

Board games and board game design as learning tools for complex scientific concepts

Fabio Chiarello

CNR IFN
Istituto di Fotonica e Nanotecnologie

**Game
Science
Research
Center**



A Brief History of Board Games



Play in advanced animals:

Engagement with reality and with others

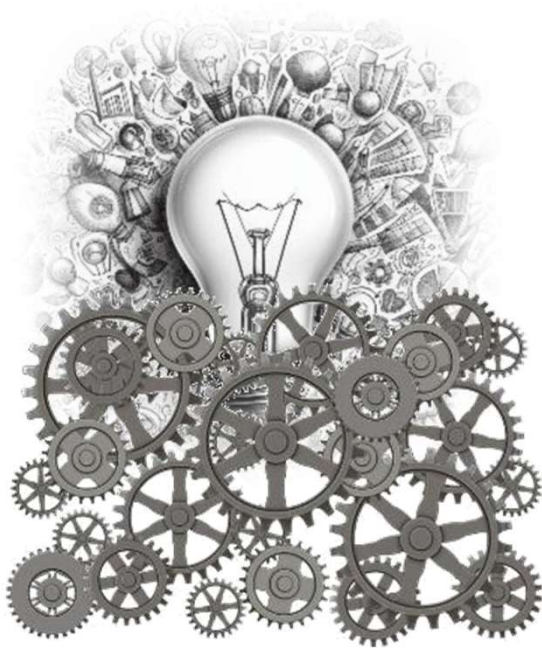
- *Exploration*
- *Experimentation*
- *Discovery*
- *Experience*
- *Training*
- *Social interaction*
- ...

In a highly motivating and immersive context
(yet protected and safe)



Playing with Ideas

It is possible to manipulate not only real objects, but also ideas and abstract concepts



Arts
Writing
Mathematics
Board games

Early Board Games

Neolithic artifact

- *'Ain Ghazal (Jordan)*
- *Around 6000 BC*

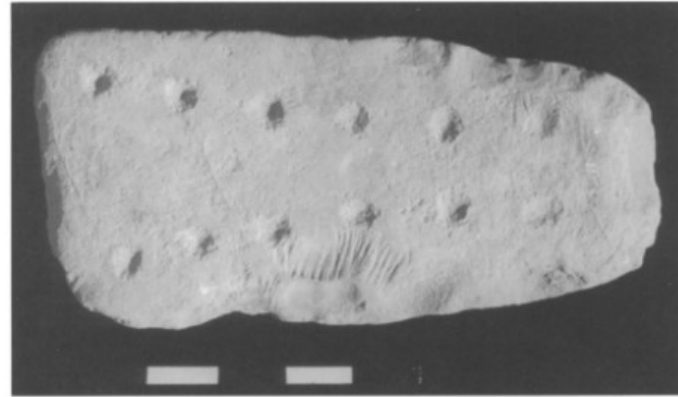


Fig. 1. Limestone game board from PPNC 'Ain Ghazal. The scale bars are 5 cm long (photo by L. Rolston).

“Mancala” family

Oware
Omweso
Kalah
Bao

...

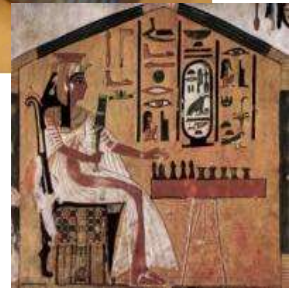
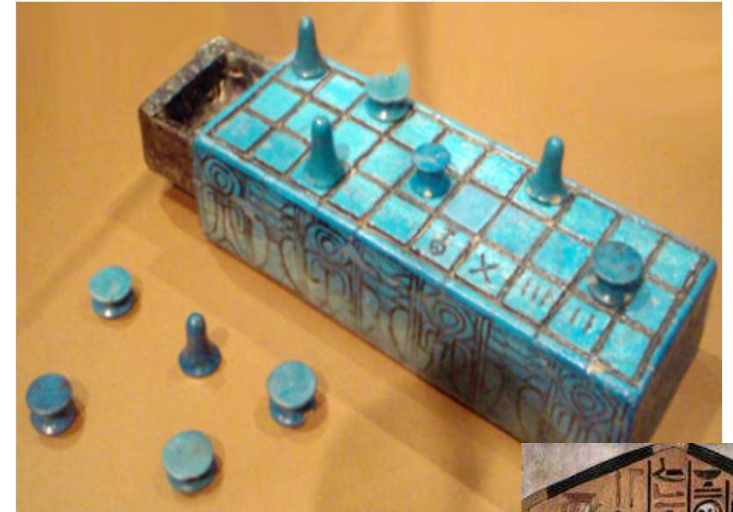


Senet

Senet: “The game of passage”

- *Egypt, around 3500 BC*
- *Game for nobles and priests*
- *Forerunner of Backgammon*

Educational purpose (studying the “Book of the Dead”)



Royal Game of Ur

Royal Game of Ur

- *Iraq, Royal Tombs of Ur*
- *around 2500 BC*



Ludus latrunculorum

Ludus latrunculorum (“the game of brigands”)

- *Ancient Rome Empire*
- *Strategy game*
- *Similar to checkers or chess*



Chess

Eastern origins (India or China, 6th century AD)

- Arab world, Europe (10th century AD)
- Perfect-information game
- *Often banned, together with other games*
- *(e.g. Louis IX, 1254, prohibition in French territory)*



Games and the Adult World

Games seen as a “not very serious” activity, relegated to:

- *Children (childish)*
- *Dissolute people (gambling)*

Still a strong cultural influence today
(fortunately now being overcome)

The importance of words

- *GAMING: play/game*
- *GAMBLING: games of chance*



Card Games

Originated in China around the 10th century

- *with the invention of paper*
- *Spread through Europe around the late 14th century*



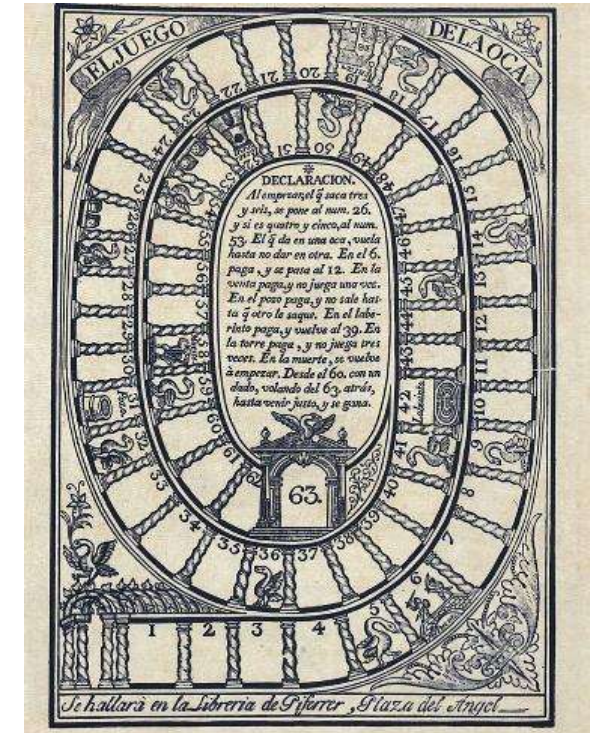
The Game of the Goose

Mid-16th century

- *Race game*
- *Pure luck (no strategic element)*
- *No interaction among players*

One of the most widespread game mechanics:

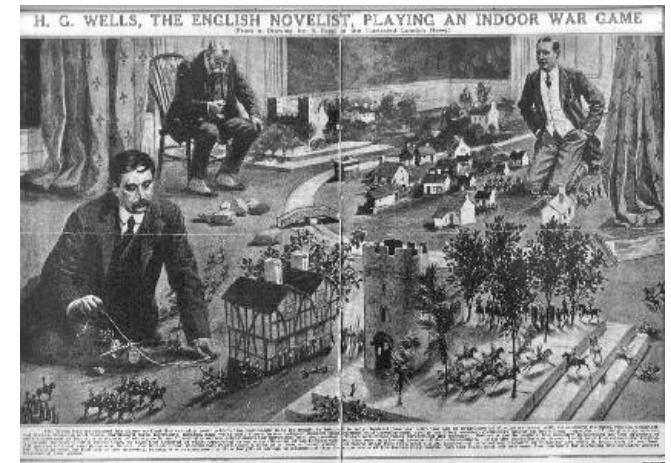
- *roll the die and move*



Wargames

Battle simulations (from the 17th century onward)

- *Derived from variants of chess, using miniatures*
- *Training in strategy and tactics*
- *(Prussian army, 19th century)*
- *Teaching history*



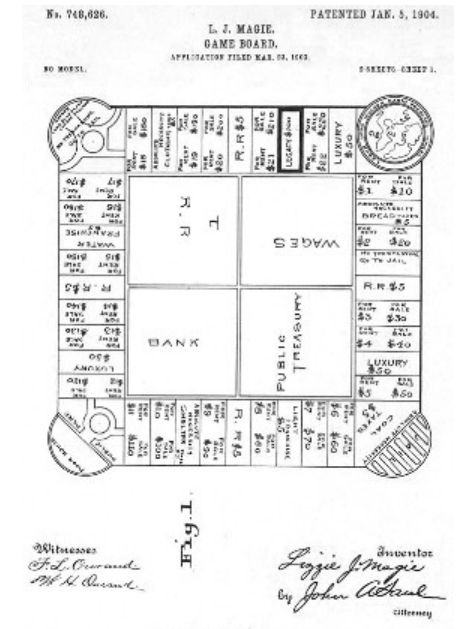
Monopoly

1903 Elizabeth “Lizzie” Magie (“The Landlord’s Game”)

- *Educational game designed to explain principles of economics (criticize monopolies)*

1935 Charles Darrow markets a version of the game

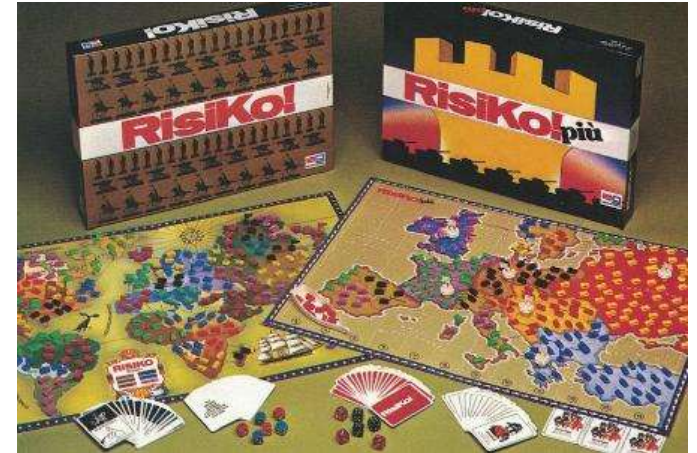
- *Elizabeth Magie receives \$500*
- *Charles Darrow earns a fortune*



Risk

1957, “La Conquête du Monde”

- *Albert Lamorisse (French film director and screenwriter)*



Modern Board Games

A new generation of innovative games

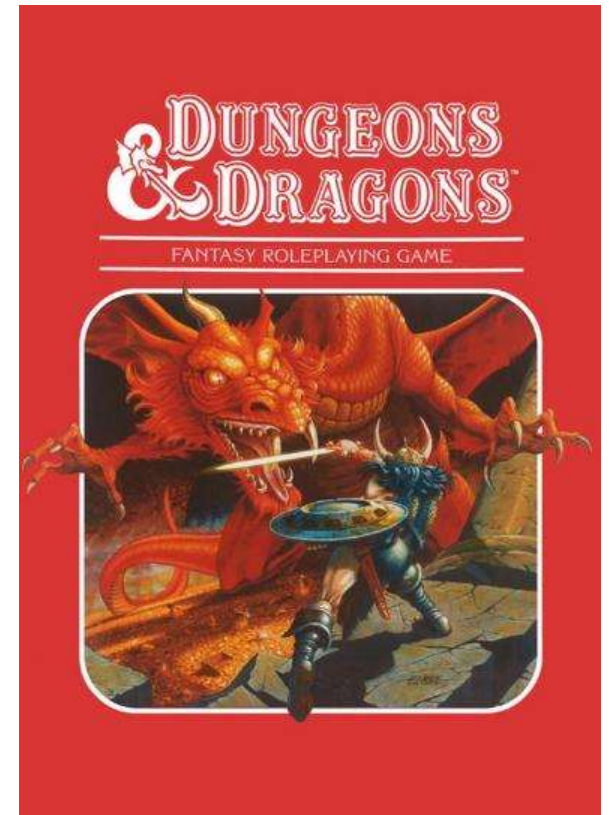
- 1995 – *The Settlers of Catan*
- 2000 – *Carcassonne*
- 2002 – *Puerto Rico*
- 2004 – *Ticket to Ride*



Role-Playing Games (RPGs)

Dungeons & Dragons (1974)

- *“Interactive” storytelling*
- *Powerful educational and teaching tool*



Live Action Role-Playing Games (LARP)

One of the earliest recordedLARPs: Dagorhir (1977, Washington DC)

- *LARP: Live Action Role-Playing*
- *Widely used for education and awareness raising*



Escape Rooms

An escape room is a collaborative game in which participants must solve puzzles and clues to achieve a goal within a limited time, usually to “escape” from a themed room.

- Early examples (video games): “Behind Closed Doors” (1988)
- First physical example: “Real Escape Game” (2007)



Educational Escape Rooms

Escape rooms used for teaching and educational purposes

- 2012: early experiments in Asia and North America
- 2015: early publications on “Classroom Escape Games”
- 2017: growing research on “Educational Escape Rooms”



What Is a Board Game?



Game: Definition

A system in which players choose to engage in an artificial conflict, clearly defined by rules, that leads to a quantifiable outcome.

(Bertolo and Mariani, 2014)

System: result of several interacting components (players, rules, ...)

Conflict: opposition (among players, or against the game system)

Artificial: opposed to real (simulation in a protected environment)

Rules: “the game is its rules” (opposed to free play)

Choice: players decide to engage (voluntariness)

MDA Framework

Hunicke, LeBlanc, & Zubek (2004)



Mechanics

The rules, components, and procedures that define how the game works



Dynamics

The emergent behaviors generated by the mechanics and by the players interactions



Aesthetics

The emotions, experiences, and feelings evoked in the players

What Makes Up a Board Game?

1. COMPONENTS

Physical elements of the game (board, pawns, dice, cards, ...)

2. THEMES

A small world (atmosphere, landscapes, protagonists, goals, ...)

3. RULES

Define the game (allowed and forbidden actions, starting, ending and victory conditions, ...)

4. MECHANICS

Actions players can perform, what happens in the game, what makes the game work (roll the die, move, capture, buy, trade, build, answer, infer, ...)

5. DYNAMICS

Emergent experience arising from the application of rules and from players' interaction (negotiation, bluffing, cooperation, betrayal, deduction, development, ...)

6. MESSAGE

What one wants to leave with the players (skill development, awareness raising, motivation, content, practical examples, ...)

Components

Physical elements of the game



Pawns



Dice



Game Board



Cards



Tokens

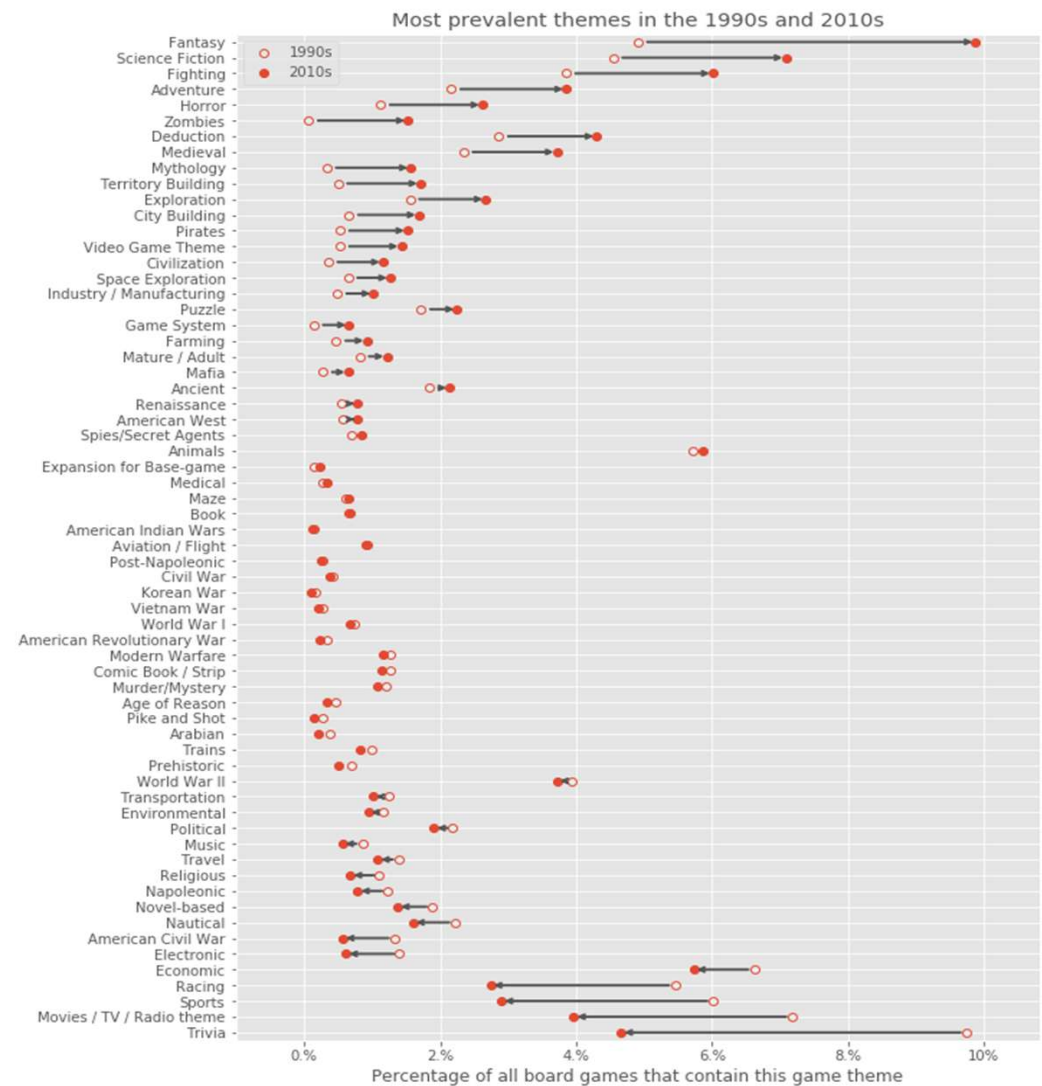


Tiles

Themes



A board game is a «small world»
(atmosphere, landscapes, protagonists, goals, ...)

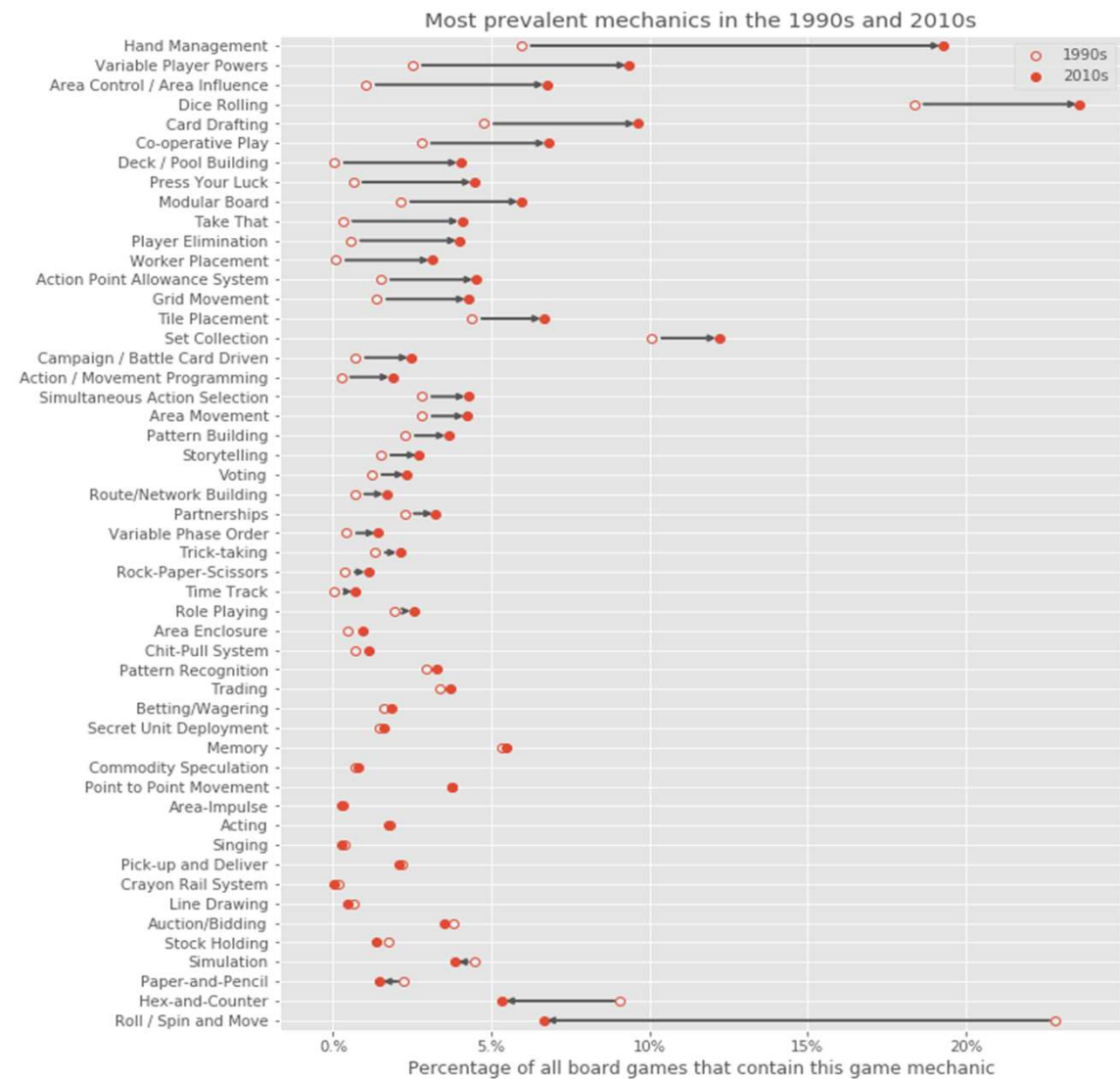


dvatvani.com/blog/bgg-analysis-part-1

Mechanics



Actions players can perform; what happens in the game; what makes the game work



dvatvani.com/blog/bgg-analysis-part-1

Move a pawn



Checkers



Risk



Chess

Roll and move



Goose Game



Snakes and Ladders



Ludo



Monopoly

Capture a pawn



Checkers



Ludo



Chess

Draw a card



Card games



Risk



Monopoly



Uno



Monopoly



Catan



Ticket to Ride

Place a tile



Domino



Kingdomino

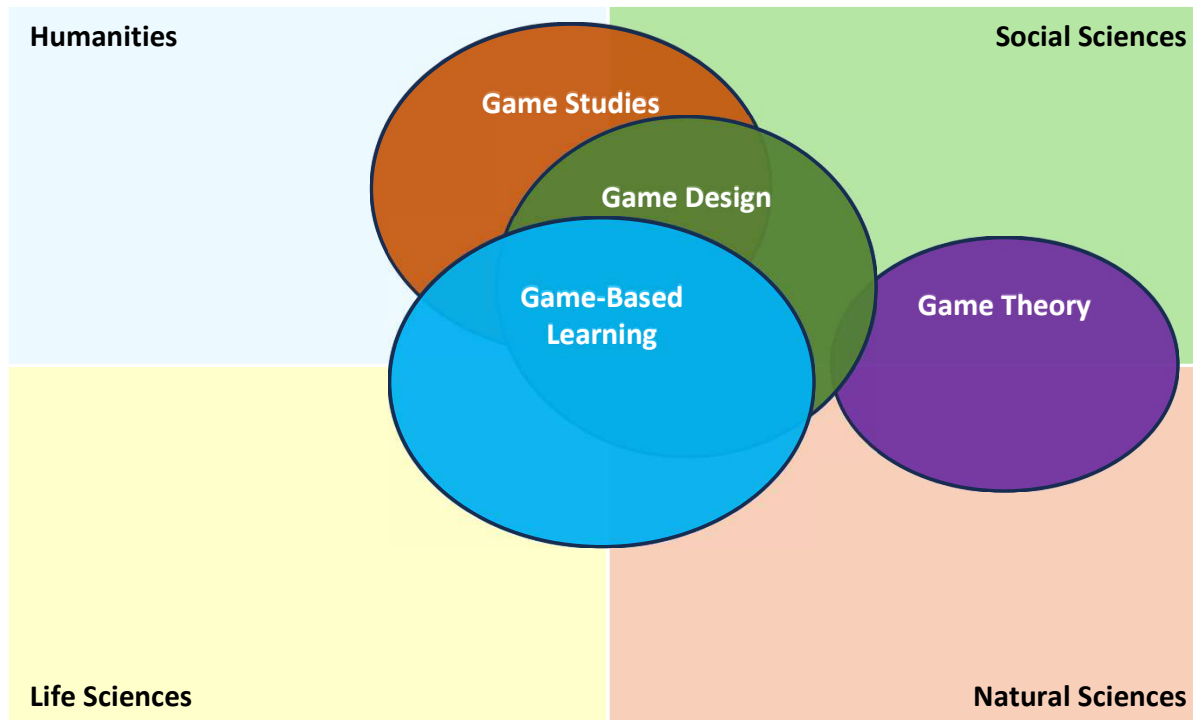


Carcassonne

Game-Based Learning



Game Sciences



- *Game Theory*
- *Game Studies*
- *Game Design*
- *Game-Based Learning*
- *Gamification*
- *Psychology of Play*
- *Computer Science and AI*
- *Sociology of Games*
- *Philosophy and Epistemology*
- *Economics of Games*
- *Game Analytics*
- *History and Anthropology*
- ...



Some Keywords



Game-Based Learning

Game-Based Learning

Application and study of games for teaching purposes

Formats and media:

- Board games
- Card games
- Role-playing games
- Escape rooms
- Wargames
- Digital games
- Interactive simulations
- ...



International Journal of Game-Based Learning (IJGBL)

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Skills Fostered by Games

ETHICAL SKILLS (behaviours)

- Respect for rules
- Respect for others
- Managing failure

SOCIAL SKILLS (relationships, group work)

- Communication
- Listening
- Collaboration
- Healthy competition

COGNITIVE SKILLS (learning, development)

- Problem solving
- Creativity
- Selective attention
- Cognitive flexibility
- Metacognition (self-reflection)

DOMAIN-SPECIFIC SKILLS (principles, concepts, notions, topics)

- Mathematics
- Science
- Environment
- ...

Some Examples

Language and literature

Storytelling, vocabulary use, construction of cause-effect relationships

- *Dixit*
- *Time's Up*
- *Kaleidos*
- *Codenames*
- *Co-Mix*

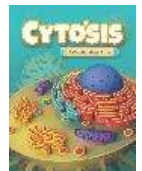
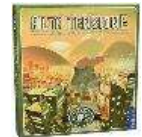
Logic and mathematics

Planning, processing, problem solving, cognitive flexibility

- *Ticket to Ride*
- *Azul*
- *Sagrada*

Specific topics

- *Cytosis*, *S.P.A.C.E.*, *Leaving Earth*, *Pandemic*, *Power Grid*, *Wingspan*, ...



Effectiveness of Games for education

Engagement:

captures attention and interest

Motivation:

drives discovery and learning

Immersion:

facilitates rapid and deep learning

Metaphors:

illustrate and “manipulate” complex abstract concepts

Model manipulation:

a game is essentially a conceptual model

Suspension of disbelief:

helps overcome mental inertia and cognitive biases

Social interaction and downtime:

encourage reflection, discussion and curiosity

Important notes:

- Teaching support tools
- Risk of misunderstanding: preparation, guidance, supervision and monitoring are required
- The purpose of a game is enjoyment! (“Chocolate Covered Broccoli”)



Game-Based Teaching Activities: Some Experiences

Game-based workshops

- Game-based experiences to introduce specific topics
- Development of dedicated games (Quantum Race, LigHit, Time Race, Lab on Chip, ...)

School pathways and projects

- Specific themes (e.g. light, quantum mechanics, ...)

Creative workshops

- Direct involvement in the creation of original themed board games (Game Design Based learning)



Creative Workshops

Creative Workshops: «design your boardgame»

Format - 90 minutes:

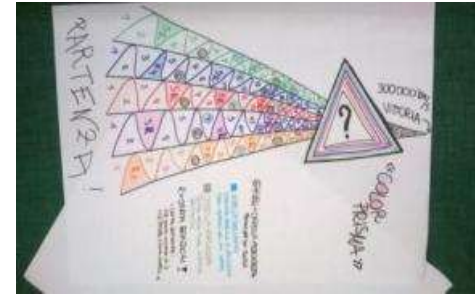
- 10' introduction to game design
- 10' the scientific subject
- 60' group activity
- 10' debriefing

Simple materials:

- Paper, pens, colors, scissors
- Dice, pawns, tiles

Used in:

- School projects
- Science and/or game Festivals



Fotonica in Gioco



National Competition for high schools students

- Create science-themed board games
- From 2015, 5 editions, ~1200 participants, 96 games
- In collaboration with the "Premio Archimede" for board games designers
- Next edition: 2026-2027

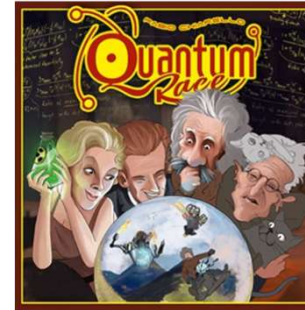
www.fotonicaingioco.it

A Practical Example: Quantum Race

Quantum Race

Board game for science outreach

- *Used to introduce basic concepts of quantum mechanics*
- *Different versions: tabletop, giant, live*
- *Uses: school projects, science festivals*



Questions?



