# ® ASSESSING THE KNOWLEDGE OF FUTURE MIDDLE SCHOOL TEACHERS IN STATISTICS BY LESSON DESIGN

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*In this paper, an assessment project conducted in a class for future middle school teachers in statistics is presented. The project consisted of designing and presenting a lesson that addressed a statistical concept taught in middle school following the Japanese Lesson Study model. Future teachers were asked to identify the big ideas covered, its connections to previous and future content by aligning the lesson to state, national standards, and the GAISE recommendations, make predictions about students misunderstandings based on readings about statistics education research, propose activities or procedures on how to teach the concept, and create an evaluation plan. Lessons were presented in pairs to the entire class and the "best" lesson presented to actual $5^{th}$ graders at a local middle school. Final reflections and evaluations from prospective teachers are discussed.*

## BACKGROUND

Until recently, statistics courses geared to prospective teachers have been non existent Rossman, Medina, and Chance (2006). With the introduction of the Data Analysis and Probability strand by the NCTM Standards (1989 and 2000) to the K-12 curriculum, the framework laid out by the CBMS *Mathematics Education for Teacher Book* (MET) (2001), and the latest *Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report* institutions of higher education are beginning to create new statistics courses tailored to future teachers at all levels that follow these recommendations and are practical for the job of teaching. Examples of new curriculum materials are *Investigating Statistical Concepts, Applications, and Methods* (ISCAM, Chance & Rossman, 2006) designed for prospective secondary teachers with calculus background, and *Data and Probability Connections: Mathematics for Middle School Teachers* (Perkowski & Perkowski, 2007) for prospective middle school teachers.

Both of these curricular materials are grounded in the fundamental ideas of collecting, analyzing, and drawing conclusions from the data presented in a way that provides prospective teachers the opportunity to discover and explore concepts. Rossman *et al.* (2006) complement their course with a reading seminar about issues of learning and teaching statistics. Perkowski and Perkowski (2007) embed into each section of the book a lesson from middle school curricula. Two main intertwined aspects are present in these curricula, the conceptual knowledge of the content and the pedagogical content knowledge. In particular, knowledge of how students learn and the appropriate instructional techniques. The question for teacher educators of future statistics teacher becomes how do we assess these two different but yet related aspects of knowledge? The assessment of conceptual knowledge has been studied and there are many suggestions by statistics educators (Garfield, 1993, 2003), however the assessment of the pedagogical content knowledge is still in development stage, especially in the area of statistics (Ball, Hill, & Bass, 2005; Burgess, 2006).

This paper builds on the ideas of Rossman *et al.* (2006) and Burgess (2006) that we need to have ways (e.g. assessment tools) to link what prospective teachers know about statistics and the use of that knowledge in the teaching context by describing an assessment project implemented in a Probability and Statistics class of 18 prospective middle school students (16 women, 2 men) at a university in the south central United States in Fall 2006.

## THE PROJECT: LESSON DESIGN

The assessment project centered on designing and implementing a lesson plan for middle school students. The project was a variation of a Japanese Lesson Study model. The Japanese Lesson Study is a method of professional development for teachers that originated in Japan and now is becoming popular in the United States (Takahashi & Yoshida, 2004). During lesson study,

teachers work collaboratively to plan, conduct, and observe a "research lesson", they carefully observe student learning, discuss and revise the lesson based on these observations (Lewis, 2002). Lesson study has been shown to be a powerful tool among teachers mainly because teachers have opportunities to make sense of content and pedagogical ideas within their practice, change their perspective about teaching and learning, learn to see their practice from the child's perspective, and enjoy collaborative support among colleagues. Based on these results on the impact for teachers, a variation of this model was thought to be appropriate for prospective teachers with slightly different goals.

*Goals of the Project*

The goals of the project focus on aspects of pedagogical content knowledge, that is, aspects where prospective teachers had to put in practice their statistical knowledge to carry out teaching activities. The main goals of the project were:

- To apply the statistical knowledge gained in the first part of the course in a common teaching activity;
- To learn about how children learn statistics by anticipating students conceptions and misconceptions;
- To reflect upon the challenges of implementing a lesson; and
- To illustrate a statistical investigation process where they are the active investigator for the "research lesson".

*Description of the Project*

The project started around the middle of the semester by asking students to form teams of two. The teams were formed according to their schedule to facilitate common time for planning. After the teams were formed, students were informed about the project, its goals, and shown the scoring rubric for which they would be evaluated (see Appendix B). Important dates were also included. At this point prospective teachers were given the first assignment. The first assignment was to develop a "proposal" or tentative plan of the project (see Figure 1) and "defend" or present it to the whole class. The purpose of this first assignment was two fold. One to start thinking about the process of designing a lesson and two to have an opportunity to see the variety of concepts and instructional techniques being proposed. Prospective teachers were given about two weeks to develop the proposal.

**Tentative Plan for Teaching Project**
**Due Friday, October 27th**

Names:_____ , _____

1. Specify the grade you are going to do the project. (e.g. 5th grade or 8th grade)
2. Identify the area in mathematics you are planning on doing your project. (e.g. Counting, Probability, Statistics, or some integration of these)
3. Give the specific topic within this area. Choose a topic that either it has not been cover in class or it was given little attention (e.g. Expected value) and identify the "big idea" this topic is part of.
4. Give the title of at least 3 references. You may use middle grades textbooks that are in reserved in the 7th floor of the library or Internet resources like nctm.org, mathforum.org, amstat.org.
5. Describe how are you going to approach the topic. (e.g. connections within or outside mathematics, using technology, using an activity)
6. Describe how are you going to present your project to the class.

*Figure 1*. First assignment given to teams of prospective teachers

Each team had about 10 minutes to present their plan to the entire class. When appropriate, teams were asked to add or extend a topic. In some cases, the professor suggested better fit according to the grade level (prospective teachers have less experience knowing what

students at certain age are able to do), to make sure that they included, as much as possible, the six recommendations of teaching statistics suggested by the GAISE Report (even though these are recommendations for statistics teachers of college undergraduates, they are also pertinent to teachers of statistics at the middle school level):

1. Emphasize statistical literacy and develop statistical thinking.
2. Use real data.
3. Stress conceptual understanding rather than mere knowledge of procedures.
4. Foster active learning.
5. Use technology for developing conceptual understanding and analyzing data.
6. Use assessments to improve and evaluate student learning.

The next stage of the project was to actually write and design the lesson. For this stage prospective teachers needed a great deal of guidance. Prospective teachers had been exposed to the concept of lesson plan in their education classes, however they had never experienced designing a lesson plan for a particular content. In the Japanese Lesson Study model, a typical lesson includes the title of the lesson, the lesson goal, the relationship to the standards or curriculum, information about the lesson (such as background and rationale), the expected learning process, and evaluation points to determine whether students are learning. This lesson-plan format would be enough for practicing teachers, however prospective teachers needed more guidance for each part of the lesson. Appendix A shows the lesson-plan format used for the project. The questions within each part are provided to give the prospective teacher a better idea of what is expected for each part. Prospective teachers were asked to read a set of articles to better address the different parts of the lesson, especially the part of the lesson where they have to predict students' responses or anticipate common misconceptions. The set of articles read were the ones Rossman *et al*. (2006) selected for the concurrent seminar for their secondary teacher course.

Prospective teachers teams were given two more weeks to write a draft of the lesson plan and to turn it in a week before the presentation. The reason for this was so that the teams would get feedback (from the professor) about the lesson plan and their presentation (from the entire class) by the end of that day. In the Japanese Lesson Study, the research lesson is conducted in an actual classroom. One of the teachers' team members volunteers to deliver the lesson and the rest of the team are observant with the job of collecting data about students' thinking and learning. For this project, both member teams were responsible for conducting the lesson and the rest of the class were acting as middle grade students and at the same time making observations about how the lesson was conducted. Students had about 35 minutes to conduct the lesson followed by 15 minutes of debriefing. The debriefing began with the presenting team's comments on how the lesson went, what difficult decisions they had to make during the lesson. Then the professor, who has prior knowledge of the lesson plan, explains the intended lesson plan and makes comments about the difference between the planned and delivered lesson. Finally, the rest of the class was invited to comment and make suggestions. The entire atmosphere of this discussion is about the lesson and how to improve it.

The final stage of the project was to write a self-evaluation portion, take all the feedback provided by the professor and fellow classmates after the presentation and write a final lesson plan. As part of an extension of this project and taking advantage of Texas State University's close ties with local middle schools, members of the class voted for the "best" lesson presented and the winners conducted the lesson with a $5^{th}$ grade class. This was an opportunity for prospective teachers to see how difficult and much different is to conduct a lesson with the "real kids".

*Assessment of the Project*

At the early stage of the project, prospective teachers were given the scoring rubric for both the lesson plan and the presentation (see Appendix B). The rubric for the lesson plan assesses each part of the lesson. First draft of the lesson was evaluated with aspects of the rubric in mind but no score is assigned. Instead, students receive detailed feedback from the professor on how to improve the lesson. The presentation was evaluated using a different rubric and the professor and fellow classmates gave oral feedback at the end of the presentation. Final draft is

evaluated with the rubric and a score is assigned. The lesson plan accounts for 60% of the project assignment and the presentation (i.e. delivery of the lesson) accounts for 40%.

## REFLECTIONS AND EVALUATION FROM PROSPECTIVE TEACHERS

Evidence of the degree of success of the project is reflected from two sources. One comes from the self-evaluation part of the lesson where preservice teachers reflect about the implementation of the lesson and the other source comes from the evaluation instrument that preservice teachers fill out about the entire class.

The following quotes reflect students' opinion about the benefit of the lesson design project for their future job as middle grades teachers:

- The lesson design project helped me to better understand statistics and probability so that it will be easier for me to teach.
- I never understood probability or statistics even before this project, now I feel comfortable enough with the topics that I could teach them.
- The project made me focus on a particular topic in relation how is taught to students.
- This project was more directed on whether you could teach the material not if you just knew it. This set up is a lot more effective than in some of my other education classes.

The following are some students' reflections about the implementation of the lesson and how to improve it. For the first lesson, prospective teachers used magnet beads at the board to illustrate an urn and in turn use it to do an activity to illustrate theoretical versus experimental probability. In the second lesson, prospective teachers used the game rock-paper-scissors to illustrate the concept of fairness.

- Having the beads on the board was really helpful. It made it easier for the students to be able to picture them scrambled up in the bag, also them being pulled out of the bag. A weakness was the directions of the lesson, they should have been clearer and it should have been clearer what I wanted the students to put on the board.
  In latter lessons I would have both the outcomes of the experimental and the theoretical probability. I would then have the students write both of the outcomes on the board. In my explanation of the lesson I would have gone into more depth of what exactly experimental and theoretical probability is and what the difference between the two is.
- We liked the lesson. It allowed the class to participate in an experiment that did not include the use of a spinner, a coin or dice. The data they collected was based on an activity that allowed them to be active. We also liked the fact that the outcome of the final probability was not apparent until the data was collected and the totals combined.
  Some problems with the lesson were not apparent until we actually presented to the class. The definition of an outcome was confusing because the outcome of each event was the player that won. But outcome is also the nine possible results of playing each round. So that would have to be cleared up. Our original table included a column that would ask students to show the probability by using a fraction. We took that off of our final lesson plan because it was too complicated a task for the grade level. It was also unnecessary for the lesson objective.

## SUMMARY

Prospective middle grades teachers often take probability and statistics classes in an introductory class where issues of teaching and learning are not addressed. Learning probability and statistics for teaching young students involves more than simple knowledge of the subject. Lesson design is a tool that can be use to apply the knowledge prospective teachers have about the subject to teaching. The lesson design integrates deep knowledge of statistics and knowledge about how student learn statistics, in particular conceptions and misconceptions. Furthermore, it involves knowledge of statistical assessment. Preservice teachers perceive this activity as very useful and help them gain deep knowledge of the concepts.

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APPENDIX A. Lesson Plan Format

Names_____ School_____
Date of Lesson _____ Grade _____

**Lesson Plan Format**

Title of Lesson:_____

I. Goal(s) or objective(s)

What knowledge/skills/ideas will students gain as a result of this lesson?

II. Purpose/Rationale

What is the significance, relevance, reason for teaching and learning this lesson? Why am I teaching this lesson this way?

What are the standards that are addressed in this lesson?

State Standards

NCTM National Standards www.nctm.org

III. Prior teacher preparation & knowledge of students

What did you have to do to get ready for this lesson? What concepts must students have mastered in advance to participate in and understand this lesson?

IV. Materials/Resources

What materials will be needed? How much time will be involved? What textbooks or materials are needed? What needs to be prepared in advance? What websites will be used?

V. Lesson procedure

Step 1: Introducing

- Make connections between prior knowledge and experiences with what is presented.
- Find out what students' ideas are on this topic – uncover misconceptions (List possible misconceptions or difficulties)

Step 2: Exploring

- Clearly explain how students will be working – individually, in pairs, or in groups.
- Describe in detail the activity or investigation students will pursue with clear directions.
- Describe the path of inquiry or process of discovery to be followed – what questions will you ask? List them!
- Explain where students will show their work – math journals or pre-designed student data sheet (include this!)
- Depending on the individual lesson – students will estimate, explain, explore, and discuss their findings.
- Provide an extension for individuals/groups who finish more quickly than others.
- In what ways will you assist students with special needs?

Step 3: Summarizing

- How will you assist students in drawing the ideas together?
- How will you provided feedback to students to correct their misunderstandings and reinforce their learning?
- How can they connect their understanding to real-life applications?
- What is a follow-up activity to reinforce concepts learned today?
- Provided relevant homework, class work, parent-involvement activity, research assignment, etc.

VI. Assessment

How will you know if students understand the problem/lesson (if they "get it"? How will students show what they know?

Have your goals and learning objectives been met? How will you evaluate the objectives that were identified?

How will you extend this lesson for students who did not fully understand (who did not "get it")?

VII. Self-evaluation

Reflect on strengths and weaknesses of the lesson as taught.

In retrospect, how would you modify the lesson?

Discuss whether or not you have evidence that your goals and learner objectives were met.

Describe individual student responses to techniques used. How did they react?

APPENDIX B.

Scoring Rubric for Lesson Plan

| | Exceeds Expectation 3 | Meets Expectation 2 | Does not Meet Expectation 1 |
|---|---|---|---|
| I. Goals/objectives | Identifies clearly and cohesive goals/objectives reasonable for one lesson plan. | Identifies clearly goals/objectives. | Goals/objectives are unclear, no cohesive and unreasonable for one lesson plan. |
| II. Purpose/Rationale | Provides clear evidence for the significance, relevance of the lesson for the target grade. List State Standards. | Provides evidence for the significance, relevance of the lesson for the target grade. List State Standards. | The evidence for the relevance of the lesson for the target grade is not convincing. Do not list the State Standards |
| III. Prior preparation and knowledge of students | Identifies, based on literature, common misconceptions on the topic. Anticipates responses and has a plan for addressing them. | Lists potential difficulties based on common knowledge and some literature. | Students' misconceptions or difficulties are not relevant to the lesson or are missing. |
| IV. Materials/Resources | Materials are provided and resources are listed. The materials are appropriate for the lesson. | Materials are provided and resources listed but it is unclear how it is related to the lesson. | Materials and resources are not included nor listed. |
| V. Lesson procedure | Describes clearly the procedures to enable a third party to try the lesson. Includes appropriate steps according the goal. | Describes fairly clear the procedures. Some steps are not appropriate to accomplish the goal of the lesson. | The description is not clear and it is hard to follow. Steps are not appropriate to accomplish the goal. |
| VI. Assessment | The assessment plan is aligned with the goals and description of the lesson. | The assessment plan is closely aligned with the goals and description of the lesson | The assessment plan is inconsistent with the goals and procedures. |
| VII. Self-evaluation | All aspects (good and bad) are reflected upon delivery of the lesson. A plan for improvement is included. | Some aspects are reflected upon delivery of the lesson. Some indication of improvement is included. | Reflection upon delivery or plan for improvement is weak or missing. |