first research goal, during the preliminary phase of the project, a probability teaching module was developed. To address the second research goal, during the subsequent phase, this module was taught to a group of prospective middle school teachers. In this report, the focus is on the first research goal - *I will describe key components of the probability teaching module. In particular, I will share two activities from the teaching module and discuss related findings.*

BACKGROUND OF THE STUDY

Empirical research on K-12 students' conceptions of probability has documented students' difficulties related to topics such as randomness, sample space, compound probability, and conditional probability and independence (e.g., Jones, Langrall, Mooney & Thornton, 2004). Compared to research on K-12 students' notions of probability, research on teachers' conceptions is still in its infancy. However, in the past two decades, many researches have focused on teacher-centered probability studies - these include investigations on teachers' content knowledge (e.g., Dollard, 2011), teachers' use of simulation tools (e.g., Lee & Lee, 2011; Pratt, 2005), and their efficacy and beliefs (e.g., Watson, 2001). For teachers to develop a strong, coherent, and intuitive background for probabilistic reasoning among students, they need to possess a strong content and pedagogical knowledge (Fennema & Franke, 1992); be aware of and be able to understand, identify, and overcome their own mathematical understandings (Pratt). Sadly, many teacher preparation programs have not been highly successful in preparing teachers competent to teach probability (Greer & Mukhopadhyay, 2005) and many teachers have a "lower confidence rating" when it comes to teaching probability concepts (Stohl, 2005, p. 354).

In this light, the onus of preparing both prospective teachers and in-service teachers who are competent to teach probability rests on teacher education programs. Current research suggests that such programs must design courses that offer ample opportunities for teachers to enhance their content, pedagogical, and curricular knowledge of probability (Lee & Lee, 2011; Dollard, 2011; Watson, 2001). I drew upon these research recommendations, and in an attempt to realize some of these implications in my own practice, designed a research project to focus both on curriculum development and teacher-conceptions of probability. In this paper, I focus on the first research goal and describe key aspects of the probability teaching module that was developed during and as part the larger probability project.

METHODS

Empirical Setting

The geographical setting for the study is a large mid-western university in the United States. The research setting is a mathematics content course *Patterns and Structures through Inquiry* (capstone) for prospective teachers. This is a three credit-hour (38 contact hours) course which a prospective teacher completes near the end of the program of study. It emphasizes sharing of ideas, synthesis, and critical, informed reflections as significant precursors to action. Preservice teachers (PSTs) pursuing licensure to teach middle school mathematics typically enrolled in the capstone course in their fourth year at the university. Pre-requisites for this course include successful completion of at least nine hours of mathematics education courses that address topics such as numbers and operations, algebra, geometry, technology and the history of mathematics.

In K. Makar, B. de Sousa, & R. Gould (Eds.), *Sustainability in statistics education. Proceedings of the Ninth International Conference on Teaching Statistics (ICOTS9, July, 2014), Flagstaff, Arizona, USA.* Voorburg, The Netherlands: International Statistical Institute. iase-web.org

Phase I: An Overview of Curriculum Development

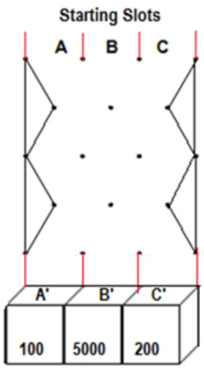
The first phase of the research project involved curriculum development. The term 'mathematics curricula' is used in a broad sense to denote a set of ideas that students are taught and expected to learn. In particular, it could also refer to a variety of instructional materials that include course content, course skills, and course concepts (Shirley & Kyeleve, 2005). Applying the same description to statistics curricula, for the purposes of this paper, I will use the term in reference to a probability teaching module that was developed to address both the research goals and the capstone course goals. In the realm of probability, research recommendations for curriculum development and instruction are specific and include the following: connect probability to other topics within the mathematics curriculum, use activity-based explorations that connect to people's lives, use technology to perform simulations and to gather experimental data, use data to make predictions and to explore both theoretical and experimental probability (Greer & Mukhopadhyay, 2005; Shaughnessy, 2003; Stohl, 2005).

I consulted seminal works in mathematics and statistics education to guide my work during the curriculum development phase of the research project. Such resources include the common core state standards for mathematics (CCSSI, 2010), the guidelines for assessment and instruction in statistics education (GAISE, 2007), Stein and Smith's (1998) task analysis guide, the international association for statistics education website (www.amstat.org), the consortium for the advancement of undergraduate statistics education website (www.causeweb.org), journal articles (both research and practitioner) and books that focused on the teaching and learning of probability and statistics. I gleaned key insights from these sources and developed a probability teaching module that comprised of twelve activities - each activity was set in an everyday context and or a cultural context to help learners establish connections between probability content, context, and culture. For each activity, I developed a series of tasks and wrote a lesson plan to articulate my visions for enacting the activity. Prior to the launch of the second phase of the research project, I piloted the activities with a group of PSTs to identify issues specific to task effectiveness, task implementation, and task interpretation and used this feedback to revise and refine the lesson plans. The following ten activities were included in the final version of the probability teaching module: *Problem of the division of stakes* (correspondence between Pascal and Fermat), *LuLu* (Hawaiian cultural game), *Ampe* (birthday game from Nigeria), *Songish* (cultural game from Canada), *Yut-Nori* (Korean game), *Pachisi* (board game that originated in India), *Casino games* (Craps, Poker, and Euchre), and the *game of Plinko*. Here, I describe two of these activities in detail.

RESULTS

Probability Module Activity 1: The Game of Plinko

Plinko is a famous stage game on the American television game show, *The Price is Right.* It is a game of chance that involves probabilities associated with the contestant choice of where to drop a chip down a board to land in a slot that will earn the contestant a given amount of money (http://www.mathdemos.org/mathdemos/plinko). A plinko board has nine starting slots; the chip falls through 11 rows before ending in one of the nine landing bins and the contestant wins the amount indicated in the landing bin anywhere from \$0 to \$10,000. For our probability module we used a smaller version of the plinko board. (See Figures 1a & 1b).



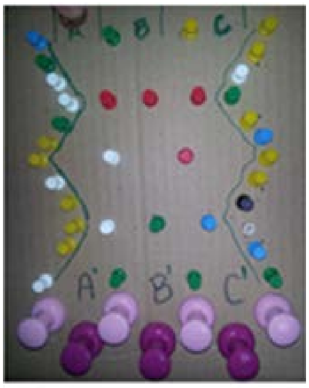


Figure 1a. Model of a smaller Plinko board Figure 1b. PST-designed Plinko board

As indicated in the figures, this board has three starting slots and three landing bins and players have a chance of winning $100 or $200 or $5000. The probability activity based on this plinko board was enacted in several stages (Naresh & Royce, 2013).

1. Watch the game on Youtube (Use search prompt - the game of plinko)
2. Play an online version of the game at www.kongregate.com/games/StapleGun/Plinko
3. Build a plinko board
4. Collect experimental data using the plinko board
5. Collect more experimental data through TI 83 calculator simulations (download program from http://www.mathdemos.org/mathdemos/plinko/ti83code.html)
6. Analyze experimental data to address the following question: *Experimentally, what are the probabilities of winning $5000 on this Plinko board*?
7. Construct appropriate representations (e.g., tree diagrams) to depict the path of a chip from each starting slot to ending slot.
8. Discuss related theoretical probabilities. *Determine the theoretical probabilities of winning $5000 on this Plinko board.*
9. Determine the conditional probabilities *of landing in slots A', B' and C' given that you started from starting slot A? slot B? slot C?*

Probability Module Activity 2: The Game of Pachisi

Pachisi (pachis means 25 in hindi, a national language of India), a board game that originated in India is widely played around the world under different names (e.g., Backgammon, Ludo, Sorry). This game is played with two dice and four players. Each player starts the game by placing four game pieces (of the same color) in their respective starting zones. The starting zones are to the right of each player. The following rules apply. Note that there are several versions of the game and the rules might vary accordingly. For our class activity, we adopted the following rules (http://www.safeharborgames.net/aboutgames/howtoplayPachisi.php).

- Each player rolls a die; the highest roller goes first, and subsequent play continues to the left.
- Game pieces enter play onto the darkened space to the left of their nest and continue counter-clockwise around the board to the home path directly in front of the player.
- On each turn, players throw both dice and use the values shown to move their pieces around the board. If an amount on one or both of the dice cannot be moved, that amount is forfeited.
- Any time a player rolls, he must use as much of the dice showing as possible. (i.e. If a player rolls 4 and 5 and could move either 4 or 5, but not both, then he must move 5.)

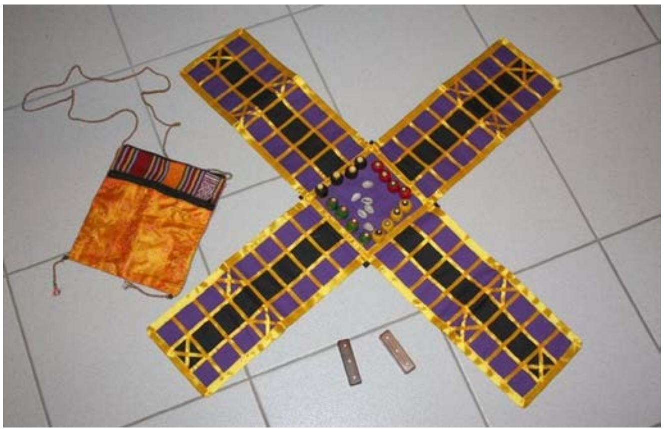


Figure 2: A Pachisi game board. Image source:
http://users.skynet.be/fb015106/NL/indexpachisi.html

Once the rules of the game were explained, PSTs were asked to create their own Pachisi boards. PSTs were encouraged to play the game in small groups and gather experimental data to address the following probability questions (Bell, 2006).

1. What is the probability of leaving the Start space on your first roll?
2. If you get out of the Start space on your first roll, how likely is it for you to get your second piece out on your next turn?
3. How could we determine possible rolls for each value from 1 through 12?
4. How could we determine the probabilities of each roll?

DISCUSSION

One of the key goals of the larger research project was to develop probability activities that would sustain PSTs' enthusiasm for this topic and allow for an in depth exploration of probability concepts. In this paper, I have presented data from the first phase of the research project. Data collected from the second phase of the project is currently being coded and analyzed. Preliminary findings (based on the analyses of classroom observations and PSTs' written work) indicate that many PSTs' struggled to comprehend the rules of the game and to establish connections between the experimental and theoretical investigations. While PSTs were actively engaged in the learning process, some were unable to apply their prior knowledge of probability topics (e.g., sample space, conditional probability, expected value) to solve tasks set in non-traditional contexts. However, explorations of the games of Plinko and Pachisi did enable PSTs to think deeper about the connections between academic mathematics and everyday contexts and better understand the use of probability in "modeling and predicting real-world phenomena" (NCTM, 2000, pp. 17–18).

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