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EDUCATIONAL GAME ABOUT RANDOMNESS & EVOLUTION FOR STUDENTS IN SCIENCE

Magali Coupaud, Alice Delserieys

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1/ EVOLUTION IN FRENCH SCHOOLS

Evolution is a complex object of teaching and learning, with existing societal controversies (Williams, 2015) standing as obstacles to its acceptance.

Teachers largely accept the ToE compare to other countries (Cl ment, 2015). In France, evolution is taught in a context where secularity is one of the key pillars of the educational system.

This secular context implies that no studies have been conducted to assess lower secondary school students acceptance of ToE with the possibility that students religious beliefs might influence their acceptance.

	End of primary school	Lower secondary school
French curriculum 	An approach to the notion of living species: - unity and diversity of living species - first classifications of living things	K6 (12 years old) idea of evolution: development of phylogenetic classification K9 (15 years old – last year of common compulsory education) Explicit teaching of the mechanisms of evolution: Mutation / genetic drift / natural selection
Conceptions of French students 	- Knowledge on some facts of evolution (emblematic figures) - Non-evolutionist and fixist ideas - Idea of evolution is mainly expressed in the form of « creation + evolution » J�gou-Mairone (2011)	- Agree with extinctions of species - Pro-evolutionist ideas (in line with scientific knowledge) to creationist ideas (reject the idea of evolution) - An anthro-centered vision of evolution Fortin (2010)

2/ EVOLUTION AND RANDOMNESS (Merlin, 2013, Fiedler, 2019)

Mechanisms of biological evolution	Sub-concept of randomness associated
Genomic variation http://evolution.berkeley.edu/evolibrary/article/evo_202	Chance Fortuitous event with no intentionality (not associated to any finality)
Genetic drift https://biologyboom.com/evolutionary-mechanisms/	Random probabilities Depending on the size of the biological population, and on probability laws. For a population to evolve, it is not necessarily linked to adaptation, it can simply reflect the effect of random probability at any stage of reproduction (Jacob, 1981).
Natural selection https://creationscience4kids.com/can-natural-selection-make-anything/	Contingency Encounter of independent causal series: the presence of external factors and the variation internal to an organism. Combines fortuitous events that are contingent in a historical perspective.



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3/ A STUDY TO EXPLORE THE LINK BETWEEN STUDENTS' CONCEPTIONS OF RANDOMNESS AND CONCEPTION OF EVOLUTION THROUGHOUT SECONDARY SCHOOL (UnRESt)

Method

Development and use of a questionnaire UnRESt (64 questions, 3 sections: A) students' acceptance and understanding of ToE (different dimensions with 3 items: examples for Humans, living and extinct animals) / B) students' understanding of randomness (sub-concepts of randomness related to 3 everyday situations) / C) personal questions) n=1634

Students' understanding of evolution

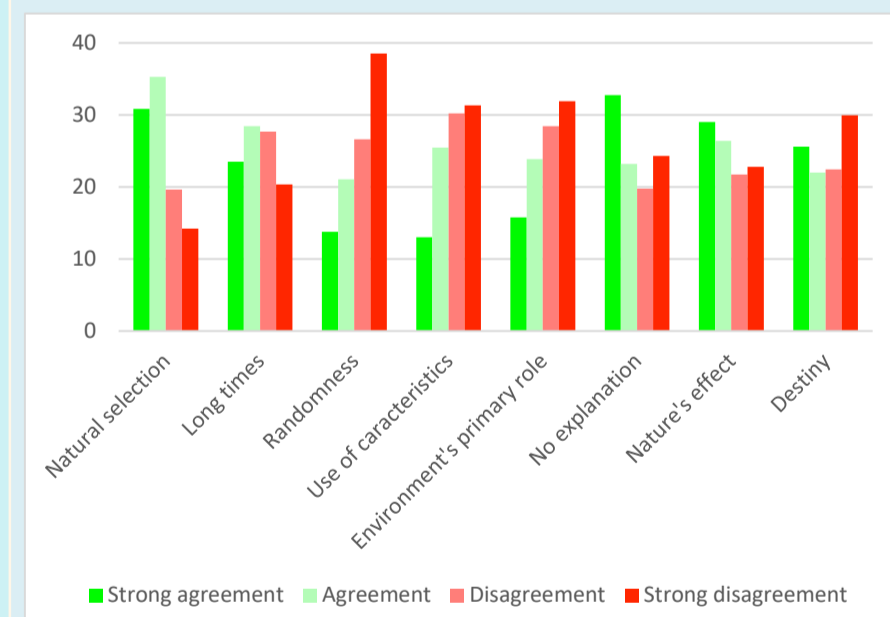


Fig. Distribution of students' answers about their understanding of evolution

An understanding of the ToE not in accordance with current theory.

Students' conceptions of randomness

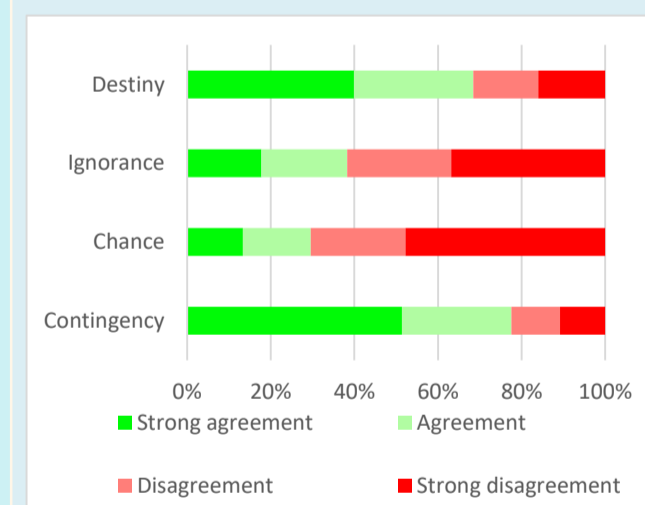


Fig. Distribution of students' answers about randomness in everyday life questions

Contingency: totally or rather agree
 Destiny: large number agree
 Students rarely recognize chance or ignorance as the random

Relation between students' conceptions of randomness and students' understanding of ToE

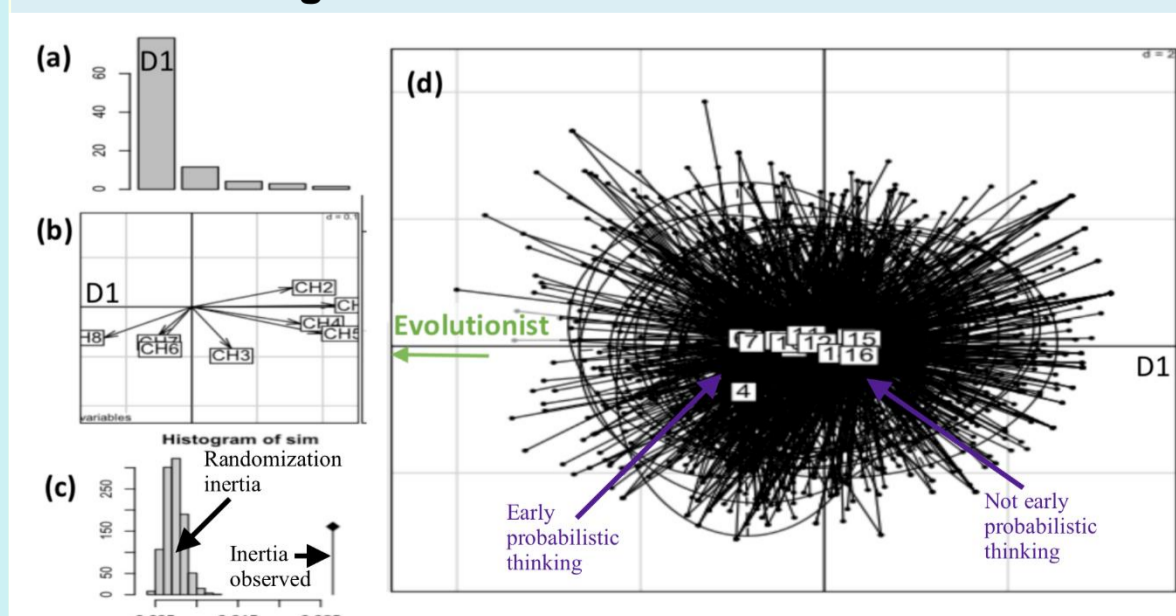


Fig. Between-class analyses of answers related to the understanding of human evolution, depending on student's answers about "probability". (a) Histogram of eigenvalues of the axes (b) Correlation circles (c) Monte Carlo randomisation test (d) Distribution of the groups of students depending on their answer about "probability" (4 for agreement with "probability" statements, 16 for disagreement)

The same type of analysis performed for 4 ideas of randomness emerges that the ideas of randomness 'probability' and randomness 'destiny' are linked to the pupils' answers to their understanding ToE.

4/ DESIGNING A GAME TO ENHANCE THE JOINT UNDERSTANDING OF RANDOMNESS AND EVOLUTION

The specific design of the board game aims to enable students to develop experience with probabilistic thinking and evolutionary thinking. As a result, we propose several game mechanics, associated with artefacts for game prototypes in order to address the 3 ideas of randomness (Gayon, 2005) identified above:

Chance: a deck of characteristic cards that players do not know in advance, can define the characteristics of a population for each player.

Random probabilities: a deck of dices that players throw successively. They can change a constructed genetic pool associated to the variation of individuals in a population within the game. In the first prototype, a roll of the dice allows to select the characteristics from a generation to another one.

Contingency: a deck of event cards (brings sudden changes in the environment tiles: "chaotic" mechanic) modeling a matching system between population and environment. With the students, it is important to underline, that this perturbing event is not predictable and not the result of players' luck or misfortune.



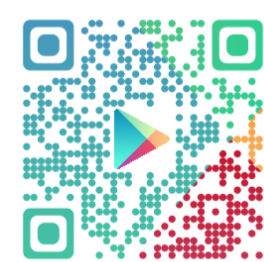
Environment tiles and population tokens

Characteristic cards, event cards and dices

Fig. Photos of first prototype of game about randomness and biological evolution

How is it ... so far ? What's next?

Several games can be played in parallel, in the class contexts. The analyses of the history and outcomes of each game can come as interesting opportunities to underline the different path taken by players. Thus, the teachers are able to insist on the unpredictability characteristics of species, and connect it to the non-deterministic nature of biological evolution.



To access the UnRESt study

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