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## IDEAS OF CHANCE AND EVOLUTION FOLLOWING A GAME PLAYED IN A FRENCH LOWER SECONDARY SCHOOL

*This chapter is part of the EGRESS project (Educational Game about Randomness and Evolution for Students in Science), which is based on the design of a board game integrated into educational resources for lower secondary school in France. The aim of the regulated play activity is to encourage students' engagement and understanding of biological evolution by following the historical and formal evolution of species through creative verbal and graphic narrative processes. This project is based on previous work that has highlighted the difficulties in understanding chance and evolution. This communication proposes a case study based on a classroom game situation with 12-13 year-old students. The phases of narrative creation and the justifying discourses of the players are analysed. The didactic analysis highlights in most players a mobilization of ideas close to evolutionary thinking and a difficult mobilization of ideas of contingency. These feedback can facilitate teachers' work in addressing chance and evolution with lower secondary school students.*

**Keywords:** Experiential Learning, Misconceptions, Secondary School

### INTRODUCTION

The work presented in this paper is based on the design of a board game integrated into educational resources for lower secondary school and is part of the EGRESS project (Educational Game about Randomness and Evolution for Students in Science). The game designed in the project engages players in processes of narrative, verbal and graphic creativity. This project is based on previous work that has highlighted the difficulties in apprehending the theory of evolution and the ideas of chance that are linked to it (Coupaud, 2018; Fiedler, Sbeglia, Nehm, & Harms, 2019).

Several authors explore the links between evolutionary theory and the concept of randomness (Gayon, 2005; Merlin, 2013). Gayon (2005) identifies three possible meanings of chance in evolution: luck, random probability, and contingency with respect to a given theoretical system. In an evolutionary process, "luck" is associated with mutations and can sometimes give genetic innovations. Random probability, the second sub-concept of chance, refers to a statistical approach to the probabilities of events associated with the mechanism of genetic drift at the population level. The third sub-concept of chance, contingency, represents a mechanism combining fortuit events, that are contingent in a historical perspective. This type of chance plays a major role in evolutionary processes by removing any idea of intentionality. It is an important aspect of the game design in EGRESS in order to overcome the epistemological obstacle of finalism.

Previous work has highlighted links between lower secondary school student's knowledge of biological evolution and their understanding of chance (Coupaud, 2018). They associate chance with destiny, good luck or misfortune, leading to a strong finalist idea of evolution. Students' probabilistic thinking seems to be linked with their evolutionary thinking. Students of this age tend to develop reasoning at an individual level, which is an obstacle to understanding evolution (Gobert, 2014). The board game designed for this project particularly mobilizes the two ideas of chance: random probability and contingency. These ideas feed into the mechanisms explaining evolution at a population level.

The purpose of this research is to identify how a board game activity in the classroom encourages evolutionary thinking. In particular, we address the research question: what ideas of chance and evolution are expressed in verbal and graphic narrative productions by lower secondary school French students following a game designed to engage players to manipulate concepts of chance and evolution.

## METHOD

This case study involves a video-captured classroom game session with 32 students. 4 games were played in parallel, each with 4 teams of 2 players. The game engages students in a fictional scenario of experimental evolution where players study changes occurring in a fictional experimental population in response to conditions imposed by the player but not totally controlled. It engages students with a physical experience of random processes combining a variety of board game artefacts such as cards, a board defining different environmental conditions, and a cube tower to throw pieces that are randomly selected (some are trapped, some are discarded). The game is based on a chaotic game mechanic incorporating fortuit events that disrupt the course of the history of a fictional animal population. During the game, each team is asked to draw a sample of their population of fictional animals at each turn to depict the intraspecific variation and its changes over time. After the game, students are asked to write the story of their population. A debriefing session was organised two weeks after the game. Students were encouraged to express their understanding of what happened during the game and how it related to evolution.

The qualitative analysis is based on written, oral and graphical expression of students in class during and after the game was played. It is based on analytical categories defined *a priori* from previous work on lower secondary school students' knowledge and acceptance of evolution (Coupaud, 2018). It provides an epistemic reading of the conceptual knowledge, the common sense ideas, or the obstacles that students express in their written and oral discourse or graphical productions. The concept of obstacle that we use refers to the idea of epistemological obstacle in the sense of Bachelard (1938) and is anchored in didactic research on the identification of specific conceptions based on obstacles (Astolfi & Peterfalvi, 1997).

## RESULTS

Our didactic analyses highlight the engagement of all the players in the game and the narrative activity that followed. The use of common sense ideas from the players' everyday world allows each player to weave stories and invent new possibilities. The texts produced by the students are narrative texts which are essentially descriptive. The chaotic mechanics that characterize the game generate random evolutionary scenarios, where events that cannot be predicted by the players occur and new characters randomly appear in the populations of fictional animals.

A cross-analysis of written and oral discourse shows:

- An acceptance of biological evolution: idea of a common origin observed at different moments of the game ("same legs as their ancestor", "All three are evolutions of one from another").
- An understanding of certain important ideas related to biological evolution in line with scientific knowledge: the spontaneous appearance of new traits which implicitly refers to the idea of random mutations ("In the 2nd generation a new thing appeared, green skin."), the idea of variability within a population related to the distribution of phenotypic frequencies ("The Nadocks tribe is composed of a majority of blue fur, webbed feet and pouch-like beaks. The minority has a yellow coat, nails and curved beaks").
- An understanding of biological evolution not in accordance with the current scientific thinking but still related to the idea of evolution: transformist thinking considering the appearance of new characters as a direct effect of the environment ("After the floods, the webbed feet remained and the claws increased as well as the green coat", "They evolved thanks to the natural elements that we could find in the forest, in the desert, in the sea...").

However, specific obstacles to evolutionary thinking are also identified:

- A non-scientific explanation of the evolution of the population that can be linked to an intention: either an intention of the animals to transform: "the Chimerus decided (...) to have new colors", or an intention of the animals to diversify: "our population has recruited new species, with different particularities".
- An absence of the ideas of contingency in the explanations of evolution.

## CONCLUSION

Within the particular context of a board game played in this study, the lower secondary school students involved seemed capable of using ideas close to evolutionary thinking, even if the use of ideas of "contingency" still seemed difficult. In their written discourse, the students reported the transformations taking place in their population, the new characters that appear, the events that occur, without trying to propose causal links or other types of deterministic explanations that would bring an external coherence or a cause to all of these elements and events. Even if the idea of chance is not thematized as such in the students' discourse, we see the expression of a certain acceptance of the random nature of what their population becomes during the game. At that point in our research, we therefore propose the hypothesis that the chaotic mechanics of the board game that was developed could influence the acceptance of the stochastic nature of evolution. Obstacles to evolutionary thinking are identified for a minority of the students in the study. Moreover, students tend to engage and capture the game quite easily by summoning their knowledge and beliefs, even about the complex and counter-intuitive concepts of chance and evolution. We think that these elements can mediate the teaching activity and facilitate teachers' work when addressing the concepts of chance and evolution with young students.

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