

## TEACHING STATISTICS IN A MATHEMATICS COURSE IN MIDDLE SCHOOL: INTERDISCIPLINARITY, REALLY?

Annie Savard and Dominic Manuel  
McGill University, Canada  
[annie.savard@mcgill.ca](mailto:annie.savard@mcgill.ca)

*Statistics is a domain combined with probability that is taught in Mathematics in all school levels. We suggest a potential in using an interdisciplinary approach with this concept, which, according to Fourez & Larochelle (2003), implies that the development of one discipline contributes to the development of others. Thus the development of the understanding of a situation might mean to use both mathematical and statistical reasoning. In this paper, we present a case study where a middle school Mathematics teacher created a lesson in Statistics where the students had the task to study a pack of colored candy and create a pie graph representing its distribution. The teacher hoped that her students made links between mathematical concepts while doing this task. Results show us that her procedural vision of Statistics lead her to focus more on a graphical representation and thus led her to avoid all statistical reasoning development (Garfield, 2002).*

### INTRODUCTION

In the last decades, we notice many phenomena and problems in our society that require more innovative and creative strategies than applying simple algorithms that are already known in order to bring possible solutions. Because of those complex phenomena, we think that rich tasks should be integrated in Mathematics and Statistics classrooms in order to support students in becoming productive citizens compared to the more traditional methods that are often used in classrooms. Such tasks include problems that are: open-ended (can have multiple answers and can be solved using various strategies); complex (require many steps, require investigation, to make choices, generalize and prove results, etc.); ill defined (missing necessary data); have different interpretations; and are contextualized (Manuel, 2010; Manuel, Freiman & Bourque, 2012). However, Mathematics and Statistics are still too often taught in a way where students develop procedural understandings of concepts. Yet, some topics especially in Statistics have the potential to be implemented inside rich tasks and also can bring possible interdisciplinary and intra disciplinary links.

In this paper, we conducted a case study of a lesson in Statistics taught by a grade 7 Mathematics teacher from Quebec. This lesson was centered on a contextual task involving Halloween colored candy and was taught a week before October 31. Our goals were to study the interdisciplinary links that the teacher made between statistical and mathematical concepts as well as in Statistics and the context presented in the lesson that she created. Her lesson was built around the idea of comparing colored candies found in bags of Halloween candy. We hypothesize that these links can be made through more rich tasks. Our last goal was to determine the teacher's representation of Statistics. Our research questions were: 1) What kind of links did the teacher create between statistical and mathematical concepts in her lesson? 2) What kind of links did the teacher create between Statistics and other disciplines? 3) What is the teacher's representation of Statistics?

### THEORETICAL FRAMEWORK

The idea of integration curriculum orientation is not new in education (Lowe, 2002). In the context of major worldwide changes during in the last decades and new complex phenomena, such as new technologies present in our daily life or climate changes, it is essential to take into consideration the new social realities. Thus, instead of integrating disciplines like it was suggested in the 70's (Lenoir & Sauv , 1998), new realities bring forth the idea of interaction between them (Legendre, 1993). This interaction could be considered as a negotiation between disciplines, where the development of one discipline contributes to the development of others (Fourez & Larochelle, 2003). It can offer an extended perspective and allows disciplines to support each other. For example, collecting and interpreting statistical data might contribute to understand social or scientific phenomena.

Instructional programs in Statistics, also known as data analysis (National Council of Teachers of Mathematics (NCTM), 2000), focus on exposing students to a statistical approach, where students from K-12 should develop the abilities to: formulate questions that can be addressed with data and collect, organize and display, relevant data to answer them; select and use appropriate methods to collect data; and evaluate inferences and predictions based on data (NCTM, 2002). Throughout this progression, it is aimed that students develop statistical reasoning where they will be able to use descriptive Statistics in order to clearly interpret data with fidelity and with rigor (Ministère de l'Éducation du Québec, 2000). In this paper, we consider that Statistics and Mathematics are two different disciplines, because they have different epistemologies. The reasoning behind those disciplines is not the same. Statistics use an interpretative reasoning that focuses on variability and Mathematics use a deterministic reasoning (Savard, 2014). Statistical reasoning involve a conceptual understanding of important statistical ideas (delMas (2004; Garfield (2002). However, Mathematics might be used to solve statistical problems (delMas, 2004). We understand that in schooling systems, Statistics are considered as a branch of Mathematics, but in opposition to researchers like Carvalho and Solomon (2012), we do not consider that developing Mathematics and Statistics together as a form of intradisciplinarity, where topics or concepts in the same discipline are related to each other.

## METHODOLOGY

This study is a part of a larger nationwide research project conducted with Middle school Mathematics teacher practices in six different regions of Canada. For each region, four Francophone and four Anglophone grades 7 and 8 (secondary 1 and 2 for Québec) Mathematics teachers were selected to participate in the project. In the project, we video-recorded three lessons with each of the teachers: a lesson he/she considered as typical; a lesson that he/she considered as exemplary; and an introductory lesson on fractions. We edited each recorded lesson and kept the best 15-20 minutes of each of them. These shorter videos were presented and discussed between the four teachers along with the team of researchers in each region. The goal of these focus groups was for the teachers to select the lessons that they believed would be the most representative of a typical lesson, of an exemplary lesson and of an introductory lesson on fractions, based on criteria they created. The lesson selected for this study is one that a teacher did as her typical lesson. During the focus group, the teacher, like all the others, started by explaining their lesson and answered preliminary questions (mostly clarifications about the lesson). Then the edited video of her lesson was shown. A discussion of the video seen would then emerge. During that time, all the members of the group could ask questions, ask for clarifications, point out practices and strategies that they thought were great and give suggestions. We took the opportunity to ask her about her representation of Statistics during that discussion. The video of the lesson and the focus group discussion for that lesson were transcribed and we used the corpuses to analyse and interpret the specific interdisciplinary and intradisciplinary actions related to knowledge building (Savoie-Zajc, 2000). In the analysis, we present the actions and the links made by the teacher. She designed the lesson in 3 parts. In the first part, she presented the task by giving each team of 3 students a pack of colored candy and constructed the question with them. She then went over the steps for completing the table that goes with the pie graph with the students. In the second part, the students solved the task. In the last part, the teacher discussed the task with the students by doing an example using the data from one team. We will mostly focus on the last part because this is where the links were made.

## RESULTS AND DISCUSSION

### *Interdisciplinary Links Between Statistical Ideas and Mathematical Concepts*

During the last part of the lesson, the teacher discussed the frequency (the number of candy in a certain color in a pack), the frequency ( $a/b$ ) for each colored candy (data expressed as a fraction) and the relative frequency (data in percentage). She made links with numbers, fractions and percentages. She reminded the students that the total should be found using addition of the numbers representing the frequency. For the frequency ( $a/b$ ), she came back to the definition of a fraction that is a part of a whole. She explicitly asked the students why we write  $3/9$  and made it

clear that 3 is the part and the 9 is the total number of candies in the pack. At the very end, she asked the students about how to fill the relative frequency column of the table but she did not give much importance to it. The teacher thus focused her lesson on the representation and the organization of data using mathematical notation. When it came to the idea of constructing a pie graph, the teacher made links with fractions, the circle and with angles. She started off by asking the students what they knew about a circle. The students answered that it had a 360-degree angle. Following that, she asked the students how to determine the angle of the sectors for each colored candy in the pie graph. A student answered that, “for the red candy, you can do  $\frac{3}{9}$  of 360”. The teacher made it explicitly clear that we can use fractions in other contexts. She added, “It is not for nothing that we discussed fractions, fractions of a number and so on before this. Now you see that we can apply fractions in other contexts other than in arithmetic”. She then went over strategies of doing this calculation by saying that you could use proportional reasoning. Then she did an example with the class, focusing on the strategy of dividing 360 by 9 in order to get the measure of  $\frac{1}{9}$  and then multiplying the quotient by 3. She proceeded that way because a student suggested that strategy. The teacher created interdisciplinary links between the representation and the organization of data (Statistics) and Mathematics: mathematical notation, proportional reasoning, geometrical representation and measurement. Thus, intradisciplinary links were created between mathematical notation, proportional reasoning, geometrical representation and measurement. But, as pointed out by delMas (2004), the lesson did not go beyond the learning of procedures and thus did not develop explicitly a statistical reasoning.

#### *Interdisciplinary Links Between Statistical Ideas and Other Disciplines*

No links between statistical ideas and other disciplines were made. The teacher simply focused on the procedure of representing the data with a pie graph. After she finished constructing the pie graph on the board, she stopped her lesson by asking the students if they had any questions. When there were none, she ended the lesson by giving the student problems to solve in the textbook. It is possible that she chose this action because there was less than 10 minutes remaining. During the discussion group, the other members noticed the fact that she didn't spend time on the interpretation of data (NCTM, 2002) and they made that suggestion to her. For example, they could compare the data between groups, they could make a set of data of the whole class and then see how the data of each group is similar and different from the whole class data, and to make links with probability, business, economy and other fields that would be beneficial. It is clear that the teacher focused her lesson on the idea of representation of data (NCTM, 2002). No inference or predictions were made based on the data.

#### *The Teacher's Representation of Statistics*

The teacher had a clear representation in mind: “My representation of Statistics is to be able to represent and compare the data. In this activity, I wanted them to be able to use the data and create a graph with it”. However, when related to the three ideas of Statistics grounded by the NCTM (2002), we can see clearly that the idea of evaluating inferences and making predictions is not in her representations. She sees Statistics as a way to collect, organize, represent and analyze data although the data was already given to them and she didn't spend much time to do an analysis of the data at the end of her lesson. She didn't mention about the ideas related to the formulation of question that can be addressed with data. However, we observed in the first part of the lesson that she took a bit of time to discuss the importance of having a clear and rigorous question. The classroom had a small debate on this issue when it came to constructing the question they would be exploring with the colored candy. The students added the ideas together to create the question. For example, one mention that just saying the representation of the colored candy is not enough so that it is important to say where the candy came from. She showed a procedural vision of Statistics and her lesson focused on a graphical representation and thus led her to avoid all statistical reasoning development on the stochastic process (delMas, 2004; Garfield, 2002).

#### CONCLUSION

This study shows that the teacher's representations about Statistics might have influenced the implementation of interdisciplinary lessons. In this case, she wanted to create those links.

However, her representation of Statistics was oriented to procedural understandings instead of the interpretation of a phenomenon. It seems that her epistemology was aligned with a deterministic reasoning on procedure than interpretative reasoning. It might mean that the links that she created were more intradisciplinary within Mathematics than interdisciplinary with Statistics. These results highlight an important question: How does the teacher's actions and representations effect student learning opportunity of Statistics? More research is needed in order to bring light to this question.

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