SIMULATING THE RISK WITHOUT GAMBLING: CAN STUDENT CONCEPTIONS GENERATE CRITICAL THINKING ABOUT PROBABILITY?

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It is known now that gambling among youth is a major problem around the world. Children and teenagers gamble and some of them become addicted to gambling. In order to help them develop mathematical knowledge about these activities without asking them to gamble, lesson plans about probability were designed and implemented in a grade four classroom. In this teaching experiment, students were asked to simulate the spinning of the wheel using a spinner. The analysis of the students' representations showed that they used deterministic reasoning to predict the outcome. The awareness of variability of outcome occurred with the comparison of the frequency of each outcome, which helped them change their reasoning to a probabilistic one. Results also suggested that student conceptions about the fairness of the spinner could be considered as a form of critical thinking about the validity of the simulation.

RISKS AND PREVENTION

Gambling activities are now very popular around the world. These gambling activities are generally considered to be recreational in nature, without risk involved (Proimos et al., 1998). In fact, there are risks of becoming addicted to gambling and youth are also at risk to develop behavioural problems and a gambling addiction. With the increased popularity of poker, the lottery and casinos in the media (advertising, internet, radio and television), youth are very sensitive to them. A survey shows that 86% of 1329 children between 8 and 12 years old have already bet money, 37% have bet an important object for them and more than 40% explained that they bet at least once per week (Ladouceur et al., 1994). Another form of gambling that has gained popularity with youth is the lottery: The average age amongst which scratch tickets are popular is 10 years old, similarly for lotto it is 11 years old and 12 years old for sport lottery (Felsher et al., 2004). Youth are convinced that they are invincible, that few risks are involved in these activities and that they can participate in gambling without any consequences. That is, 36% of all Quebec teenagers gambled in the past 12 months, 3.8% of them are at risk of developing an addiction and 2.1% are considered to already have an addiction (Martin et al., 2007).

In order to avoid negative consequences, it is important to inform them about these risks. They also need information about how these activities work and what the probability of winning is. In fact, a conception called 'illusion of control' (Langer, 1975) appears when people believe that they can control the issue of the game. For example, they think that a lucky charm or priest can have an effect on the outcome. Youth need to counterbalance this thinking by using probabilistic knowledge or critical thinking, that must be learnt in school (Crites, 2003): Prevention must start in elementary school (Ladouceur et al., 2004). That is, critical thinking can be developed in mathematics courses (Krulik & Rudnick, 1999). According to Lipman (2003), critical thinking is a process for making a judgement or to construct a point of view. Critical thinkers evaluate their thinking and they have sensitivity to the context. They give solid and valid arguments (Duval, 1991) when they defend their claims. Thus, mathematics provides youth with tools to understand and analyze social and political issues (Mukhopadhyay & Greer, 2001).

LEARNING PROBABILITY

The concept of probability involves reasoning with the parameters of uncertainty. This uncertainty can be expressed by variation and distributivity. Variation is not often employed in other mathematical contexts (Watson & Kelly, 2004). In fact, probabilistic reasoning is different from what we habitually use: deterministic reasoning. This reasoning supposes that things are determined: experiences from the past and observations in the present can provide an answer. Deterministic reasoning leads students to look at one definitive answer. They use a deterministic model (Shaughnessy, 1992) to represent the situation and then can give personal explanations also called conceptions, to explain the outcome. Konold (1989) calls this personalist interpretation. For

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example, Amir and Williams (1999) show that students explain the outcome of a trial by the manipulative orientation of the dice or the spinner. These deterministic conceptions use a deterministic reasoning. In many case, it seems that students didn't used a probabilistic reasoning for modelling a probabilistic situation in gambling activities or learning situations. How can we develop a probabilistic thinking in a fake gambling situation?

A TEACHING EXPERIMENT

A teaching experiment was conducted in a grade four classroom in a Quebec City suburb. The aims of this teaching experiment were to study the probabilistic thinking of the students and to see how this thinking was developed within fake gambling situations.

The researcher was the teacher in this class of 27 students. Six learning situations were proposed: drawing two pictures, answering two questionnaires, giving two formative evaluations and doing a bibliographic research. Each lesson proposed a gambling context to be studied with a mathematical context about probability within it, and a citizenship context focusing on critical thinking was also embedded (Savard, 2008). All situations and student productions were analyzed with DeBlois (2003) theoretical framework. This model focuses on the representation of the situation by the learner, the procedures employed, and on the effects of the didactical contract (Brousseau, 1998). Coordination between these things can create awareness toward the concept.

SIMULATE THE RISK

A learning situation using spinners was presented in class. Spinners are popular gambling activities, which involve a frequentist approach (Konold, 1991) of probability. In teams of two, students were asked to experiment 100 trials with a five-coloured spinner and record their outcomes. A discussion about their simulations and their results followed the experimentation. At the beginning of the lesson, some students wondered about making a prediction or not, because in a previous lesson, they had made predictions. This time, the teacher gave them the possibility to do so or not. After the simulation of 100 trials, comparing outcomes gave the opportunity to discuss the variability of the results. A student quit a deterministic reasoning for a probabilistic reasoning by recognizing the random effect. Thus, this student represented prediction as a way to determine the outcome with certainty but, once he took care of the variability of the outcomes, he became aware that the outcome couldn't be predicted with certainty:

> *Félix-"Then, it is not about that, but it is when we were told to choose a colour. Me, I say that it cannot work all the time. It is instead of chance. It is because I tried, I was on the purple section and I said that I would like to go on the red one, but it doesn't work all the time because the needle, it spin fast and it can go on the next side of the red section".*
> *Teacher-"Why do you want to go on the red section?"*
> *Félix- "Then, I did a prediction. Predictions are not always true. It is not always true."*
> *Teacher- "Wait a minute. You said that you did predictions, but you didn't write them. You did it in your mind."*
> *Félix- " I did, but like…"*
> *Teacher- "Yes?"*
> *Félix- "Sometimes it worked, sometimes it didn't work. Then, it is why we did it. Predictions, it is not always true." (R.790).*

For this student, to predict means to determine the next outcome. Because prediction requires to reason under uncertainty, we cannot predict the outcome with certainty. This created an obstacle when a student used deterministic reasoning, because this kind of reasoning is used in contexts where there is no variability. When Félix claimed that predictions are not always true, he represented variability as a possibility. In this context, using prediction like a process of determining an outcome is useless. Félix did not see the need for using it and then discontinued. He shows an awareness of the randomness, because the outcomes are randomly occurring.

Later in the discussion, the teacher asked 10 teams to write the frequencies for each colour of the spinner on a table posted on the blackboard. Students wondered about the variability of the results. Students did not recognize that the theoretical probability for each colour was 1 out of 5. It was when they added their results for a total of 100 for each colour that they were able to compare theoretical and frequency probabilities. The comparison between student's frequencies and theoretical probability lead students to an awareness about relative frequency and equiprobability. Taking care of the distributivity of the results drives students to interpret variability, based on the relative frequency:

> *Teacher-"Did you get 20 for each colour?"*
> *Group- "No."*
> *Mélissa- "It was always pretty closed, like 17 or 18. It was pretty closed. But, for example, you said that it was supposed to be 20. But some got more than that. For example, they got 50. Then, others will get less. In fact, it will be almost the same thing." (R.1654).*

Mélissa understood that if a team got 50 purple sections, they had less in other colour sections because of the 100 trials. It was relative. She also suggested that if it was 50 purple sections, the other teams can have less than that and so, the mean of the purple sections could be close to 20. So the equiprobability of the spinner was discussed in accordance with the frequencies achieved by students. This led toward a discussion on the fairness of the spinner. Students presented some *conceptions about the manipulative such as the strength used by them when spinning the needle*, the needle's will and why some sections appeared more frequently than others. They tried to explain the variability of the outcomes using personalist interpretations. But some students were more concerned with the fairness of the spinner for explaining the variability. In order to confirm the equal area covered by each colour of the spinner, the *dimensions of each coloured section* were measured and compared. The black line separating each coloured section was also discussed. In some cases, students found that the needle stopped on the black line. This technical problem was discussed and students wondered about spinners in a game show. Students agreed that on a game show, this is not a problem because coloured sections are framed by a piece, which helps to stop the needle. Then they tried to figure out ways to cheat the wheel in a game show in order to evaluate the validity of the game. In their study, Amir and Williams (1999) showed that students had conceptions about using devices such as dice and spinners. But in this case, students used their conceptions about manipulation of a device in order to assess their simulations. So, the fairness of the spinner appears to lead to a critical thinking about the equiprobability of the spinner and, by extension, critical thinking about the validity of the simulation. Furthermore, this played a role in gambling prevention because, not only did students learn about the probabilities of winning using a wheel or a spinner, they also developed a critical thinking about the game itself. Thus, it is more than to get informed about gambling and risk, it is about how to think about these games and evaluate the real chances of winning in order to make the decision about participating or not.

CONCLUSION

Results of this study suggested that a simulation using spinners could lead students to construct probabilistic thinking. In fact, it was when a student compared his outcomes with the prediction made that led him to see variability. And it was when students compared their frequencies and the theoretical probability that critical thinking occurred. The simulation itself, and the comparison of the results led to critical thinking toward the validity of the simulation and overcoming deterministic reasoning. These results suggested that critical thinking is an important aspect when learning probability, because it helps students to evaluate the validity of the simulation and thus, avoid having some conceptions about manipulative'.

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