# On the Mathematics hidden behind games

**Yannick Rochat, Sophie Bémelmans**
Department of Language and Information Sciences
Faculty of Arts
University of Lausanne
yannick.rochat@unil.ch, sophie.bemelmans@unil.ch

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## INTRODUCTION

Mathematics is ubiquitous in game design, whether when creating board games and video games or in the analysis of their systems. It remains rarely discussed in scholarly texts[1] outside educational sciences and STEM-oriented research on solved games (Van den Herik et al. 2002), strategy optimisation (Paul 2011), or game theory (Smith 2006; Simons 2007). In game studies, mathematics is often absent from discussion, suggesting a "disciplinary divide" (Aycock et Finn 2019).

This article aims to highlight the role mathematics has played in the history of games and encourage the video game research community to engage more with mathematical concepts. We begin by tracing important historical interactions between mathematics and games, then examine two contemporary case studies that highlight the role of mathematics in the construction of game mechanics and aesthetics.

## HISTORY OF GAMES AND MATHEMATICS

Mathematics and games share a long history. According to Rougetet (2024, 276), the use of mathematics in games can be traced back to ancient times with games of chance (Egypt, Greece, Rome) and territory capture games (Japan). Problems that required mathematical insight would turn popular in early modern period and are coined today as "Recreational mathematics". On several occasions, solving them led to scientific advances, such as Euler's Seven Bridges of Königsberg problem (1736) and the graph theory, or Kirkman's Schoolgirls problem (1850) and the combinatorial design theory. Recreational mathematics still exists today, as the formalised combinatorial game theory (Berlekamp et al. 2001) and as playful problems. These activities are named "games" because they have rules and a winning objective, but they are intended to be solved rather than played.

In parallel, formal solving of actual games began in the 19th century (Rougetet 2024, 279) and continues today with the solving of well-known games, such as *Nim*, *Connect*

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*Four* (Allis 1988) or *Checkers* (Schaeffer et al. 2007). The development of computing is connected to the history of game solving. For instance, Lovelace and Babbage, considered pioneers of computing in the 19th century, used *Chess*, *Solitaire* and *Tic-tac-toe* in their work (Pizelo 2024). Games were used in the 1950s, such as *Nim* and *Tic-Tac-Toe,* to demonstrate computers' capabilities and suggest a form of "intelligence" since mathematics allowed programmers to implement games that always played the best strategy. Later, digital games would use mathematical and physical concepts such as translation, rotation, randomness, velocity, gravity, and friction to simulate environments, still demonstrating computer capabilities as computing power increased.

## CASE STUDIES: MATHS AND PLEASURE IN GAMES

In research, mathematics is regularly used to analyse game balance (e.g. operational research, tree search methods). However, it is less mobilised to study game creation. Many game mechanisms rely on mathematical concepts: projective geometry in *Dobble* (2009), for example, or graph theory in *Risk* (1959), *Catan* (1995), and *Ticket to Ride* (2004). The two case studies below illustrate how mathematics contributes to the design, practice, or the aesthetic of a game.

The first case concerns Frank Crittin, a mathematician and the co-author of board games such as *Tower Up* (2024), *Botanik* (2021), and *Ankh'or* (2019). When creating a new game, Crittin usually starts with a mathematical principle, which he then seeks to exploit as a mechanism. For example, *Tower Up* is based on the four-colour theorem which states that regions on a map can be coloured with a maximum of four colours so that no adjacent regions share the same colour. However, his games and their mechanisms evolve with the necessity to adapt these models inside of game systems, gradually moving away from his mathematical inspiration. Maintaining uncertainty, balance, and the pleasure of play are essential aspects of game design (Brougère 2024). Balancing a game is a process based on experience, gaming preferences, and the author's anticipation of the audience (Becker & Görlich 2020). In Crittin's case, a game does not need to be mathematically 'perfect'. The feel and experience of the game are enough to create a balanced game from his point of view, which playtesting helps to identify. This case illustrates the creative task of articulating mathematical knowledge with the necessity to adapt these models inside of game systems and meet expectations from the public in terms of gaming practices, play styles, and pleasure.

*Hyperbolica* (2020), a video game built in a non-Euclidean space, explores hyperbolic and spherical geometries. In these cases, when given a straight line and a point distinct from that line, one can draw either an infinite number of parallels to that line passing by the point (hyperbolic geometry), or none (spherical geometry). The game was developed to help players discover and grasp the particularities of non-Euclidean geometries, by exploring the world environments that evolve, appear and work quite differently from what they are used to. Despite the underlying mathematical complexity of the world of *Hyperbolica*, the game remains accessible to anybody, thanks to thoughtful game design choices. In this case, mathematics shapes not only the mechanics but also the aesthetic and the experience of a game.

## CONCLUSION

This article highlights diverse roles of mathematics in the history of games, a subject that has been little studied in the current game studies literature. By tracing the origins of recreational mathematics to contemporary mechanisms through two case studies, we show that mathematics is expressed in other dimensions than optimisation and algorithm management. Mathematics contributes to the structure of games, to their mechanics, and even their aesthetics. We invite game studies to consider mathematics more broadly, as a tool for data analysis and as a cultural source for creation. We call for more research combining mathematical models, game design practices, and the experiences of players and developers, to better understand how games are designed and experienced.

## REFERENCES


Allis, L. V. 1988. *A Knowledge-Based Approach to Connect-Four. The Game is Solved: White Wins*. Master thesis, Vrije Universiteit, Amsterdam, The Netherlands.

Aycock, J., Finn, P. 2019. "Uncivil Engineering: A Textual Divide in Game Studies." *Game Studies* 19 (3). https://gamestudies.org/1903/articles/aycockfinn.

Berlekamp, E. R., Conway, J. H., Guy, R. K. 2001. *Winning Ways for Your Mathematical Plays: Volume 1* (2nd ed.). Wellesley, MA, USA: A K Peters/CRC Press. https://doi.org/10.1201/9780429487330

Becker, A., Görlich, D. 2020. "What Is Game Balancing? - An Examination of Concepts." *ParadigmPlus* 1 (1): 22–41. https://doi.org/10.55969/paradigmplus.v1n1a2.

Paul, C. A. 2011. "Optimizing Play: How Theorycraft Changes Gameplay and Design." *Game Studies* 11 (2). https://gamestudies.org/1102/articles/paul.

Pizelo, S. 2024. "Games Built the Computer: Babbage, Lovelace and the Dawn of the Ludic Age." *Game Studies* 24 (3). https://gamestudies.org/2403/articles/pizelo.

Rougetet, L. 2024. "Mathématiques." In *Dictionnaire des sciences du jeu*. Érès. https://doi.org/10.3917/eres.broug.2024.01.0278.

Schaeffer, J., Burch, N., Björnsson, Y., Kishimoto, A., Müller, M., Lake, R., Lu, P., Sutphen, S. 2007. Checkers Is Solved. *Science* 317 (5844): 1518–1522. https://doi.org/10.1126/science.1144079

Simons, J. 2007. "Narrative, Games, and Theory." *Game Studies* 7 (1). https://gamestudies.org/0701/articles/simons.

Smith, J. H. 2006. "The Games Economists Play - Implications of Economic Game Theory for the Study of Computer Games." *Game Studies* 6 (1). https://gamestudies.org/06010601/articles/heide_smith.

Van den Herik, H. J., Uiterwijk, J. W. H. M., & Van Rijswijck, J. 2002. "Games Solved: Now and in the Future." *Artificial Intelligence* 134 (1): 277–311. https://doi.org/10.1016/S0004-3702(01)00152-7.

## GAMES

Blue Orange Games. Blanchot, D., Cottereau, J., Gille-Naves, G., Polouchine, I. 2009. *Dobble*. Boardgame.

*Checkers*. Undated. Boardgame.

*Chess*. Undated. Boardgame.

CodeParade. 2022. *Hyperbolica*. Videogame.

Days of Wonder. Moon, A. R. 2004. *Ticket to ride*. Boardgame.

KOSMOS. Teuber K. 1995. *Catan*. Boardgame.

Milton Bradley. 1974. *Connect Four*. Boardgame.

Monolith Board Games. Crittin, F., Largey, G., Pauchon S. 2024. *Tower Up.* Boardgame.

*Nim*. Undated. Boardgame.

Parker Brothers. Lamorisse, A., Levin, M. 1959. *Risk*. Boardgame.

Space Cowboys. Crittin, F., Largey, G., Pauchon S. 2019. *Ankh'or*. Boardgame.

Space Cowboys. Crittin, F., Largey, G., Pauchon S. 2021. *Botanik*. Boardgame.

*Solitaire*. Undated. Boardgame.

*Tic-Tac-Toe*. Undated. Boardgame.

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## ENDNOTES

[1] A search for "mathematics" (considering this token as well as theme-related tokens) in the DiGRA conference library provides two papers in education and one research mentioned later on the history of computing (Pizelo 2024). Meanwhile, a search in the corpus of Game Studies journal articles brings forward more educational papers, but also a small selection useful for our topic, that we mention in the text.