The role of uncertainty in developing sustainable futures scenarios

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Abstract. This contribution explores the integration of uncertainty as a pedagogical tool in a climate change course designed for 12th-13th grade students. Drawing on interdisciplinary perspectives from physics education and futures studies, the course utilises an original board game to foster students' awareness of climate complexities and support sustainability competences development. The board game incorporates three kinds of uncertainties and leverages a simulator to explore climate-related decision-making, to stimulate students' critical reasoning while creating future scenarios. Findings suggest that the game effectively enhances students' comprehension of climate phenomena and decision-making processes, albeit with varied emotional responses, ranging from curiosity to hopelessness.

Introduction and Theoretical background

Present times are dominated by a socio-political crisis and questioned by huge challenges such as climate change [1]. Hence thinking about the future is difficult yet important. Research about students' future perspectives highlights difficulties in creating alternative future scenarios or making sense of the complex connections between science and policy, and in seeing themselves as agents to achieve societal changes [2]. Particularly, complexity and uncertainty stand as central aspects preventing students from thinking about their future [3].

Physics Education can help illustrate how uncertainty, a multidimensional and interdisciplinary concept, can be transformed into a fruitful instrument to deal with many aspects of climate change, like the scientific, the political and the societal [4,5]. In particular, we use the distinction made by Shepherd [6] concerning uncertainties in climate science: reflexive uncertainty, epistemic uncertainty, and aleatoric uncertainty.

Research and research questions

This work is framed within both the PLS national program (Piano Lauree Scientifiche), which aims to connect schools and universities to orient students in their future career choices and the FEDORA H2020 project, which introduced themes, methods and approaches of Futures Studies into Science Education [7]. This contribution presents a board game designed within a course for 34 12th-13th grade students where uncertainty - as conceptualised in physics and science education research - is used to make students learn about climate change and develop sustainability competences through the tools of Futures Studies [8]. The game has been designed appositely for the course to make students adopt a systematic perspective, considering different variables at the same time and negotiating decisions with different stakeholders. In the game, groups of players simulate a " council" that has to make decisions for reaching climate-related goals, such as decreasing sea-level and global warming rise, by 2100. To make decisions, students were asked to use a simulator (en-roads.climateinteractive.org) which shows quantitatively the connections between global temperature and sea-level rise and some technology, politics and society-related variables such as carbon price, energy sources taxation or population level.

Uncertainty plays a key role in the game, both in the design and the rules. We indeed designed wildcards, i.e. game cards connected to real-life events (extreme events, scientific discoveries, pandemics, social movements, etc.). We associated each of them with one of the different uncertainties as categorized by Shepherd. Also, students are asked to critically reason about the

data presented by the simulator, in that, as predictions, they are marked by uncertainty. The research questions we aim to address with this contribution are: i) how can uncertainty be used to structure a course and a game board on climate change and scenario making?; ii) in what way can a board game for constructing future climate scenarios centred on uncertainty help in developing decision-making and sustainability competences?

Methods and findings

Throughout the course, we collected data using questionnaires, recordings, and individual semi-structured interviews, analysed through thematic analysis. Results show that students were able to perceive climate phenomena' complexity and grasped the importance of uncertainty as a thinking tool rather than a limitation. The course helped students imagine and represent future scenarios and understand the issues related to science and policy decision-making. Also, the course led students to perceive "how the world works": we called this effect reality shock, to which students reacted in different ways, spanning from curiosity to an increased sense of hopelessness.

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