THE EFFECT OF CONTEXTUALISING PROBABILITY EDUCATION ON DIFFERENTIATING THE CONCEPTS OF LUCK, CHANCE, AND PROBABILITIES AMONG MIDDLE AND HIGH SCHOOL PUPILS IN QUEBEC

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On the one hand, the field of probabilities is certainly the most obscure and the least developed area in the sphere of statistical education in Canadian middle and high schools. On the other hand, mastering probabilities is doubtless the field of school learning that offers the most potential for transferring knowledge to other fields of experience in the pupils' lives, notably regarding gambling and money. Within the scope of this study, carried out among over 1,600 pupils in middle and high schools, we have collected their implicit definitions of gambling, luck, and probabilities. A textual data analysis of their discourse shows that they confused these concepts and strongly associated them to luck, while the notion of random variability remained obscure. Contextualising probability education from the point of view of what youth really does facilitates in this respect the construction of distinct notions.

INTRODUCTION

Scientific documentation reviews few studies pertaining to the effects of school learning on the development of a "realistic" relationship between the future citizen and the laws of chance. Yet, the relationship youths have with chance and probabilities has an influence on the numerous behaviours that involve decision-making as consumers or citizens.

Chance stems from what is not attributable to linear causality. Youths therefore tend to progressively develop intuitive strategies that seek to control it. These theories, consolidated by the social practices around them that confuse luck and chance, support the development of erroneous conceptions while processing the probability concept. Since teaching this concept is rarely based on the use of real learning situations, erroneous reasoning has a free reign. In addition, this kind of reasoning is generalized to all common situations and has an impact on pupils' academic success and daily practices (Musch & Ehrenberg, 2002). The major rift between the naive theories that make up, on the one hand, the foundation of the relationship that pupils and teachers have with chance and, on the other hand, the linear nature of education, constitutes one of the main difficulties of learning probabilities in a school environment (Steinbring, 1991; Wassner, Martignon & Seldmeier, 2002). Teachers conceive the concept of chance as a generalization that postulates randomness as a fixed and universal explanation, rather than a conceptual tool that enables one to identify the fluid relationship between the concepts of chance and random variability. It is this relationship that makes it possible to refer specifically to the concept of probability in mathematics and, thus, to appropriately support the pupils' theorization process. In Quebec, teaching probabilities and the concept of chance has been mandatory from the beginning of elementary school since the inception of the new curriculum in primary and secondary school, in 2001. It has been especially promoted at the end of elementary school (grades 5 and 6) and continues until the end of secondary school (from grade 7 to 11). However, teaching probabilities rarely takes into consideration the pupils' previous representations of the concept or mean. What are the social representations that correspond to preconceptions regarding the definition of such concepts as luck, chance, and probability among pupils in middle and high school? This is what we have explored by asking two samples, distinct but complementary, of Quebec pupils (N= 1,882) to define what each concept meant.

CONCEPTUAL FRAMEWORK

The social representations (SR) are worlds of knowledge regarding common sense, which correspond to a collective activity of interpreting and building reality. In its turn, this activity produces a body of knowledge whose cognitive, affective, and symbolic contents play a crucial role

in the way people think and in the everyday actions of members of the group (Larose & Lenoir, 1998; Liu, 2004). The SR, as a socially shared construct, convey not only cognitive definitions of conceptual objects, for example luck and its attributes, probabilities and their role in youths' daily lives, but also prescriptions concerning what to do when faced with these objects. In this sense, SR become guidelines for attitudes and direct the predictability of behaviours among the members of a social group (Joffe, 2003; Tafani & Souchet, 2002).

METHODOLOGY

Within the framework of two studies, respectively funded by the Social Sciences and Humanities Research Council of Canada and the *Fonds québécois de recherche sur la société et la culture*, we conducted a survey questionnaire consisting in 94 items distributed in 13 sections on two convenience samples. For the purpose of this presentation, other than some descriptive variables of the sample, we will present the analysis results of 9 items in the form of a scale that measures attitude regarding the controllability of chance ($\alpha = 0.772$). One of the items, an open-ended question, asked the pupils to define and differentiate the concepts of luck, chance, and probabilities. Content analysis of the answers to the open-ended questions in the questionnaire was achieved with a lexical analysis (Lebart, Salem & Berry, 1998). In this approach, which uses correspondence analysis on a body of discourses, a certain number of forms (words) or segments (concepts) characterize certain individuals. These discursive elements, as they pertain to operators reflect the more or less off-centered position of individuals in relation to the centre of the factorial plan. In turn, these off-centered positions reflect individual residual variance components or, in more practical terms, the part of the variance that is not explained by successively taking factors into consideration. When analysis is carried out on a relatively limited group of texts by a large number of subjects, as it was the case in the analysis of the pupils' answers in this study, variation factors in relation to the barycentre generally correspond to a polar distinction at the level of individual variation sources regarding specific discourse components belonging to a small number of individuals.

SAMPLE

The sample was composed of 1,882 subjects (40% boys and 60% girls). Regarding the socio-economic distribution, 55% of the pupils came from middle-class families while 45% came from disadvantaged groups. The pupils' average age was 13 years and 11 months, but the actual age went from 12 to 18. With respect to schooling, the sample was distributed as follows: 8% of pupils were in the 3rd cycle of primary school (grades 5 and 6), 31% in the first year of secondary school, 27% in the 2nd year, 17% in the 3rd year, 12% in the 4th year, and finally 2% in the 5th year.

RESULTS

Our results indicate a difference in attitude according to the pupils' representation of the determinism pupils felt about success in mathematics. Pupils who thought they were *per se* good or bad in this subject matter obtained the highest scores on the perceived controllability of chance scale ($F = 10.33$ [4.1443], $p < 0.0001$; Scheffe's test < 0.05). In the same way, the more pupils considered having bad grades in mathematics, the more they believed in the existence of a kind of perceived controllability of chance ($F = 3.81$ [4.1445], $p < 0.004$; Scheffe's test < 0.05). When we took into consideration their attitude regarding the possibility of using strategies to control chance when gambling, we noticed that pupils who obtained the highest scores on the scale of perceived controllability of chance were also those who thought they would be able to apply wining strategies when playing poker ($t = 5.74$ [1457], $p < 0.00001$), instant lottery ($t = 5.60$ [101.1], $p < 0.00001$), jackpots and draws ($t = 5.60$ [101.1], $p < 0.00001$), Internet casino ($t = 6.96$ [1457], $p < 0.00001$), as well as slot machines (Video Poker) ($t = 6.20$ [1457], $p < 0.00001$). In short, pupils who developed a positive representation of the perceived controllability of chance were also those who presented the highest risk of obtaining low scores in mathematics, of considering their academic performance as determined by chance, and of deluding themselves concerning the possibility of influencing the probability of wining when gambling if they use specific strategies.

We also asked the subjects to produce different definitions for the concepts of chance, luck, and probability. The lexical analysis of the pupils' discourse led to a certain number of interesting conclusions (see Figure 1). Luck was mainly associated with determinism, which affects daily

actions. It is seen as an individual characteristic (green parallelepiped). The concept of chance turns out to be polysemous (blue ellipse). It both refers to the computation of odds–an estimate of probabilities–and to the quality of that which determines an individual, thus reflecting a characteristic of the French language, which is our pupils' mother tongue. Finally, for its part, the probability concept was specifically associated to school, and more particularly to teaching and learning mathematics (red parallelepiped). It came down to school practices relative to calculating the possibilities of obtaining good or bad results (left side of the figure) and estimating the occurrence of events under uncertainty (unpredictable possibility). Lastly, regarding games of chance, elements of luck are determining (black rectangle).
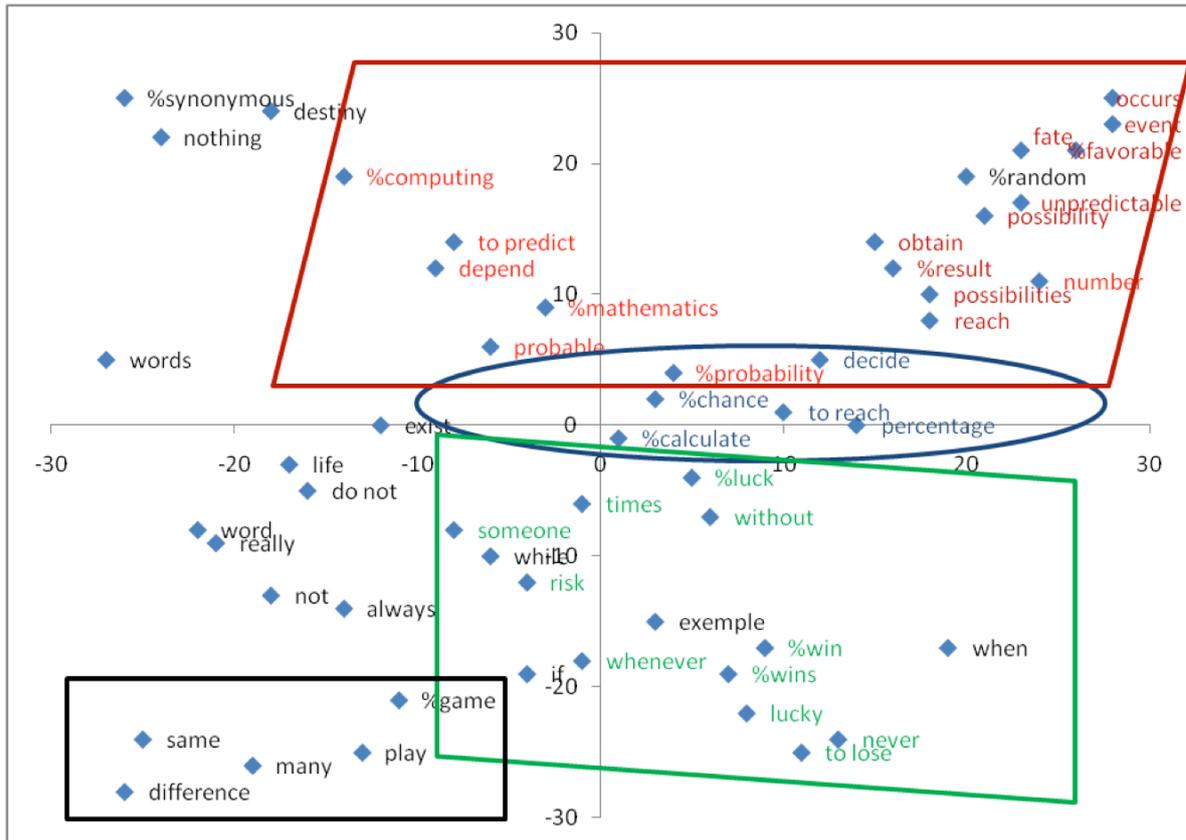

Figure 1. Correspondence analysis, axes 1 and 2, definitions of concepts

DISCUSSION

In a scientific literature classic that tackled the concepts of chance, luck, and statistics, Levinson (1939/2001) claimed that "Among the superstitious ideas that have persisted in a well-nourished state is that of luck. According to this notion chance events do not take place impartially. They are influenced by a mysterious something called luck that is attached to every man, like his shadow, except that he can rid himself of the latter by going into a dark place, while the former follows him everywhere" (p. 4). The author made a difference between two worlds of beliefs or representations. The first, which is related to the concept of luck and chance, stems more form psychology and tends to define an individual characteristic. The second, which he associated with statistics, stems from a scientific perspective of the world. For Levinson, as with several authors, the concepts of statistics and probabilities tend to get mixed up. More recently, André (2009) defined the concept of luck as a multidimensional construct composed of at least two facets. The first corresponds to luck as a determining factor in individual behaviours that lead to various forms of cognitive distortions, while the second would correspond to a more realistic, even scientific, point of view of luck, which would be studied from the point of view of random variability, as characterizing more or less predictable yet uncontrollable events (Maltby, Day, Gill, Colley, & Wood, 2008). Our results located the conceptual map of Quebec pupils, ages 12 to 18, in relation to these two perspectives. On the one hand, youths in our sample tended to confuse luck and chance on a psychological level. Both concepts characterize the individual and the events that people must

face on a daily basis. On this level, the psychological representation of the controllability of chance enabled us to note the existence of two extreme postures among the pupils. The first shows that there exists a form of determinism among individuals–they are either lucky or not–but that it is possible to develop strategies to act upon this determinism. The second rejects individual determinism and the possibility of applying strategies on it. The second posture opposes a linear conception of the relationship between human action–for example, school related would be work and perseverance–and obtaining more or less positive results, consigning chance to the realm of randomness, thus to the field of science, statistics, and probabilities. It is this kind of polarity that characterizes most studies on the theories of motivation in school (André, 2006; Weiner, 1986). On the other hand, our pupils tended to dichotomise the concepts of luck, chance, and probability according to a system of categorizing that opposes everyday life, stemming from a psychological perspective, to school life, stemming from a mathematical perspective and dismissing probabilities as a school subject that is disconnected from their everyday life.

CONCLUSION

In this sense, an academic problem is revealed, whether opposition is made between luck, chance, and statistic, as Levinson noted, or whether it emerges between luck and probabilities, as it was the case with our pupils, statistics and probabilities are part of the same academic field, the subject matters as much as the way they are taught (Wassner, Martignon & Seldmeier, 2002). This observation brings us to mention yet again the importance of a mathematics education, and more specifically of probabilities within the scope of this subject matter, in a perspective of real practices, which take into consideration pupils initial representations while applying their social practices as leverage that will enable the construction of an integrated world view. Only this perspective will make it possible to get beyond the gap between education, erroneous conceptions regarding school learning, and maintaining implicit theories that are unrealistic such as the controllability of chance hypothesis in the pupils' everyday life psychology.

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