

Learning from Designing a Board Game for Policy Thinking in Computer Science

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Abstract: Technology does not exist in a vacuum, but is influenced by society and at the same time shaping it. In order to educate future computer scientists to be able to assess and create technology in a conscious and responsible manner, we provide first-year Computer Science (CS) students with an introductory course on different ways of thinking about CS by offering them a transdisciplinary view of the field. As we continuously strive to use engaging teaching methods to foster long-lasting interest for the topics of the course, as well as enhancing students' learning experiences, we have introduced a unique game-based learning pipeline: In a game design course, advanced CS students design non-digital games that address various topics from the introductory course. These games are later played by first-year CS students, who are reflecting on the content and their experience as a part of their course assignments. In order to learn from the first iteration of this process, we analyse one of the games created, in particular its design and the educational objectives intended by the game designers, including the students' feedback. We found that the game was perceived to be good in achieving learning outcomes; however, it scored even higher in terms of being an interesting and entertaining game. Overall, we conclude that the game was successful in creating an engaging learning experience, demonstrating the potential for game-based learning with non-digital games. This case study also highlights the importance of creating a suitable environment for game-based learning approaches to enhance the educational effects and utilise individual strengths of educational games, providing inspiration and groundwork for future research.

Keywords: Game-based learning, Serious Game Assessment, Educational Board Game, Non-digital Game, Policy Thinking, Computer Science Education

1. Introduction

When working with or on technology, it is essential to recognise that technology does not exist in isolation, but within the broader societal context. Education in the field of Computer Science (CS) should not only provide foundational technical skills but also foster a broader understanding of the societal implications of technological advancements. Thus, it is crucial to lead students to explore their understanding of socio-technical systems, fostering their development into conscious and responsible computer scientists.

Recognising the potential of game-based learning to make students' educational experience more engaging, a significant addition to the curriculum was made: Advanced CS students in a game design course were tasked with designing non-digital games that address various transdisciplinary approaches of thinking about CS. These games were then utilised in a course for first-year CS students, who played and reflected upon the games and their experience as part of their course work.

Our analysis of this innovative teaching method focuses on one specific game designed by students - "The Policy Maker". Two of the authors of this paper, Naemi Luckner and Peter Purgathofer, acted as the educators of the game design course and utilised the resulting games in the course for first-year CS students. The other two authors, Shuyin Zheng and Victoria Fischer, designed the game "The Policy Maker" as students and participated in analysing the results.

In Section 2, a brief overview of the state of the art is given, before we present our methodology in Section 3. In Section 4, we describe and analyse the design of the game. Section 5 presents the results from the evaluation of first-year CS students' perception of the game and its effectiveness in achieving educational objectives. Section 6 is the discussion of our results, and we close with the conclusions in Section 7.

2. State of the art

Game-based learning (GBL) has found application across various educational institutions and purposes, showing positive effects in transferring educational content to learners in an engaging way, and fostering skills such as problem solving and creativity (Vlachopoulos and Makri, 2017; Qian and Clark, 2016). The games used in GBL are as varied as their usage contexts. Projects presented by Caldwell et al. (2017) and Castronova and Knowles

(2015) used off-the-shelf games to enhance their teaching, while others created games to target specific educational purposes (Einsenack, 2013; Iakovidis et al., 2023). Using the process of designing an educational game as a pedagogical method has found its application as well, e.g., in Mayr et al. (2016) and Kuo et al. (2023), showing beneficial outcomes in having context-specific knowledge while designing for specified target groups.

Designing an educational game entails great complexity. Natucci et al. (2023) pointed out the lack of generalisable results from game-based learning and serious games studies as an indication for this complex endeavour. Battistella and Wangenheim (2016) found in their systemic review that games used in GBL for CS education tend to focus on reviewing and reinforcing learned content and are often lacking in the game design aspect.

Natucci et al. (2023) located the key challenges for designing games for GBL in balancing game elements, pedagogical theories, and players' emotional experience. Similarly, Plass et al. (2015) emphasised the need for going beyond incorporating game elements in teaching, advocating for the integration of cognitive, motivational, affective and sociocultural perspectives into game design. Mitgutsch and Alvarado (2012) highlighted in their work the importance of basing the design of serious games on the intended purposes. They suggest that an effective serious game is a cohesive and coherent system based on different but inter-related elements: content, fiction & narrative, mechanics, aesthetics & graphics, and framing. These should reflect the core - the purpose of the game, and their relation to each other constitutes the cohesiveness and coherence of the whole game.

In summary, GBL can be realised in numerous different ways. Designing an educational game for a specific context and purpose involves many challenges, but has the potential of achieving learning goals effectively. The following case study analyses such a game, purposefully designed with the intention to enhance students' understanding of lecture concepts, grounded in game design theory. The analysis serves as an interesting addition to the corpus of educational non-digital games.

3. Methodology

The game "The Policy Maker" was designed by Shuyin Zheng and Victoria Fischer as part of the course "Gameful Design". In the summer semester of 2023, the course was held for Master students of Media and Human-Centred Computing at TU Wien (University of Technology Vienna, Austria) but also included a number of Bachelor students who planned on writing their Bachelor thesis around the topics of this course. "Gameful Design" aims to familiarise students with theoretical concepts of game studies and game design research as well as teach students to understand and apply game design methods to solve real-world problems. While these real-world problems vary from year to year, the challenge in this particular semester was for students to create non-digital games addressing the content of a first-semester lecture called "Ways of Thinking in Informatics".

Ways of Thinking in Informatics can be understood as a transdisciplinary approach to teach students about different perspectives that impact problem-solving approaches in CS. Through the lens of different "ways of thinking", students should understand the need for critical thinking and reflection in the design of technical systems, e.g. Scientific Thinking, Computational Thinking, Design Thinking, Responsible Thinking or Creative Thinking. This particular case study investigates the game, "The Policy Maker", that dealt with Policy Thinking.

Many games created in the context of "Gameful Design" were then used in "Ways of Thinking in Informatics" in the winter semester 2023. As part of their course work, first-year CS students played at least two games from a curated list of games, dealing with the lecture content. For each game, the students filled out a short survey. Additionally, they had to write a short reflection about the games, outlining their take aways as well as their understanding how the games transported their underlying way of thinking. Data collected in the survey and the students' reflections was anonymously analysed and used as a basis for this paper.

Quantitative data presented in Section 5 came from these surveys outlining the students' demographic data, and how the students experienced and rated the specific games they had played. Qualitative data was compiled from relevant quotes distilled from the students' short written reflections, using Thematic Analysis as coined by Braun and Clarke (2022). It should be mentioned that this data set is biased, since there was no hard requirements for these reflections, and students who had rather negative experience with the task or course might be less likely to have written elaborate reflections, thus eliminating their quotes from this data set as they were monosyllable or simplistic to add considerable information to the evaluation.

4. Design of “The Policy Maker”

The “Gameful Design” course provided the development structure of three prototype iterations with play-testing sessions in-between: the first prototype concentrated on basic game mechanics, the second prototype on learning outcomes using the SGDA Framework (Mitgutsch and Alvarado, 2012), and the third prototype mainly tackled the issue of balancing.

The game for three to four players involves a game board, game pieces and cards, as shown in Figure 1. One player assumes the role of the policy maker and the others are investors. The goal for the investors is to establish a monopoly in one of four business sectors; or, if no monopoly is established before the game ends naturally according to a fixed timeline, the investor with the highest investment score wins. The policy maker follows the diametrically opposite goal of preventing the forming of monopolies, in addition to pursuing their own, secret goal, all while ensuring balanced economic growth.



Figure 1: Game board with game pieces, investment cards and public initiatives.

Using asymmetry in board games is an effective way to simulate real-world scenarios (Schell, 2020), demonstrating the imbalance that can occur between political and financial players in real life. Unlike symmetrical games, where starting conditions, the set of actions and the gameplay are the same for all players, these aspects may differ in asymmetrical games, offering diverse players' experiences and therefore increasing the likelihood of replay-ability, and enhance strategic decisions (Shafer, 2013). Another benefit of asymmetrical game design is that it offers players with different game genre preferences different gameplay aspects, bringing diverse players together as a group (Harris, 2016).

4.1 Investors' Gameplay

In the game, two to three players assume the role of investors, managing investment cards in their hand, which they collect throughout the game in order to purchase investment tiles in the four sectors: Infrastructure, Food, Information Technology, Education. The objective of investors is the establishment of a monopoly in one of the business sectors, which wins the game for the investor immediately. In order to hinder others from establishing

a monopoly first, the investor has to either catch up to the leader of a sector, meaning that there will then be balanced growth in the sector; or use market manipulation to harm others' investment. In this case, the active investor, if they have the right amount of investment cards for the sector, forfeits their chance to make investments in a round, but instead uses the cards to engage in market manipulation, setting the targeted investor back in their business development.

Each turn, investors may aim to fulfil public initiatives that are open for everyone to see while investing, in which case the investor gets additional investment cards. Initiatives fulfilled are replaced immediately, so there are always two open initiatives to fulfil for every investor. They contain objectives like making certain amounts of investment in a specific sector at once, or using joker cards while investing. In the event of investors failing to establish any monopoly and the policy maker not reaching their secret goal before the fixed timeline reaching its end, the investor with the highest investment score, which is the sum of investment fields in each sector and public initiatives won, is declared as the winner. Introducing incentives that may not align with investors' immediate goals in mind opens up more possible strategic choices.

If an investor has more than 20 hand cards at any point during the game, a wealth tax is imposed, resulting in the targeted investors losing half of their cards. This mechanic was introduced to balance the game, preventing players hoarding investment cards until they can win the game at once.

After their turn, each investor draws two new investment cards. There are always two cards revealed and placed face up next to the closed deck. Investors may decide to draw one from the closed or the open deck. If the decision was for an open card, a new card is revealed and fills up the place just opened up. This enables the policy maker as well as the investors to gain information about others' plans.

Through this described gameplay, investors not only rely on luck in drawing investment cards each round, but are also able to play strategically: managing their own resources, reacting dynamically to fellow investors' actions, adapting their plans, as well as reacting to the policy maker's actions.

4.2 Policy Maker's Gameplay

The titular policy maker is assigned a secret goal each game, prescribing which business sectors the policy maker should focus on developing. This supplements their main objective of preventing the establishment of a monopoly. Fulfilling the secret goal ends the game, winning it for the policy maker; while maintaining the main goal is essential until the end of the legislative period, in order for the policy maker to not lose the game.

The game not only varies in objectives but also in the available set of actions for the different roles: while the policy maker has significant influence over the game's proceedings with their own set of actions, they cannot make choices on their next actions freely. This is instead constrained by the sequence of actions dictated by the timeline at the bottom of the board (shown in Figure 2), each tile also indicating the start of a new turn. This relatively strict sequence should reflect the real-world setting, where it takes time to implement regulations and laws, and there is a delay between change in jurisdiction and this taking effect on market and society.



Figure 2: Timeline with policy maker's actions.

Overall, there are four actions for the policy maker: audit, tax adjustment, grant funding and holiday break. With audit, the policy maker examines the investors' investment cards in hand. This allows the policy maker to gain insight into the next possible turns and actions of the investors, providing decision support for the policy maker's next actions in line. Tax policy allows the policy maker to regulate the market prices by lowering or raising the costs of investing in each business sector, creating incentives to invest in certain sectors, or discouraging from investing in others. Grant funding allows the policy maker to distribute investment cards among investors, giving the policy maker the opportunity to influence the trajectory of future investments, furthering they work towards their own secret goal, and ideally maintaining or restoring balance on the market.

The policy maker therefore has to observe the investors' actions and their dynamics closely, without knowing their plans. The decisions made by the policy maker may have immediate or long-term effects on the investments, upon which the policy maker cannot react immediately - notice that it is not possible to change the tax policy two turns in a row. This asymmetry in the gameplay is further enhanced by the fact that there are more investors than the single policy maker.

The investors' plans may get disrupted by the policy maker's actions, and they may engage in negotiations with each other while playing. While the policy maker tries to balance the economic progress, the investors try to get clues about the policy maker's secret goal from their actions while racing each other in the investment game.

In summary, the players experience the constant negotiations between political and financial institutions by interacting within the game. The policy maker takes actions that influence the market both directly and in the long-term. Reacting to changes in the political frame and each others' moves, investors adapt their plans and experience what it is like to pursue different goals in the same given system. At the same time, the policy maker learns to observe the dynamic market, to plan ahead and effectively achieve their development goal. The importance and far-reaching consequences of policies is transferred in a simple and understandable gameplay with strong, coherent framing, inviting players to think about real-life occurrences of such political and economic events.

5. Results

This section outlines the results of the first iteration of using "The Policy Maker" in the course "Ways of Thinking in Informatics". Students' survey responses from after having played the game constitute the basis for the quantitative results. The qualitative results give an insight into students' reflections on their perception of the GBL method and the game.

5.1 Quantitative Results

To engage in the topic of Policy Thinking, students were offered a variety of games to play. In addition to our non-digital game "The Policy Maker", there was also a themed version of the classic game "Memory" available. Furthermore, there were three digital, single-player games to choose from: "Green New Deal Simulator", "Moderator Mayhem", and "Bad News". A survey was conducted after students played their chosen game, asking them to rate ten statements (shown in Figure 3) on a scale from 1 to 7, where 1 is strongly disagree and 7 is strongly agree. The median of all responses is shown.

From the 514 students who handed in their exercise on the game-based learning part of the course, we received 78 survey responses regarding "The Policy Maker", and 108 regarding other Policy Thinking games. Since the students were asked to play at least two games in a two-hour play session for one selected "way of thinking" from the course, the survey responses on "The Policy Maker" each come from a different student, while the responses on the other Policy Thinking games are not. All in all, the analysis of the survey results shows that "The Policy Maker" is rated as more entertaining, recommendable, and interesting compared to the other evaluated games on the topic of Policy Thinking. Through the gameplay, participants mostly agree that they could deepen their understanding of Policy Thinking and gain new knowledge about this political topic. Additionally, with the help of the game, students were mostly able to connect different concepts of Policy Thinking, and perceived to have a better understanding of how these concepts are applied after they had played the game. The only considerable drawback of the game is that students thought they did not get to know or better understand concepts in Policy Thinking through the game.

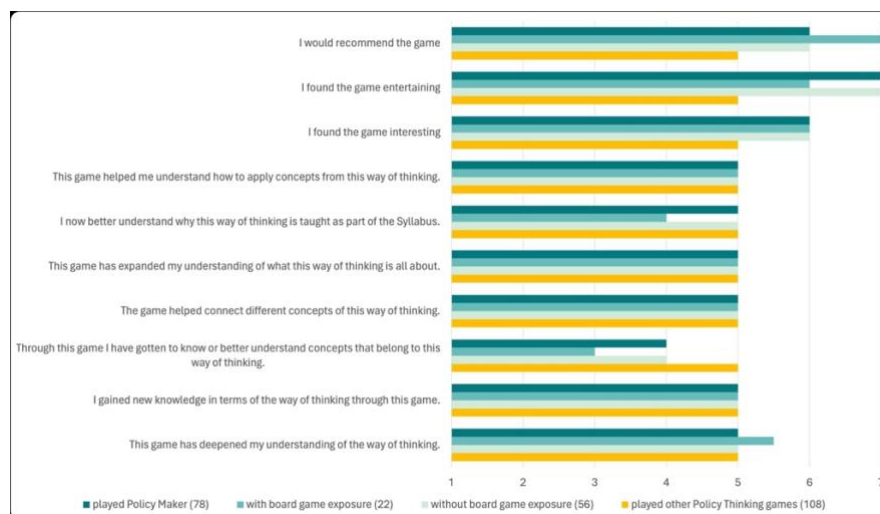


Figure 3: Quantitative data.

The data also revealed differences between students with (n=22) and without (n=56) self-reported prior board game exposure, among the 78 students who had played “The Policy Maker”. Initially noticeable is that the interest in the game and the entertainment factor are both rated quite high by both groups. Additionally, students with board game exposure would highly recommend the game, while students without board game exposure beforehand found the game highly entertaining. For students with board game exposure, the game seems to have rather deepened their understanding of Policy Thinking, than achieved the effect of the students learning new concepts through playing. Furthermore, these student group stated that they did not gain a better understanding of why Policy Thinking is taught as part of the syllabus.

5.2 Qualitative Results

From the short reflections provided by the students after playing the games, 303 comments were distilled and selected for qualitative analysis, of which 16 referred to “The Policy Maker” specifically. We grouped the comments, according to their themes, into three non-exclusive overarching categories: learning, method, and feedback.

Eight comments touch on the topic of *learning*. Students reflected on recognising the concepts of Policy Thinking in the game and consolidating them through playing. While some students gained knowledge on the topic through the game, others strengthened their understanding thereof, making note of experiencing the different roles in the political system: “*You get a real sense of how ‘investors’ react to different policies.*”; “*Now I definitely have a little more appreciation for the actually quite difficult task of politicians*”. The game also inspired students to reflect on the real world, with one student writing: “*[The game] offered a fascinating perspective on political and economic decision-making processes and stimulated reflection on the consequences of political decisions in the real world.*”

However, some students were neutral towards the aspect of knowledge gain through playing the game, reporting that since they already knew a lot about politics and Policy Thinking before, they did not gain new insights through the game. Other students had difficulties connecting the game to Policy Thinking, stating that it could be due to their limited knowledge about the topic. This raises the question of when to best introduce the game to the students — some seem to prefer to already knowing the basic concepts of the way of thinking before playing, while others appreciated playing the game first and amplifying their interest for the topic.

Students’ comments in the category *method* are positive. They remarked on the variety the game-based learning approach provides in their study program, it being more practical as compared to the more theoretical nature of students’ studies, and the game being engaging and fun. The gaming events also provided an opportunity for students to get to know fellow students, and through engaging in discussions that occurred naturally while playing, the learning effect was further enhanced, and more in-depth reflection about the topics was encouraged.

In addition, students provided *feedback* on the game and the organisation around the game events. The game was lauded for its unexpectedly high quality, but the game instructions were at times too complex to understand. It was also mentioned that one hour of playing time was not enough for fully understanding the game, with some students suggesting that the game instructions should start with an overview of general rules and go into detail and edge cases later.

6. Discussion

In general, the written reflections of the students support their reported perception of the learning outcomes, showing that “The Policy Maker” enhances understanding of the topic of Policy Thinking. The game’s mechanics were designed with the intention of transporting the intricate relationships between political institutions and financial actors, with asymmetry being the core of the gameplay. Players also experienced the limiting nature as well as long-lasting possibilities and consequences of political decisions. The dynamics between different roles and their responsibilities received positive feedback as well, achieving the intended effect of students getting the, albeit abstracted, experience of working inside the political frame with different interests and thus having to act with constant negotiations and adaptations to one’s plans. Following Mitgutsch and Alvarado’s SGDA Framework (2012), we also created a coherent narrative frame by naming mechanics, e.g., policy maker and investors’ actions, according to the theme. This naturally transfers events that occur through players’ interaction into narrative story beats.

Although most students recognised the concepts of Policy Thinking in the game, and indicated that they were able to consolidate their understanding thereof through playing, the aspect knowledge gain is not the strongest in “The Policy Maker”. Some students did not see a firm connection between the game and the lecture content, failing to make the connection back to the broader context of CS. A possible explanation for this is the trade-off we made in the design: Since the game’s purpose is to deepen the players’ understanding for the complex interplay of political and financial interests, we did not put emphasis on the element of “content & information” (Mitgutsch and Alvarado, 2012), which would have entailed providing players with relevant facts and information on the topic. Another possible contributing factor is the abstraction level of the game. It is abstracted in a way that it focuses on general concepts of Policy Thinking rather than on specific contexts of e.g., scenarios related to CS. The decision for this approach is grounded in considerations regarding the complexity of the topic, and our attempt in making the game appealing to broader audiences.

Similar to the element of “content”, we did not focus on the element of “aesthetics” beyond creating a visually minimalistic board and card sets, relying on the asset of non-digital games that the aesthetic arises during dynamic social interaction itself. In regards to framing of the game, we think that we were successful in making the game appealing to the target audience of first-year CS students. Due to the nature of non-digital games, the play literacy required to play the game is generally lower, compared to digital games. However, as students’ feedback suggests, the game instructions can be improved to ensure a smooth start into the gameplay. Furthermore, we have seen interesting differences in perception of the game between students with or without prior board game exposure. The high recommendation rate by experienced board game players especially suggest that “The Policy Maker” is a board game of good quality, assuming that these more experienced players have a broader and deeper knowledge of the entertainment-focused corpus of non-digital games.

Drawing from the students’ reflections, we suggest that the point at which a game is introduced and used in a course is also influencing the learning outcomes. While playing a thematically suitable game before engaging with the course content can be beneficial for raising interest for the topic, playing the game after acquiring knowledge and understanding about the topic can further enhance these learning aspects, and possibly even prolonging and deepening interest in the topic. The decision for the ideal timeframe for game-based learning therefore depends on the intended effects of the approach for the specific educational context. Additionally, it should be considered that students have different previous knowledge and experiences, which can affect how they perceive certain lecture content and educational approaches, as demonstrated in the different ratings from students with or without prior exposure to board games. In the case of “The Policy Maker”, since the data from the first iteration of using the game in the course “Ways of Thinking in Informatics” suggest that our intended learning effects of enhancing understanding of Policy Thinking concepts are well received by students, we make the proposition of using the game after students have engaged themselves in the topics of Policy Thinking, so they can better see the concepts reflected in the gameplay.

In order to aid students in making this connection between their playing experience and the lecture content, we plan on refining the reflection step of the GBL pipeline, by providing reflection prompts that target each game’s educational strengths individually, to provoke deeper reflection in students. This can be approached by 1) eliciting explicit and elaborate design considerations on intended learning effects from the students designing future educational games, 2) analysing games we plan to use in these aspects, and 3) taking into account which parts of the lecture content can be best connected to the games.

7. Conclusion

In conclusion, our case study on “The Policy Maker”, a non-digital game designed by advanced CS students, highlights the successful first iteration of integration of game-based learning in an introductory Human-Computer Interaction course. This educational approach not only engaged first-year students, but also facilitated a deeper understanding of Policy Thinking, a crucial aspect of CS education that connects technology, market interests and political realities.

The game’s design, rooted in the SGDA Framework (Mitgutsch and Alvarado, 2012), effectively demonstrates the complex interplay between political and financial entities, allowing students to experience these dynamics in a social and reflective environment. Although the game was more successful in enriching students’ understanding for Policy Thinking rather than introducing new concepts, it enhanced the learning experience overall, fostering engagement and reflection.

However, the case study also identified areas for improvement, such as improving game instructions and better timing the introduction of the game with students’ learning progress in the course.

Future iterations of this game and others used in a game-based learning approach should consider these insights to further enhance the educational impact of games. This case study serves as a foundation for further research in the effectiveness of non-digital games in education, not only in fields like CS, but also across disciplines.

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