Pedagogical Outlook

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PEDAGOGICAL OUTLOOK

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VISION

Core aspects of students' human-capital investments will be codified. They will not only control the means of human-capital production, but create them. Thus, their educational investments are crystallised as engines for further development. As such, objects for future creative destruction.

Whether or not students master all details, the most sophisticated knowledge within the curriculum will be at their disposal regardless. Their knowledge arranged to deal with any solvable riddle, within the domain and range of theory corresponding to syllabus, with a few keystrokes. They will be encouraged to ask relevant questions, create and cooperate while conquering the necessary conditions for their independence. The tremendous increase in productive potential following from the realisation of this vision, naturally demands adaptation in pedagogy to regulate supply.

One crucial adaptation is to dissolve tension between theoretical and practical. Code is employed as a vehicle for independent exploration of fundamental principles, not to focus on what programmers are specialised to do. Domain and range of theory cease to be philosophical speculation, in important respects, as the question rather is whether or not a given theory can be computed. Learning incentives exhibit similar clarity associated with problem solving, like immediate feedback; exact thinking; articulation and communication. Although theoretical in nature, students can nevertheless look forward to tangible labour-market skills

This endeavour grants tangible rewards through output which expands the set of feasible future creative undertakings. Incentive schemes for knowledge growth through free exchange and cooperation are given more options. Students will be encouraged to make use of their techniques in a variety of realistic settings, including innovation and teaching. In terms of organisation, synergies across courses and faculties are far-reaching. These knowledge keys may someday become part of what is to be a student. Even the Alumni will have incentives to come back for updates as evolutionary forces of each generation of students will exert pressure towards refinements with increased levels of scope and sophistication.

REFLECTION

The structure of my pedagogical framework, presupposes active students and teachers. It brings together desirable traits such as clear theoretical objectives, experimentation, mastery, relevance, framing, feedback and agency. It is consistent with research on learning at an individual cognitive level, and as an arena for reflective development.

The pedagogical practices and aims of this vision are compatible with findings in the literature regarding general thinking, learning, critical thinking and inclusion. Tricot & Sweller (2012) show that what once was thought of as innate and domain-general, including notions of memory and intelligence, has turned out to be crucially dependent on experience or domain-specific, and can thus be taught. They recommend worked problems as a first stage in achieving problem-solving mastery. This does not necessarily imply docility. Research shows it is feasible to improve critical thinking both with generic and content-specific approaches when dialogue, mentoring and ‘authentic’ problems or examples are employed (Abrami et al. 2015).

Research also suggests that inclusion, by supporting the less privileged, does not necessarily come with a cost for the rest. Active learning is a teaching practice with statistically significant positive effects on overall student performance (Freeman et al. 2014)[1]. Evidence indicates that all benefit from a structured active learning, but less privileged groups improve most (Eddy & Hogan, 2014). Therefore, this approach allows adaptation to bridge general thinking and particular skills; structured environments and independence; inclusion and high academic standards.

The 'backend' environment where coding takes place is mental-simulation intensive. It combines assessing the syllabus, employing it while reflecting, and looking forward to begin to plan applications. A similar process takes place at a 'frontend' phase but more narrowly directed towards the realisation of research aspirations and problem solving.

Teaching thus becomes naturally in tune with reflective adaptive learning practices which emerge as vouge in pedagogical and psychological research. For reference see Walsh et al (2023; 2022) and Cole et al. (2021). The positive effects in a heterogeneity of cases suggest a general mechanism to be harnessed. The project under consideration aspires to add evidence in favour of reflective learning in university settings, and research provides ample reasons for optimism in this regard. As my plan makes clear, my research is a reciprocal extension of my teaching practices.

This pedagogical project prepares students and researchers for imminent uncertainty. Heterodox approaches have become a survival strategy for Economics. Evidence refuted some of its long-held assumptions, and currently supports alternative perspectives such as MMT. Hence, an intriguing era of hypothesis testing and ground-breaking theoretical syntheses is within reach, for those open to the new challenges ahead.

[1] This paragraph benefits from the generous information on the subject provided by Georgetown University. For more info https://commons.georgetown.edu/teaching/teach/

SOFTWARE RELEVANCE

This section is an appendix is concerned narrowly with alternative software for the project. **Data** is provided to explain:

- **Why** my code is relevant in view of freely available alternatives.
    - **How** it is comparatively efficient, with a greater scope:
        - ✓ **including** alternatives materialising virtually ex nihilo in terms of online accessibility/visibility recently.

In summary, emphasis of my pedagogical project is on learning Game Theory, and related principles, by constructing software. It distinguishes itself from use of a 'complete-package' – as a manner of speaking – by engaging backend, but with 'frontend' applications. Accessible free online software has been of limited scope until one project appeared virtually *ex nihilo*, quite recently, in terms of visibility on the web (see Data below). Notwithstanding, my code stands firm also in view of this commensurable software, which may readily be seen as complementary. Indeed, it is a windfall gain advancing my project. The Data section below provides figures and graphs. Please visit my new **homepage** for additional information.

Supply-side conditions have so far been favourable for embarkment on a pedagogical outlook based on universal solvers for Game Theory. Although *free and accessible online software* is a generous contribution to the community, their *scope has mostly centred on 2-person games or other special cases over the years*. Moreover, leading mathematical software have not included Nash-equilibrium modules in their Economics packages.

In addition, fresh theoretical contributions on Nash-Equilibria computation in mathematical journals underscore foundational research appeal. Furthermore, social-science curriculums in Sweden and elsewhere, are not by any means known to be satiated with pedagogy based on coding universal solvers or anything similar. Data below is not in conflict with this latter assertion, especially regarding Swedish curriculums.

THE EX-NIHILO ALTERNATIVES

Algorithms for computing Nash Equlibria have been around for decades (Lemke, 1964; Halpern, 2008), curriculums based on such software usually have not. Recently, n-player m-strategy Excel-software[2], by Sugiyama and Leoneti (2021), was advertised but it is not available online. However, their software assessment underscores the actuality of a project based on universal solvers. The most ambitious one on their list is *GamePlan by Langlois* which solves a wide variety of games under different information settings[3]. As such it serves as delimitation benchmark to 'complete-package' software.

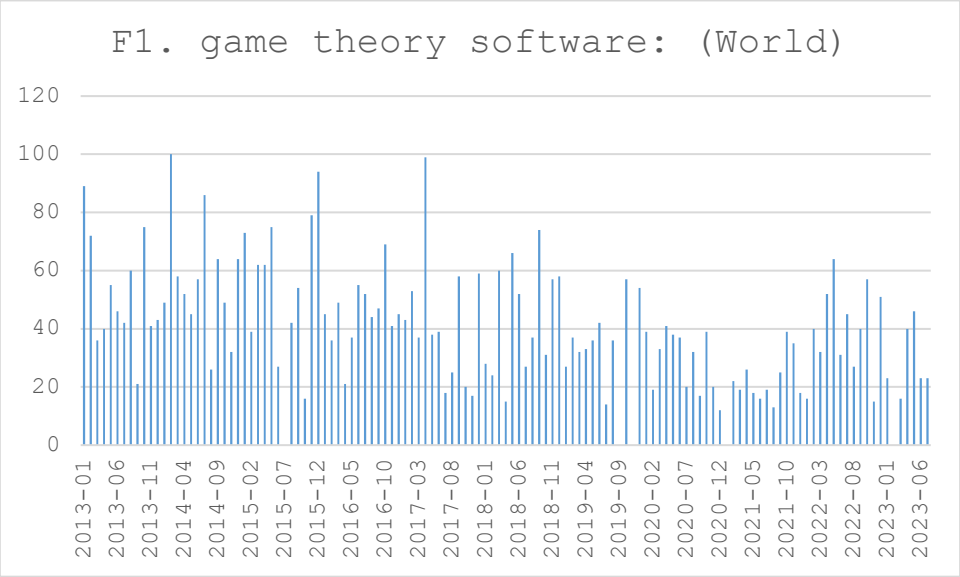
Although presumably decades old with capabilities comparable to the rest of the alternatives combined, data indicates that it is a recent phenomenon in terms of online accessibility and visibility. Data in the next section shows that this ambitious software (GamePlan) is conspicuously invisible on the most frequently used engines of the web, and so is its associated developer who appears to be missing, in important regards.

Moreover, its user-friendly interface has some disadvantages. Pointing-and-clicking is required both when constructing extensive and normal-form games. Such software cannot readily be used to e.g. generate and solve hundreds of games from heterogenous distributions (not necessarily independent, obviously), at its current state. Furthermore, there are associated practical restrictions on the number of players and strategies; and it currently is unclear how to integrate it with other platforms to make use of a more general set of mathematical procedures. To appreciate how these points diverge from my Pedagogical Outlook, and constrain research, please consult **Footnotes on The Foundations of Game Theory**.

[2] **Please note** that although I provide some data in Excel-format along with Footnotes o*n the Foundations of Game Theory*, my code has nothing to do with it.
[3] The games I have checked were successfully solved with *GamePlan*, no objections so far.

DATA

This section provides data for evaluation of online supply and demand as part of a routine market assessment; including quality and authenticity. Game-Theory software has a rather stable search-history cycle over the past decade around the world. However, corresponding searches on Swedish sites are too few to register on Google Trends. [4]

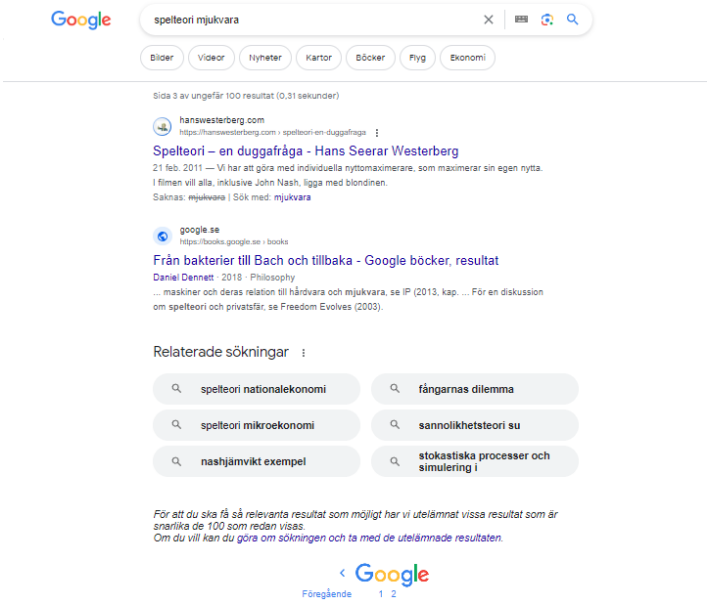


Typically, only introductory courses are in Swedish at the Economics departments. There are no traces of a separate domestic pedagogical culture generating associated traffic which would upset the lasting impression of its absence over the years.

This is consistent with supply-side indicators, such as Swedish sites associated with game-theory software over the years. According to Google, ~86.9 billion searchers are made per month; 9/10 internet users depend on it; for demand of goods and services especially.

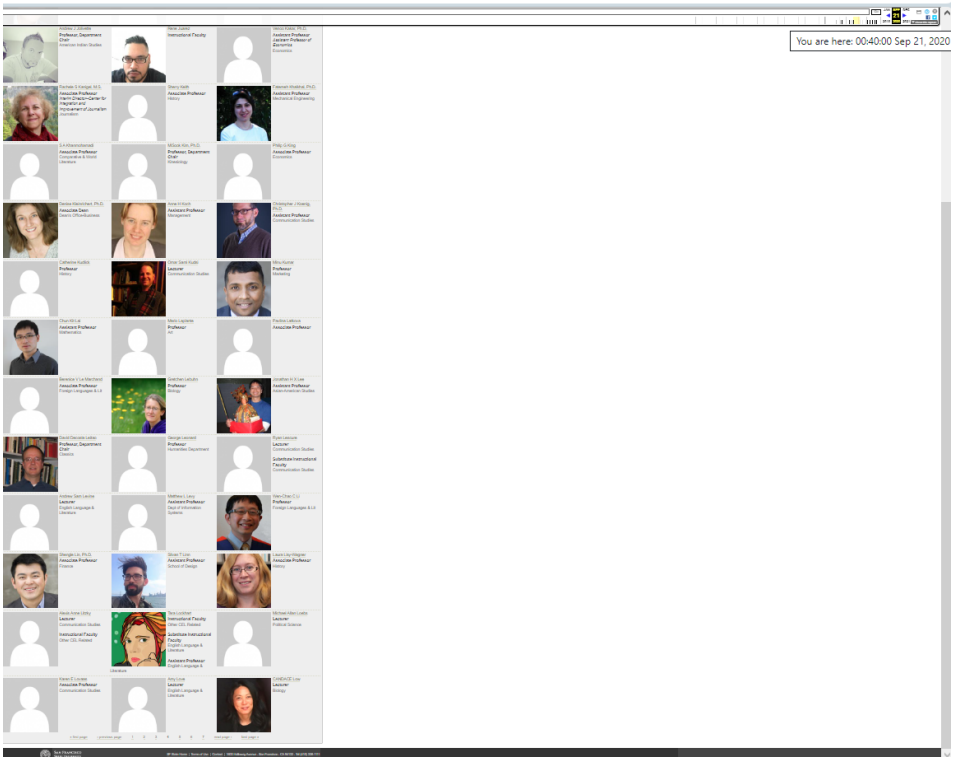
Only a handful results have anything to do with Economics.

[4] Data to all graphs and other empirical assertions are downloadable **here**.

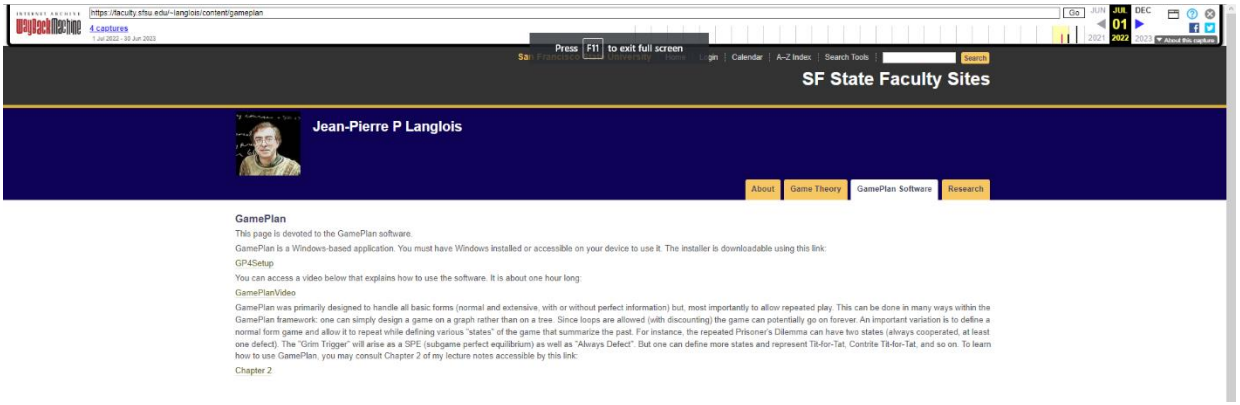


Only two courses with code related to Economics were found with alternative searches. Their scope resembles what is to be found at the international scene, commonly revolving around 2-player games.

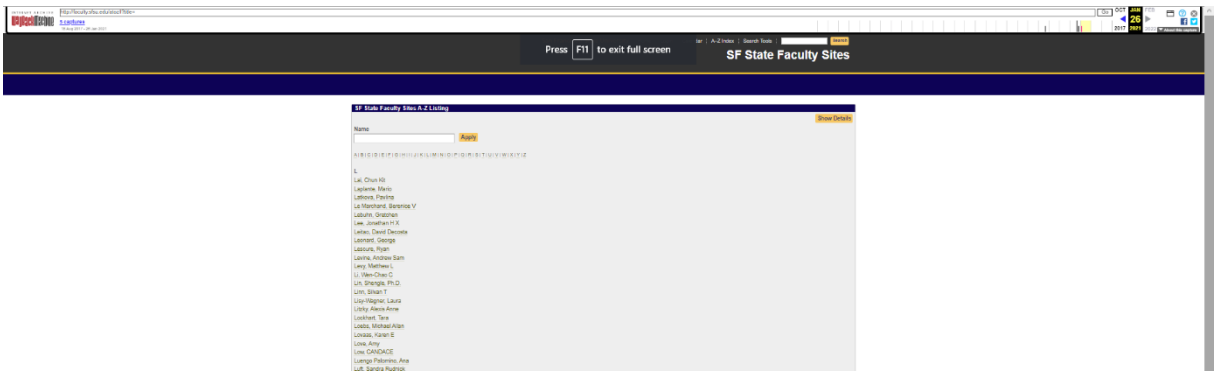
Online interest on specific software entails similar contrasts. The *GamePlan* software is invisible on the supply side. To begin with, its author Jean-Pierre Langlois is absent from historical records of San Francisco State University staff, where he supposedly has been active over the years.

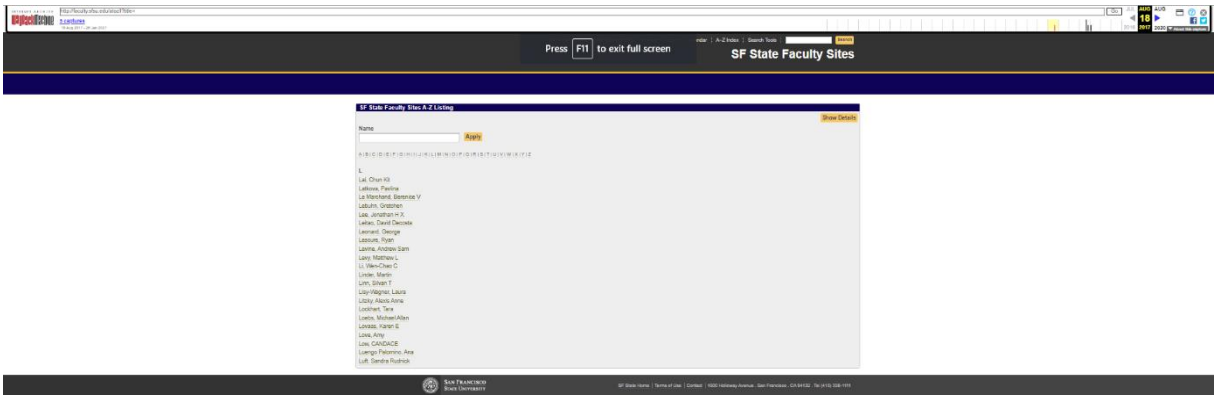


His homepage is visible from 2021, and a link to *GamePlan* is to be found from July 2022. This also is consistent with the staff list without pictures.

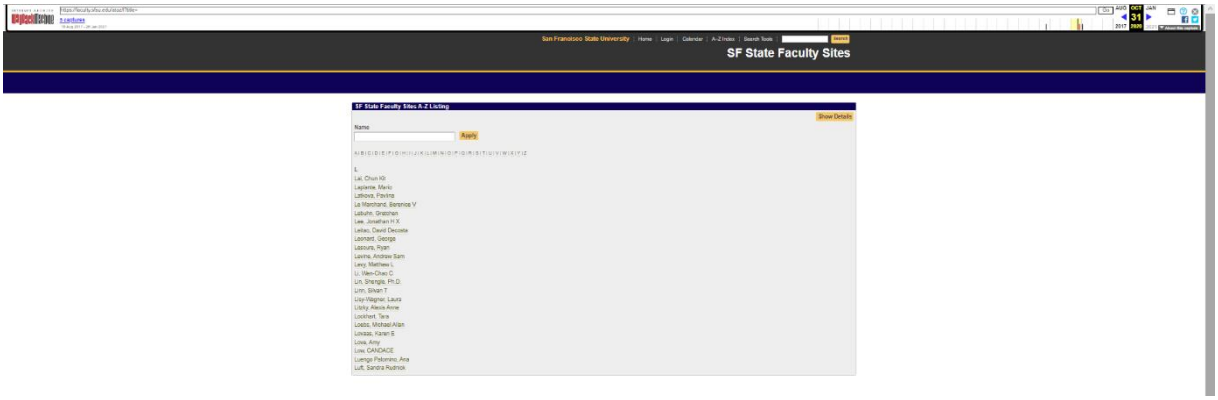


He is absent from the whole list over the years, and not to be found in the particular list under letter L from 2014.



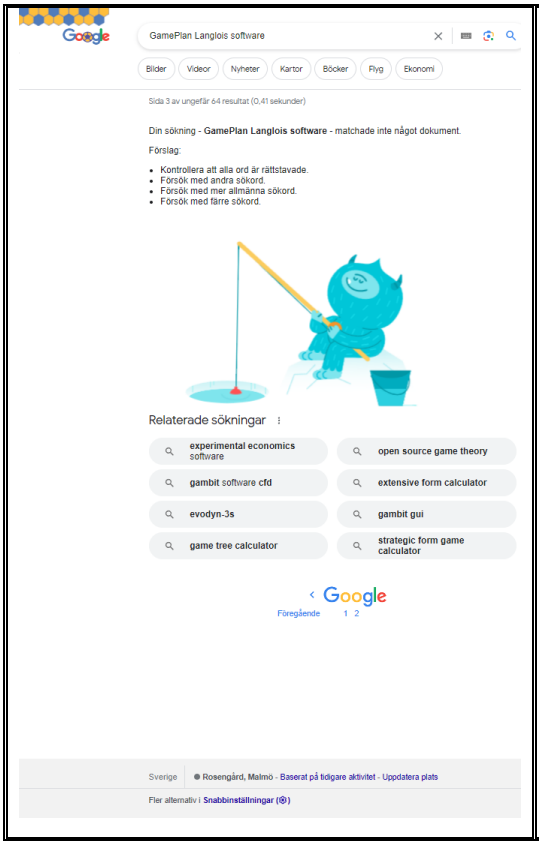


On the demand side, there is no detectable traffic on *Google Trends* over the years (*GamePlan software*). When requested otherwise with a standard search engine, only two university sites of repute were found: San Francisco State University (his homepage), and an LSE document. Game Theory Society's software list is an honourable mention. All of these have only recent Internet Archive history.

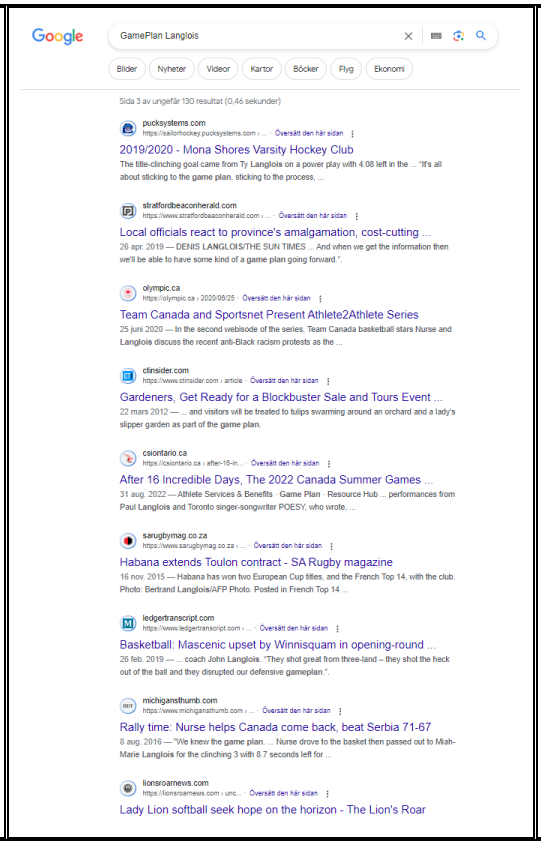


None of the regular search engines yield more than a handful relevant results.

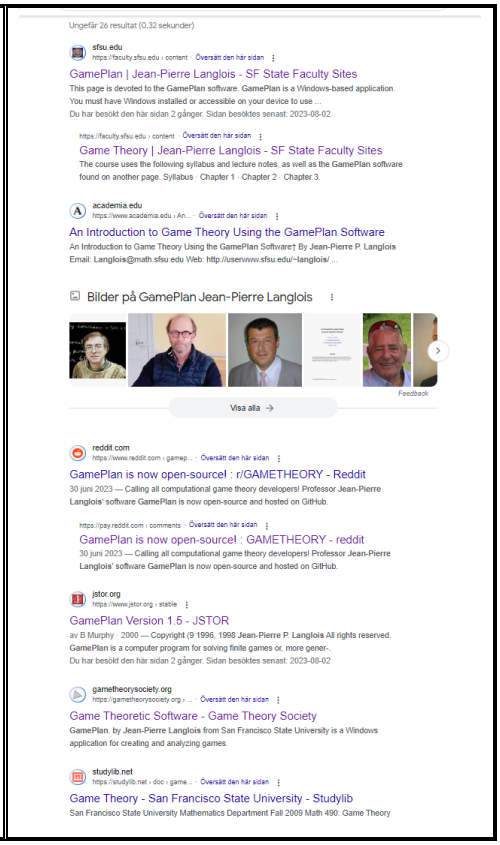
GamePlan Langlois software (64)



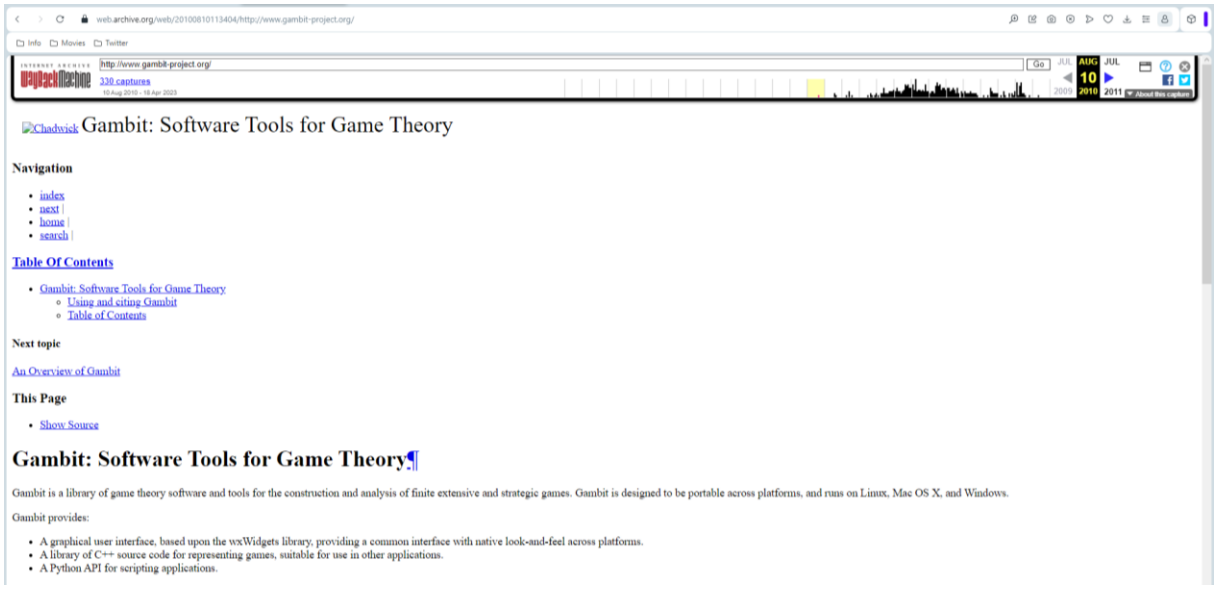
GamePlan Langlois (<100)



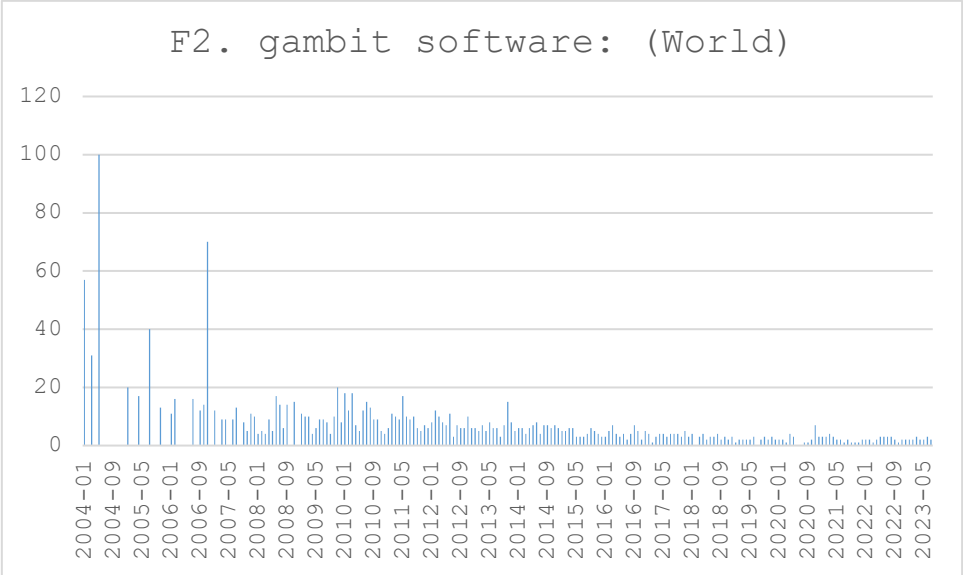
GamePlan Jean-Pierre Langlois (26)



In contrast, Gambit's history is well-documented since 2010, with numerous relevant results at regular search engines.



Searches have been recorded since 2004. Notice that this is a focused search, e.g. not displaying a recent spike attributable to a certain popular chess-series. Both software have intersecting keywords with unrelated things, GamePlan in particular.



The findings so far: The perhaps most comprehensive and ambitious project appears to have emerged virtually ex nihilo, on the web, according to the most used engine. Robustness checks do not alter the picture.

Historical archive searches indicate GamePlan is visible for most people in the 20s, not earlier. Moreover, associated developer name and homepage is absent historically until recently. The exact reason of this elusiveness remains an equally evasive question, but assuredly is remarkable. However, the implications for my enterprise are straightforward. It is a windfall gain which secures the viability of my project at all levels, as GamePlan is an excellent tool for beginners with its colourful pedagogical interface. Notwithstanding, its usefulness for more advanced students cannot be overlooked, especially now that it has become open source. Time will tell if it relies on code suitable for learning theoretical principles, or if it is an application of common algorithms leaning towards the brute-force side.

As a corollary, Carbon dating of related papers point in a similar direction (see data online). I would also like to assert searches were made on a comprehensive academic engine (Lund University's LUBsearch), with similar meagre results. But considering the popup character of certain software, the intrusiveness of mine and perhaps others lately, may induce evident perturbations of the picture. The essence of the web is interactive after all, which naturally renders it suspectable to more or less discernible and not exclusively intentional alterations, influencing perceptions over time.

SUMMARY: INVISIBLE SUPPLY & DEMAND

Starting with the supply side, searches on *GamePlan* AND *Langlois*, and related Google searches, give a meagre number of actual results, but only a handful are relevant. This remains true when omissions are included, as these either are irrelevant or mirrors.

The only direct references in university sites found were a San Francisco State University homepage, and one LSE document. The former supposedly is Jean-Pierre Langlois' mathematics course employing *GamePlan*. However, this homepage cannot be found at the Internet Archive before the 20s when searching the staff homepage – Langlois is simply missing (see pictures). A link to the actual software cannot be found at the IT-Archive before July 22. Game Theory Society is however an honourable mention with a link, unclear from when.

The demand side was checked with *Google Trends*. Overall, Game Theory software was much more searched in the 00s, but with quite stable cycles over the past years. This may partly reflect diffusion of knowledge of a set of novelties with dampening cycles which stabilise eventually, in contrast to e.g. holidays exhibiting exploding cycles with network growth over the decades. *Gambit* AND *software* is visible on Google Trends in a manner consistent with results on Google searches. In contrast, Trend-searches on *GamePlan* And *software* (and similar) yield no observable results[5].

These and other findings below are in line with more informal perceptions of the social-science curriculums around the world over the years, Economics in particular. As stated above, also indicative of the online *invisibility* of more ambitious Game Theory software, commensurable withmy project, until recently. This is in sharp contrast to software such as *Gambit*, with plenty of results and historical entries at the Internet Archive.

[5] *Software* is a fairly international term, also common in other European languages. *Logicel* was used to cover French demand. Variations of search terms and browsers were used and repeated on different days to check robustness, with invariant results.

In summary, there is one software freely available online with rather ambitious scope, namely *GamePlan*. It works, is a good complement for my purposes, but has been *conspicuously invisible* online. It has some limitations at its current state, but became open source recently.

Finally, it is important to underscore that alternatives reviewed so far do not emphasize code particularly suitable for pedagogical purposes backend, to learn principles, before 'frontend' applications of theory.

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