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Cognitive Biases in Group Decision-Making – Raising Awareness through a Collaborative Serious Game

Sandra Schlick*, Hans Friedrich Witschel, and Corina Stampfli

FHNW University of Applied Sciences and Arts Northwestern Switzerland,
Riggenbachstrasse 16, Olten, 4600, Switzerland

sandra.schlick@fhnw.ch, hans-friedrich.witschel@fhnw.ch,
corina.stampfli@hotmail.com

Abstract. Several challenges, especially cognitive biases, accompany the growing importance of collaborative or group decision-making in business projects. This article focuses on identifying the key cognitive biases that affect group decision-making and explores the potential of a serious role-playing game as a training method to identify group decision-making biases. Using a design science research approach, a game prototype was developed to improve group decision-making in a corporate context by increasing players' awareness of their biased decisions. The findings indicate that there is a need to provide specifically designed games for group decision-making, and only a limited number of existing games are specifically designed for corporate decision-making contexts. Our contribution addresses the lack of training tools such as role-playing that increase cognitive bias awareness for group decision-making in projects, demonstrating the potential of a collaborative serious game to mitigate biases such as groupthink bias, authority bias, and social loafing while providing actionable insights for companies wishing to develop their own game on how to adapt the game's design and effectiveness. It shows that every bias requires specific game characteristics, such as storyline, feedback mechanisms, and role concepts.
Keywords: Group Decision Making, Cognitive Bias, Serious Game, Role-Play, Adventure, Project Management.

1 Introduction

Group decision-making is essential to the success of projects, especially in complex contexts where diverse stakeholders must be involved, and various interests and factors must be considered. Although group decisions have become increasingly common for effective project implementation, they pose challenges, including the risk of poor or indecisive outcomes, often leading to project failures [1]. A primary cause of ineffective group decisions lies in cognitive biases, which usually stem from the inherent limitations described by Bounded Rationality, such

* Corresponding author

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Additional information. Author ORCID iD: S. Schlick – https://orcid.org/0000-0003-3661-0479, H. F. Witschel – https://orcid.org/0000-0002-8608-9039, and C. Stampfli – https://orcid.org/0009-0008-7384-6476. PII S225599222600262X. Received: 19 December 2025. Accepted: 9 March 2026. Available online: 31 July 2026.

as constraining people's processing capacity and incomplete information. Further theories, such as Behavioral Economics and Prospect Theory, explain how individuals make decisions under risk and uncertainty, and demonstrate that risk behavior varies with the perceived certainty of outcomes.

This research focuses on group decision-making because teams are involved in decisions in projects, regular meetings, and the workplace [2]. The reason for this choice is to make teams aware of biases in their decisions. Group dynamics are investigated only in terms of a single change of awareness during a serious game [3]. This is relevant to this article as awareness of biases in decisions is investigated. The emphasis lies on the forces of group dynamics on individual behavior in team decision-making [4]. Insights into group dynamics, such as the changes in team behavior during a project or interaction between teams [4], are out of the scope of this research. Therefore, group dynamics are investigated between group members and their cognitive biases based on their roles in group decision-making. Research in group decision-making aims to understand how individuals collectively make decisions in an organization and incorporates theories from psychology, sociology, and management. Several key theories provide a background for this study [5]:

- *Bounded Rationality:* Herbert Simon proposed the concept of bounded rationality, which suggests that although individuals aim for rational decision-making, their choices are often restricted by limited information, cognitive constraints, and time limitations. This theory is valuable for understanding cognitive biases and the constraints that influence people's decision-making [6], [7].
- *Behavioral Economics* combines psychology with traditional economic theory to understand why people sometimes make irrational decisions. It explores how psychological, cognitive, emotional, cultural, and social factors influence the choices made by individuals and organizations [6], [7].
- *Prospect Theory:* This theory relates to behavioral economics. It describes how people make choices in situations involving risk and uncertainty, often in organizational decision-making. Prospect Theory suggests that people value gains and losses differently, leading to irrational decision-making, which can significantly impact group decisions [8].

These theories highlight the complexity of decision-making and emphasize the role of cognitive biases. For instance, Bounded Rationality explains the limitations and heuristics involved in decision-making, while Behavioral Economics and Prospect Theory provide insights into why individuals may deviate from rational decision-making. Understanding these foundational theories helps frame the problem of cognitive biases in group decision-making.

In this study, using the example of a large enterprise in the transportation sector, the most common biases hindering project group decisions were identified through interviews. One frequently occurring bias in practice was groupthink, where team members withheld opposing opinions to maintain harmony and consensus. Hierarchical structures often reinforce these dynamics, where authority bias plays a role. This leads to adopting leadership opinions and suppressing critical thinking and alternative perspectives. Leaders who dominate decisions reduce motivation and engagement, leading to social loafing [9].

Awareness of these biases is essential to improving group decision-making. Traditional training methods are often ineffective, whereas experimental methods promise better results [10]. They create interactive learning environments where participants can directly experience the dynamics and consequences of decision-making processes and learn to identify and overcome biases [9].

This article aims to analyze the challenges posed by cognitive biases in group decision-making within project management and proposes a serious game as a training solution. The main research question is, "How does implementing a collaborative serious game as a training strategy improve group decision-making in project teams by addressing cognitive biases?"

The article's relevance lies in its dual contribution: first, from a research perspective, it seeks to address a gap in the literature at the intersection of group decision-making, project management, and serious games; second, from a business perspective, it provides implications for organizations facing the limitations of traditional decision-making methods.

Related research is discussed in Section 2. Research methodology is presented in Section 3. Section 4 explores the challenges in decision-making and discusses the possibility of raising awareness of cognitive biases through a serious game. Section 5 proposes the respective serious game. Game design is discussed in Section 6. Evaluation of the proposed solution is available in Section 7. Section 8 concludes the article.

2 Literature Review

The literature review provides a comprehensive examination of the theoretical and practical foundations relevant to this research by connecting the challenges of group decision-making, the potential of serious games as an innovative training approach, and the existing research gap. The literature review followed a structured approach to identify relevant theories and practical studies on group decision-making, cognitive biases, and serious games. Scientific databases (Web of Science, Scopus, IEEE Xplore) were used to search for publications between 2000 and 2024. The following search queries and keywords were used: ("cognitive bias" AND "group decision*"), ("serious game*" AND "bias"), and ("project management" AND "group decision*" AND "bias")

Group decision-making, involving formally established groups of 3 to 20 individuals with specific tasks and shared goals, represents a challenge for collective decision-making [1]. As projects become increasingly complex, group decision-making is essential for project management, which requires considering individuals' personalities, past experiences, and intentions. Despite the advantages of collaborative decision-making, it can sometimes lead to poorer outcomes than individual decision-making because it is influenced by biases [11]. These biases arise from individual perception of social reality, where subjective interpretation of information creates systematic deviations from rational decision-making [6], [12].

2.1 Biases in Group Decision-Making

While group decision-making can help to increase efficiency and effectiveness in outcomes, some problems appear in the workplace. One of the primary reasons for failure in complex projects is poor decision-making [1], [13]. Figure 1 shows the relationship between group decision-making, project management, and serious games. The key literature is shown in the figure, and challenges are in red. The focal area of this article is shown in the center of the figure, namely that a serious game can help leverage group decision-making in projects by raising the awareness of individual cognitive biases.

From a business perspective, biases in group decision-making present a major challenge. One practical example of this is the tendency of project groups not to express opposing opinions in the group to maintain harmony and speed up decisions. This behavior is a symptom of groupthink bias, which often leads to reduced effectiveness and increased errors in decision-making [10], [12].

Consider projects where superiors delegate employees to work on an interdisciplinary project. Even when being chosen by their superiors, management boards or supervisors often override decisions. This problem is associated with cognitive biases, particularly groupthink, which arises when multiple stakeholders are involved, and hierarchical structure allows decisions to be questioned or overridden [10]. Group members might prioritize conformity and consensus over critical thinking, suppressing diverse perspectives, and potentially resulting in flawed decisions [14]. Therefore, this research focuses on how biases arise that lead to poor decisions in projects.

The literature distinguishes between different individual and group biases, which can affect decision-making. One common individual bias is overconfidence, which occurs when decisions are made with excessive confidence and risks are underestimated. Another is the sunk cost bias, where people continue investing in a project based on previously committed resources, even if it no longer makes rational sense [10]. Additionally, individuals often over-rely on past experiences, misinterpret new evidence, and underestimate their abilities, resulting in poor decisions [12].

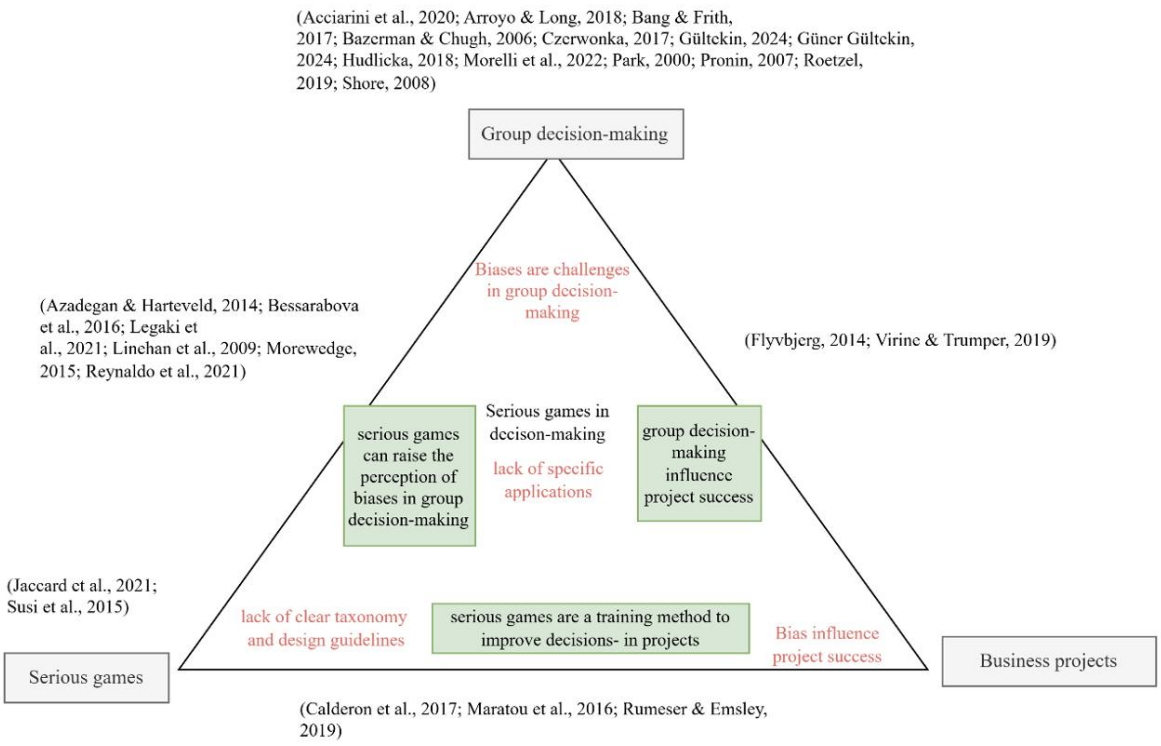


Figure 1. Relationship between games and applications with references; Morelli et al., 2022 [1], Rumeser & Emsley, 2019 [9], Virine & Trumper, 2019 [10], Bang & Frith, 2017 [12], Acciarini et al., 2020 [15], Gültekin, 2024 [17], Arroyo & Long, 2018 [19], Bazerman & Chugh, 2006 [20], Czerwonka, 2017 [21], Gültekin, 2024 [22], Hudlicka, 2018 [23], Park, 2000 [24], Pronin, 2007 [25], Roetzel, 2019 [26], Flyvbjerg, 2014 [27], Susi et al., 2015 [33], Reynaldo et al., 2021 [34], Calderon et al., 2017 [43], Maratou et al., 2016 [50], Morewedge, 2015 [57], Jaccard et al., 2021 [64].

Individual biases are closely linked to information biases, demonstrating how personal predispositions and limited perception influence the processing and interpretation of information in decision-making [15]. Decisions in a group can help to overcome individual biases. For instance, individuals may recognize biases in others more quickly than they recognize them in themselves, potentially leading to better decision-making outcomes [10]. However, it is essential to note that not all problems of individual biases are eliminated in groups. Sometimes, they may be amplified, or new group biases, such as the groupthink bias, arise [10], [12]. This psychological bias affects social dynamics by suppressing independent thought and reducing information diversity. Groupthink aims to minimize conflicts in favor of consensus, but this often leads to poorly informed decisions due to the undue influence of a dominant minority. Janis [16] identified eight key symptoms of groupthink that illustrate how it undermines decision-making: the illusion of invulnerability, collective rationalization, belief in inherent morality, stereotyped views of outgroups, direct pressure on dissenters, self-censorship, the illusion of unanimity, and the emergence of self-appointed "mind guards" who block alternative viewpoints. These symptoms contribute to a false sense of consensus and discourage critical evaluation, ultimately reducing the quality of decisions. Understanding and recognizing these symptoms is essential for developing strategies that foster open dialogue and mitigate groupthink in team-based decision-making contexts. Mitigating group biases requires promoting diverse viewpoints and critical evaluation of information to enhance decision quality [10], [12].

Furthermore, group decision-making dynamics are also influenced by cultural contexts, as reflected in Hofstede's cultural dimensions [†] (power distance, uncertainty avoidance, and

[†] https://www.ebsco.com/research-starters/business-and-management/hofstedes-cultural-dimensions-theory

individualism) vs. collectivism. For instance, authority bias, a tendency to overly trust authority figures, often arises in hierarchical cultures, leading to conformity and suppressed dissent [17]. In addition to cultural factors, the roles of participants within a group also affect the occurrence of these biases. The composition and dynamics of project teams significantly influence the prevalence of biases. Projects often involve diverse participants representing different departments and opinions, but their temporary nature means that team members are generally unfamiliar with one another [18]. A mix of personalities and roles fosters creativity, counters biases, and improves decision quality [14]. Additionally, ensuring openness to diverse opinions and promoting awareness of bias among team members is essential for effective group decision-making [10].

The literature on group decision-making has explored the challenges that hinder effective decision-making in projects [1], [10]–[12], [15], [17], [19]–[26]. The impact of biases is also examined [10], [27]. However, there is a significant gap in providing specific guidelines for training groups to reduce biases in decision-making [10]. The suitability of different game genres in augmenting group decision-making competencies, especially in biases, is poorly understood. This gap is highlighted by the absence of universally accepted taxonomies and clear definitions, making it difficult to determine which game types best address biases in business projects [28], [29].

Social loafing is the tendency for individual members of a team to exert less effort than their fellow team members [30]. Making group members aware of being passive despite their ability to contribute is one of the essential points of this research. The existing paradigm of inevitable social loafing assumes that cooperation during examinations is at best misdirected and at worst a form of cheating [31]. Authority bias can lead to decreased motivation and awareness of participation. This often results in social loafing, where some group members do not contribute, believing their input is irrelevant [12]. As cognitive biases cause inferior decisions, this research focused on how to debias decisions in groups [32].

2.2 Leveraging Biases with Games

Serious games, defined as all types of games used for more than just entertainment, offer several advantages over traditional training methods for group decision-making [33]. They can enhance critical thinking, simulate decision-making processes, or increase participant engagement, which provides benefits in addressing group decision-making challenges, particularly in dealing with complex issues such as reducing cognitive biases in project decisions [34]. Numerous studies confirm the effectiveness of these games in raising awareness and mitigating biases by creating controlled environments that allow participants to navigate scenarios and identify their cognitive errors [35]. Furthermore, games can be adapted to address cultural aspects, thereby increasing awareness of specific challenges faced by particular groups. Research highlights that game genres such as simulations, role-playing, and adventure games are particularly suited to improving group decision-making. These genres offer diverse opportunities to combine interactive scenarios with realistic or narrative approaches. However, there is a lack of clear classifications and guidelines to identify the optimal genre for specific training goals. Varying approaches and inconsistent taxonomies complicate the systematic integration of serious games into complex decision-making contexts, particularly in business projects [36].

Different game genres can be appropriate for tackling group decision-making issues. Each game genre has distinct features, but there is no clear classification of game genres in serious games. Different papers use varying terminology and subdivisions [36]–[40]. The most frequently mentioned categories include puzzle, simulation, role-play, strategy, platform, action, and adventure games, which are further explained in Table 1.

Table 1 shows that different game genres can enhance decision-making skills. Simulation, role-play, and adventure games have the broadest applications in enhancing group decision-making abilities and are particularly relevant to this research.

Despite the potential of serious games, a significant research gap persists. While some cognitive biases, such as overconfidence or groupthink, are well-documented (e.g., [9]), specific guidelines

to help groups systematically reduce biases in decision-making are lacking. Moreover, most existing applications focus on specific biases or educational contexts, neglecting their combination with business requirements or complex group scenarios. The literature further reveals that integrating serious games into professional contexts is underexplored, and various examples are not designed to address bias reduction [41].

Table 1. Game Genre and Features

Genre	Features and suitability	Examples of group decision-making
Simulation Games	Simulation games immerse players in detailed environments where they manage and interact with dynamic systems, blending elements of realism and fantasy [36]–[40].	Widely applicable in showing bias consequences [35], [43]–[45].
Role-Play Games (RPGs)	Role-play games (RPGs) come in different forms, such as Tabletop, Live-Action, Computer, and Multiplayer Online, each offering unique immersive experiences to cater to different player preferences and mediums [46]. Greco (2009) [29] synthesized various definitions and characterized RPGs as "a game where each player takes on the role of a character." RPGs involve players assuming characters and making decisions that shape the character's story. The type of experience influences the effectiveness of role-playing games in addressing biases played, emphasizing the importance of choosing the right implementation of role-playing game features [47].	There are different examples in the field of role-playing games. One variant is, for instance, Dungeons and Dragons. This is a long-term tabletop role-playing game. It encourages cooperation and can break down biases through role-playing [48], [49]. Another example is adventure role-playing, shown in different examples [9], [50]. Adventure games involve the integration of compelling storylines typical for adventure games [51].
Strategy Game	Strategy games require careful planning and resource management, often involving complex decision-making and bias awareness [37]	There are relatively few examples of strategy games in use. The authors of [35] show how a strategy game can improve decision-making through bias awareness.
Action Game	Action games trace their origins to classic arcade and console games, encompassing various genres such as side scrollers, jumping games, and shooters [52]. In the serious game context, action games include escape games and live-action scenarios where players solve puzzles and complete tasks to achieve specific goals [53]. These games can enhance decision-making and collaboration skills [54]	Escape games can address different biases depending on their design. While escape rooms are characterized by the need for collective engagement in addressing individual biases, other game genres, such as role-playing games, may be better suited for addressing group biases by promoting an understanding of different team roles and dynamics [55].
Adventure Game	In adventure games, players take on the protagonist role, navigating through levels to achieve specific goals. These games emphasize puzzle-solving and overcoming obstacles through interaction with characters and objects [56]. Key elements include a rich narrative and engaging logic puzzles that advance the story.	Adventure games have the potential to address various biases, as demonstrated in the literature by the serious game "Missing," which encourages reflection on biases and is applied to several different biases [57], [58].

This research addresses the above-discussed gap by connecting the three themes, namely group decision-making, cognitive biases, and project management. It is an extension of the work presented in [42]. The aim was to develop a training solution that reduces group- and culture-specific biases in decision-making. Building on existing work (e.g., [41]), a structured approach to designing serious games is applied to close the gap.

3 Methodology

The research aims to close the gap in the interplay between group decision-making, cognitive biases, and project management, and to develop and evaluate a serious game that mitigates group biases in decision-making. This approach aligns with Design Science Research (DSR) [59], emphasizing iterative artifact development. As there was no business transformation ongoing in the studied company, action research had to be ruled out as an alternative approach, although it would also fit in principle.

The study takes a pragmatic perspective, combining qualitative methods to explore the problem and design solutions. It employed multiple methods, integrating interviews, observations, and questionnaires to gather data across four distinct phases of DSR. The data collection was conducted from October 2023 to April 2024.

The selection focused on studies that provided conceptual clarity or practical insights related to the application of serious games in decision-making contexts. The insights from this review informed both the biased selection and the game design requirements.

During the *awareness phase*, cognitive biases were identified through semi-structured interviews conducted in two rounds with project managers and team members from a large transportation company. The first round explored practical decision-making challenges, while the second round focused on bias awareness and validation. These findings were validated through a thorough literature review described above. Sample interview questions and interviewee selection are demonstrated in Tables 2 and 3.

Table 2. Interview questions for the awareness phase

Round	Question	Expected Outcome
1	Take an example of a recent project and try to answer the questions based on the example. From your perspective, what is the typical decision-making process in projects at your company?	The answers are specific and related to an example. The typical decision-making process involves group decision-making. Strategic, tactical, and operative decisions need to be made.
1	What difficulties and challenges are encountered in group decision-making? Why? How does this become apparent?	Challenges related to biases are expected. Decision-making is prone to errors or takes a long time.
1	How is knowledge shared and transferred in projects? What are the consequences?	Understand the mechanism of knowledge sharing and the challenges. Biases also influence knowledge sharing.
2	Explanation of several biases and the concept of bias. What biases do you think are present in project decisions? Give an example.	The most important biases are individual and group biases.

Table 3. Interviewee selection

Name	Role	Perspective	Interview round	Interview
Interviewee 1	Project leader and team leader of the project team	Provides problem insights in projects Has a strategic view	Two interviews (Rounds 1 and 2)	Interview Round 1 [60] Interview Round 2: [61]
Interviewee 2	An employee in a project team	Team view can elaborate on problems in the project team	Two interviews (Rounds 1 and 2)	Interview Round 1: [62] Interview Round 2: [63]
Interviewee 3	Department leader (member of project boards)	Strategic view Importance and consequences of problems in group decision-making	Only one interview (Round 2)	Interview Round 2: [63]

Five interviews were conducted in two rounds. The first round explored whether group decision-making poses practical challenges and helped narrow the focus to cognitive biases. The second round aimed to raise awareness of these biases in practice and compare them with findings from the literature.

During the suggestion phase, the design requirements and characteristics of the game were formulated to address biases, with a focus on enhancing group decision-making. No further data were collected during this phase. In the development phase, a serious game prototype was created using Microsoft PowerApps, leveraging the Jaccard framework for collaborative game design [64]. The game progressed through several stages, where participants had to collectively navigate scenarios designed to expose and mitigate biases. The game development process, guided by the Jaccard framework [64], was structured to create a tool for raising awareness of cognitive biases. No further data were collected during this phase. One of the authors designed the game as part of a master's thesis in Business Information Systems. While this author does not have a formal background in psychology or game design, the development was informed by established literature on cognitive and group decision-making biases (e.g., [6], [10]) and serious game design. Interviews with subject matter experts provided critical feedback throughout the project's development and evaluation phases. The game was tested with participants from a corporate environment, focusing on perceived learning, engagement, and awareness of biases.

The game was tested in the evaluation phase with 22 participants from the project environment of a large transportation company, where the relevant biases had previously been investigated. Focus was on evaluating applicability and effectiveness (see Table 4). They were organized into five groups of 3 to 5 members and consisted of project team members or managers actively involved in group decision-making processes within their current projects, ensuring relevant practical experience with the decision-making challenges addressed by the game. Simultaneously, an additional control group of 18 non-players with similar professional backgrounds and project experience was selected to assess differences in bias awareness between players and non-players through a post-game questionnaire.

Data were gathered through observations, discussions, and group interviews, and a questionnaire was administered to the five groups that played the game. Evaluation criteria were: Applicability, Effectiveness (improving group decision-making) of the game characteristics (for details of game characteristics, see Appendix, Table A).

Table 4. Evaluation of artifact (based on [65], p. 393)

Input	Output	Evaluation Criteria
Prototype of artifact (game)	Validated artifact in a naturalistic setting (proof of usefulness)	Applicability Effectiveness (improved group decision-making)

The context of testing the game that took place with individuals working at a transportation company with project management roles [64] can be described in detail as follows:

- *Group formation:* Groups of three to five people,
- *Equipment:* Participants need business laptops,
- *Venue/Setting:* on-site in one room,
- *Software:* PowerApps, due to restrictions on using tools on business laptops, PowerApps was used. PowerApps is a part of the Office 365 suite, is easily accessible, and is sufficiently versatile for game design purposes.

The study was conducted in moderated workshop sessions, including gameplay, observations, and post-game group discussions. Participation was voluntary, and all data was anonymized to ensure no personal information could be traced back to individuals.

All participants who had previously participated in the awareness phase of interviews did not take part in the game; however, the game participants had a similar professional background. To

address potential concerns about overlap, this separation ensures that prior exposure to biased concepts during interviews did not influence the game's evaluation results.

Feedback for evaluating the collaborative serious game was gathered through gameplay observations, group interviews, and post-game questionnaires, which were conducted two to three weeks after the game. Both players and non-players completed a post-game questionnaire to assess their knowledge of biases and analyze the differences. The following methods were used:

- Semi-structured group interviews with predefined questions covering bias recognition, game experience, and learning transfer;
- Post-game questionnaires were administered 2-3 weeks after gameplay, including Likert-scale questions on bias awareness and open-ended questions about real-world application;
- Observation protocols during gameplay using structured coding sheets;
- Bias awareness assessment questionnaire for both players and non-players, measuring pre- and post-game knowledge differences.

The collaborative serious game session lasted approximately 90 minutes, including gameplay and debriefing phases.

The questionnaire was designed to ask participants to provide examples of biases implemented in the game, assessing their understanding and perception of these concepts. For groupthink, for instance, the following question was asked: *"Groupthink refers to a behavior where individuals align with the group's position or judgment, regardless of their own opinion. The desire for unanimity within a group can suppress critical thinking and individual opinions, ultimately leading to poorer decisions. How would you rate your awareness of groupthink in group decision-making? Can you provide an example of a decision where you, in hindsight, think these biases might have played a role?"*

The data analysis includes:

- Qualitative data analysis for semi-structured interviews, observations, and group debriefing (thematic analysis, content-structured qualitative content analysis),
- Qualitative analysis of questionnaires (selective coding, clustering).

The study was conducted according to the ethical guidelines of the University of Applied Sciences and Arts Northwestern Switzerland (FHNW). All participants were informed about the study's objectives, procedures, and content, and provided written informed consent before participation.

Ethical clearance was not required; the study was conducted with the agreement of the company, and no sensitive data was revealed.

The methodology is limited by the small sample size and its focus on a single organizational and team context, which reduces generalizability. The short game duration may also limit its ability to simulate complex decision-making dynamics or measure long-term impacts. The methodology ensures a rigorous and iterative development process that balances practical relevance with theoretical contributions. Despite the limited sample size and organizational scope, the study offers practice-based insights that demonstrate the game's effectiveness in raising awareness of bias, providing a valuable foundation for future, broader applications.

4 Challenges in Group Decision-Making and Debiasing Methods

This section examines the challenges of group decision-making, strategies to mitigate cognitive biases, and game characteristics and genres that can effectively address the issues.

Various biases often influence effective project decision-making, as highlighted in the literature and reinforced through interviews. In total, five semi-structured interviews were conducted with project managers and team members from the participating organizations. The interview process consisted of two rounds: the first round explored whether group decision-making poses practical challenges and helped narrow the focus to cognitive biases by interviewing two relevant stakeholders; based on the insights, the second round aimed to raise awareness of these biases in practice and compare them with findings from the literature. This was done by interviewing the

two stakeholders again (with the new focus), as well as a third stakeholder (a department lead who was able to contribute a more strategic view).

Decision biases occur in decision-making processes and can be attributed to individual or group dynamics [66]. While individual biases are well-documented in the literature, interviews indicate that groupthink, sunflower bias, and authority bias are more critical to address in project environments due to their significant impact on group dynamics. Hence, in contrast to the literature, interviews highlighted the prominence of group biases and their connection to cultural factors. In the context of our study, biases identified through interviews were found to encompass both individual and group aspects, necessitating a further division into decision-making biases. Authority bias is commonly observed in group decisions and is particularly substantial in project decision-making. For instance, interviewees reported decisions being overridden by the management board or aligned with management opinion. Some statements from interviews indicate a corresponding authority bias, where individuals or groups defer excessively to perceived authority figures, assuming leaders possess superior knowledge or insight: "*In our setting, the difficulty is that the team does not have the skills and cannot decide*" (Interview 1, respondent 1). Interviews further showed that cognitive biases influence group decision-making, including most prominently sunflower bias, social loafing, authority bias, and groupthink. They also showed that biases can interact with each other, e.g., sunflower bias and social loafing. It was also evident from the interviews that many of the biases' occurrences in real projects are rooted in certain cultural peculiarities, e.g., a lack of error culture, leading groups to delay decisions in order to reduce risk and uncertainties even in the presence of time pressure. Withholding information to create power was also mentioned as a reason for the emergence of group biases. Although interviewees were able to mention examples of biases when confronted with them, interviews revealed a general lack of awareness regarding biases in decision-making.

The literature review indicates that authority bias is strongly linked to group biases and cultural factors. Authority bias is also closely related to sunflower bias. While authority bias pertains to individuals excessively deferring to authority figures, sunflower bias involves group members overly aligning with a dominant individual, typically a leader, thereby suppressing critical analysis and diverse perspectives [12]. This interplay between the two biases underscores the impact of hierarchical and cultural factors on organizational decision-making. Furthermore, authority bias can lead to decreased motivation and awareness of participation. This often results in social loafing, where some group members do not contribute, believing their input is irrelevant [12].

Groupthink and sunflower bias complicate decision-making by suppressing dissent and promoting uniformity, thereby increasing the risk of suboptimal outcomes. The examples of decisions overridden by management from the interviews indicate a combined occurrence of groupthink and sunflower bias. These dependencies of the different biases were not highlighted in the literature review; however, the interviews indicated a relationship between the various biases. Groupthink and sunflower bias frequently co-occur, and sunflower bias can exacerbate groupthink by discouraging dissenting views and promoting uniform decision-making processes.

To mitigate group and authority biases, research highlights various debiasing strategies for detecting and addressing these challenges. Fischhoff [67] identifies core approaches, including educating individuals about specific biases, illustrating their influence, and providing feedback complemented by coaching and targeted interventions. Muntwiler [32] expands this framework by introducing strategies for strategic decision-making, highlighting the diversity of debiasing techniques.

Games, when serving as single training interventions, have proven effective in raising bias perception and contributing to its mitigation by demonstrating their effects. Games can educate about biases and their directional influence on decisions by integrating feedback mechanisms [58]. This relates to Fischhoff's first two debiasing strategies [67].

Given the lack of awareness of decision-making biases and the prevalence of certain cultural aspects in the studied organization (which, while being different, also exist in other organizations), our game's primary goal is to increase awareness rather than attempt comprehensive cultural

change. To achieve this, the game targets the awareness of four key biases: authority bias, groupthink, sunflower bias, and social loafing. These learning goals guide the exploration of specific game characteristics that can effectively address and mitigate these biases, thereby enhancing group decision-making.

As a consequence of these insights, the learning goals to be reached by participants after playing our game are as follows:

- Understand how biases can influence decision-making in group decision-making in projects,
- Have strategies to collaborate with others to overcome their biases (collaboration),
- Identify and apply actions to take in practice to overcome the biases and improve decision-making (transfer),
- Develop an increased perception of biases in project group decision-making, enabling participants to identify and address biases proactively (transfer).

5 Proposed Serious Game

To create an effective educational game, it is essential to include clear learning objectives and elements that demonstrate the intended learning outcomes [68]. The game should, in part, achieve the learning goal and, in part, implement a game mechanism to make learning activities fun and motivate the players [41]. The following factors (see Table 5) should be incorporated to fulfill these requirements.

Table 5. Game and Learning Characteristics

Characteristic	Characteristic type	Reason
Incorporating clear learning objectives	Learning [68]	Alignment of the goals
Demonstrating the effects of this bias	Learning [69]	Bias awareness
Focusing on tactical and operational decisions	Learning [60], [70]	Transfer to practice
Incorporating experiential learning theory	Learning [35]	Engagement and transfer
Providing a feedback and reflection system	Learning [43]	Reflection and learning
Implementing a role-concept	Game	Simulating team decisions (dynamics)
Having a time limit	Game [26]	Realistic pressure
Compelling storyline	Game [51]	Immersion
Collaborative elements	Game [47]	Team Interaction

The analysis of game genres meeting the specified characteristics concludes that adventure, role-playing, and simulation games – or their combinations – offer substantial potential for mitigating cognitive and group biases [35]. Incorporating role-based dynamics is particularly important, as players who identify with their assigned roles may behave more authentically[‡]. On the other hand, characteristics of simulation games are well-suited because of their emphasis on realistic scenarios in which players get immersed: to learn effectively about group decision-making and its potential biases, it is not only important to meet other players embodying different roles and personalities, but also to embed the interaction into a realistic and/or exciting scenario.

For decision-making scenarios, this can be very well combined with the puzzle-solving characteristics of adventure games, in the sense that the game should offer challenging tasks involving non-trivial decision-making [4] and the potential to "go wrong" and thus get feedback on suboptimal decisions that a group may have taken. Failure to complete parts of a mission is an effective way of giving players feedback regarding suboptimal approaches to group decision-making.

Key design decisions were made based on the pre-analysis of potential game types. Given these characteristics, role-playing games emerge as the most suitable option due to their adaptability in

[‡] https://peer.asee.org/increasing-authenticity-in-pre-college-software-engineering-education-through-role-play

addressing various biases. Role-playing games, combined with adventure games' features, provide various learning opportunities by allowing players to explore and experiment with different options at every stage of the game [29]. The game's main idea is to introduce a team of players to a scenario where they must collaborate to make decisions and solve problems together. Each player has a role that may comprise hidden instructions. This makes it possible to create game situations that act as "traps" for cognitive and social biases, i.e., increasing the likelihood that the team will make a biased decision. Then, the game simulates the adverse outcomes of those biased decisions and discusses the findings to allow participants to experience these consequences, thereby raising their awareness of the underlying biases. The game centers on role-play, with predefined roles tailored to simulate social dynamics such as authority and groupthink. These roles are designed to encourage perspective-taking and highlight biases during gameplay. An additional alternative involves participants creating a preferred avatar before the game to enhance identification and engagement with their roles or playing their real-life roles [29], [71].

The literature offers contrasting views regarding the use of storylines. Some studies emphasize the importance of an engaging and exciting narrative [29], while others argue that realistic scenarios are more effective in ensuring the transfer of learning [72]. For this game, a fantasy storyline was chosen to captivate participants and focus their attention on identifying biases rather than relying on prior knowledge. We considered varied prior knowledge as a confounder for what we wanted to observe: our goal was to expose all participants to a task where everyone had the same chance of contributing to a solution, rather than risking that individual participants would have a strong (and previously hardly known) advantage in solving the task. The game incorporates a feedback system, combining immediate feedback after key decisions with reflective debriefing sessions to reinforce understanding. Sometimes, as in reality, feedback can be delayed, i.e., negative consequences of decisions only become known later in the game. This can increase the sense of severity since a wrong decision early in the game may require significant rollback of actions taken thereafter. In addition, when the group discovers the problem, they can be led to collectively rationalize/defend the earlier choice (see "Collective Rationalization" in Table 6). Collaborative elements, such as information sharing and team-based challenges, replicate real-world group dynamics and promote interaction.

Different simulations are integrated into the game for each bias, summarized in Table 6.

Table 6. Learning goals: Biases to become aware of

Bias	Simulation (Trap)	Integration in the game
Groupthink Bias	Illusion of unanimity	Early feedback reinforces the group's consensus perception, even when it is inaccurate, unless it is actively questioned.
	Self-Censorship	One person is instructed to play the role of a "reserved member" withholding important information.
	Direct pressure	Time pressure discourages dissent.
	Collective rationalization	Contradictory evidence is introduced to question an initial decision (see the first row of the table), but at a stage when much effort has already been put into implementing it.
Social Loafing	Non-participation	Distracted roles simulate a lack of contribution.
Sunflower Bias	Deference to authority	Non-player characters give misleading advice that influences decisions.
Authority Bias	Over-reliance on leadership opinions	Implement a leadership role; a leadership role is instructed to give misleading advice.

The bias simulations in Table 6 are theoretically grounded in perception and reaction patterns observed in organizational settings[§]. Each bias trap exploits specific perception errors: groupthink leverages the human tendency to perceive false consensus through selective information processing, while authority bias exploits the automatic deference reaction to perceived expertise or hierarchy. Sunflower bias manipulates social perception by presenting dominant figures as credible sources, triggering conformity reactions even when information quality is questionable. Social loafing occurs when individuals perceive their contributions as less significant, resulting in reduced engagement and subsequent reactions. These perception-reaction cycles illustrate how cognitive shortcuts and social dynamics interact to create systematic decision-making errors in projects, which the game reveals through controlled scenarios that expose the gap between intended rational decision-making and actual biased behavior patterns.

6 Development of the Game

The first step in the development process was to define the context and objectives. The game was designed for individuals in project management roles at a large transportation company in Switzerland. It was played in groups of three to five players. Each participant needed a laptop, and the game was conducted on-site in a room (see details in Section 3). The game was built using PowerApps, part of the Office 365 suite, and is easily accessible. The game combines learning functions, such as rewards and scores for motivation, collaborative interpretation of information, structured analysis of bias-related scenarios, and timely feedback mechanisms that guide player reflection and enhance learning outcomes.

Derived from the game mechanism introduced in Section **Error! Reference source not found.**, the learning goals of a concrete game prototype were defined. The game is designed to raise the perception of groupthink, sunflower, authority, and social loafing biases in project group decisions. The previous discussion suggests that the learning objectives should be broken down, and the effects of the bias should be demonstrated within the game. For each symptom of groupthink, one learning goal was formulated. The game addresses collective rationalization, direct pressure on dissenters, self-censorship, and the illusion of unanimity (see Table 6).

The created game, set in a fictional scenario of rebuilding a fantasy city, was structured into five decision-making rounds, each followed by a reflection or feedback phase to encourage learning and awareness of bias. Table 7 provides a brief overview of the goal and rules for each decision round. The game prototype is accessible via the provided link[**] as a downloadable zip file. Additionally, a demonstration video of the artifact has been made available.

Set in a fictional environment, players took on the roles of an adventure team tasked with rebuilding a damaged fantasy city. Their objective was to make the right decisions as a group. To succeed, the team must work together and overcome/avoid biases. At the beginning of the game, participants were assigned to predefined roles, each representing distinct characteristics designed to stimulate specific cognitive biases, such as authority bias and the suppression of dissenting opinions. It is important to note that, on the one hand, specific roles were designed to create certain biases, but on the other hand, each bias requires a certain behavior of only one role, such that all the other players are still exposed to the "trap" without any hints. Some traps (e.g., the "Illusion of unanimity", see Table 6) do not require any specific behavior from the players.

Screenshots for four decisions reflected in Table 6 are shown in Figure 2 (Decisions 1 and 2) and Figure 3 (Decisions 3 and 4).

Throughout the game, players received points based on their ability to recognize and avoid bias-driven decisions.

[§]https://www.mckinsey.com/~/media/mckinsey/business%20functions/strategy%20and%20corporate%20finance/our%20insights/the%20case%20for%20behavioral%20strategy/most_frequent_biases_in_business.pdf

[**] https://1drv.ms/f/c/c208b2ce2e975d8a/EgiB_CO3gJpFnuYA-ADX78UBGMVgdwNwIl18Y-4izk71IQ?e=xg0ljn

Table 7. Game Description (adventure team tasked with rebuilding a damaged fantasy city)

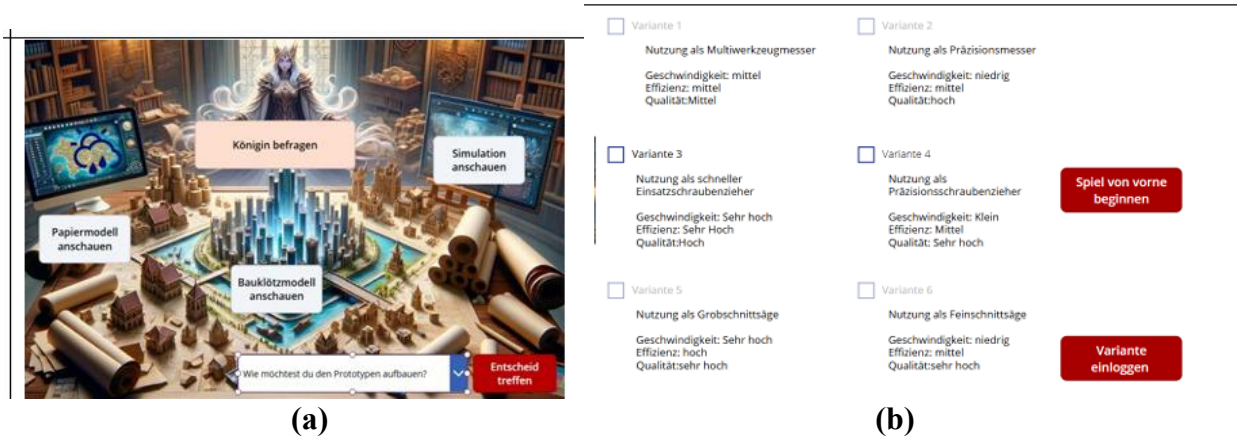
Game Step	Description
Role choice / introduction	The roles in the game are divided (authority person, harmony-oriented person, reserved person, long-established person). The players are introduced to the challenge and the evaluation criteria (fast, efficient, quality)
Decision 1	In the first round, all players receive the same information and are asked to jointly select a tool for future tasks. This initial decision is intentionally kept simple to familiarize participants with the game mechanics. It has a rather obvious outcome (the knife) – which will later turn out to be problematic – see Decision 4. For a screenshot, see Figure 2a).
Reward	All participants are awarded ten points to build motivation regardless of their choice. The reward strengthens their consensus perception and their trust in their decision-making capabilities – which is not completely justified.
Decision 2	In the second round, players have to choose a technology for rebuilding the fictional city. This scenario requires active discussion and role-based argumentation, with asymmetric information distribution across players. Groupthink, self-censorship, and authority bias are actively triggered and subsequently reflected in a structured debrief, which includes a theoretical explanation of these biases. For a screenshot, see Figure 2b).
Decision 3	The third scenario involves selecting a prototyping method. All participants have access to the same materials—images and videos—but are misled by a non-player character, the "queen," who suggests incorrect conclusions. With the help of embedded hints, players are encouraged to identify conflicting arguments. This round simulates the sunflower bias by illustrating the risks of over-reliance on a dominant perspective. For a screenshot, see Figure 3a).
Decision 4	In the following round, participants have to choose a strategy for city construction. The options available are directly influenced by the first decision, creating an opportunity to reflect on earlier choices. Although the group had received points for the initial decision, they were now asked to question its validity, thereby simulating groupthink under consistency pressure and the sunk cost effect. The team could restart or continue with a suboptimal strategy. For a screenshot, see Figure 3b).
Decision 5	The final decision required the group to determine how to support citizens moving into their new homes. Again, information was distributed unevenly: one player had all the necessary details but was distracted by a side activity embedded in the game. This scenario once simulated social loafing and tested the group's ability to mitigate information asymmetry.

(a) **(b)**

Figure 2. Screenshots for (a) Decision 1 and (b) Decision 2. For Decision 1, the team needs to choose between a knife, a screwdriver, and a chainsaw. The pros and cons speak clearly for the knife. In Decision 2, the team needs to choose a technology. Players receive different instructions on which choice to support. Here, on the left side of the screen, the player is influenced by the choice of "intelligent machines".

Game mechanics such as point systems and rewards enhance engagement and motivation. Players were required to interpret information, analyze scenarios, and provide structured feedback, ensuring a close alignment between game mechanics and learning objectives. The user interface featured interactive elements and a consistent layout to support intuitive use. Nevertheless, the prototype had limitations: moderator guidance replaced auditory feedback, and complex group dynamics such as groupthink could only be partially simulated. While the narrative provided sufficient structure for gameplay, it left room for more in-depth interactive storytelling. Future

iterations will enhance interactivity, expand narrative elements, and integrate the game into a broader training framework for sustained learning impact.



(a) **(b)**

Figure 3. Screenshots for (a) Decision 3 and (b) Decision 4. The buttons lead to images and a simulation video that players can look at. The button in the top middle region of the screen allows a player to ask the Queen. In the end, all members need to select the same decision from the drop-down in the bottom right corner. In Decision 4, the group becomes aware that, because of their earlier choice in Decision 1, some favorable options are no longer available to them. The two red buttons allow them to either restart the game (the upper button) or use a sub-optimal variant (the lower button).

7 Evaluation

In the evaluation, the characteristics from Table 5 are assessed first, followed by an evaluation of the biases (learning goals) reflected in Table 6. The findings are based on observations, discussions, and group interviews performed directly during gameplay with five groups. Additionally, a questionnaire was conducted with participants who tested the artifact and a small "control group" who did not assess learning outcomes and provided further feedback.

From the group of players, 12 people who responded to the questionnaire, there were 4 project members, 7 project leads/product owners, and 1 member of the decision-making boards. From the control group of non-players, 10 members responded; out of these, there were 4 project members, 5 project leads/product owners, and 1 customer consultant.

7.1 Game Characteristics

Evaluating the game's characteristics, including the game setting (physical presence or not), role-playing, social interactions, feedback mechanisms, and storyline, revealed significant discrepancies between theoretical expectations and practical outcomes.

Some of the characteristics we planned for the game (cf. Section 5), were realized, but led to somewhat unexpected outcomes:

Role concept: The role concept, widely regarded in the literature as essential for enhancing social interaction and raising awareness of bias, was validated in the game but revealed notable deviations. Predefined roles are widely accepted for games to improve social interaction and guide participants to think from different perspectives [29], [73], [74]. However, as participants' feedback shows, they struggled to fully assume the predefined roles described during the short game duration, highlighting the importance of sufficient time for role adoption. For instance, one participant stated: *"It was difficult to take on a completely different role […] it is not always easy to find the right role in the game."* (Group 2). Further feedback indicated that while participants initially kept their roles in mind, they often deviated from them during discussions.

Roles that aligned with participants' personalities were more effective, while those that diverged posed challenges. Additionally, roles had varying impacts on biases; they effectively addressed social loafing and authority bias when paired with specific instructions but had minimal influence on tackling sunflower bias. The absence of role-specific feedback in specific scenarios further limited their effectiveness. Finally, while Greco [29] explained that role-play increases the engagement and interaction of players, it was not apparent, based on the observations during gameplay, that groups that were more involved in the roles had better interaction.

These findings suggest that while the role concept is valuable, its design must consider game duration, participant traits, and targeted biases to maximize its impact.

Collaborative elements: Although there was no direct feedback on the social interactions, it was observable that the players engaged in discussions and collaborated during the game. Participants consistently engaged with each other by asking questions such as *"What do you see?"* or *"What information do you have?"*. Based on the observations, the players' motivation was high; however, no significant difference in motivation was found when two groups played simultaneously, and a winner was subsequently determined, i.e., it seemed that competition and the eagerness to win were not a significant factor for motivation, as opposed to some claims in the literature, see [47]. Another important aspect frequently mentioned by participants was the information division between the players. They recognized that not all participants had the same information, leading to discussions and bias traps, in turn, leading to effective learning experiences as expected based on the literature [47].

Storyline: The fantasy storyline was more engaging than realistic scenarios, contrasting with some literature suggesting realistic settings might be more effective [72]. Statements like *"It was exciting to take on a role and play a fantasy scenario"* (Group 2) were mentioned in all groups. Unlike realistic scenarios, the fantasy setting eliminated reliance on project experience, forcing participants to focus solely on their roles and the provided information. However, we noted that participants did frequently attempt to find solutions using rational arguments and their experience from real-life projects. For instance, they often referred to examples, such as *"Building blocks are still commonplace in IT for visualizations […] We should take that […]"* (Group 4, Player 3). However, their prior knowledge was useless since the game was based on a fantasy scenario.

This approach emphasized cognitive biases and effectively achieved the game's learning objectives. In particular, demonstrating biases and luring participants into traps proved to be very important. This was confirmed by the questionnaire results, where players particularly remembered the content on bias and noted the effects of decisions. This aligns with the literature that highlights the importance of clear learning objectives. However, since no variant with a different design approach was developed, an in-depth evaluation of alternatives was not possible. Finally, there was feedback regarding time pressure. Participants indicated – as expected – that under time pressure, it was not easy to make the right decisions, making it more likely to fall into "bias traps". One participant noted that social loafing intensifies under time pressure, as some perceive the situation as hopeless and choose not to participate.

The characteristic of having a clear time limit (see Table 5) worked as expected: this was clearly an effective property that led participants to heuristic-based decisions.

There were game characteristics where our game design differed from literature recommendations from the beginning, partly due to practical or storyline-related constraints:

Feedback mechanism: The feedback approach implemented in the game differed from the literature. which advocates immediate feedback after each task. Instead, a staggered approach was employed, providing feedback after the initial decision and emphasizing reflection during the debriefing. This method proved more effective in maintaining the game's flow and enhancing understanding. By withholding explanations of biases until the debriefing, participants engaged in open discussions and independently identified biases, enhancing their critical thinking and awareness.

Physical presence: Although prior literature highlights the importance of on-site collaboration and competitive elements for engagement [47], the evaluation revealed that these aspects were less

influential in practice. Hybrid or online settings proved to be just as effective as in-room play. Furthermore, the competition and the claim to win were less relevant than expected and suggested by the literature [47]. Participants responded positively to the game's simplicity and reported that hybrid or online formats were equally effective as in-person sessions. Collaborative elements, such as the distribution of asymmetric information among players, were more critical to engagement and learning, aligning closely with findings in the literature, and were frequently emphasized in participant feedback.

7.2 Learning Outcomes Regarding Biases

The statements regarding the learning goals and the implemented biases were compared to evaluate the effects and the importance of cognitive biases. The game focused on groupthink bias, as the literature emphasized the most significant influence on group decisions and highlighted various symptoms of groupthink in the artifact [10], [12]. However, below we will also discuss sunflower bias, social loafing, and authority bias.

Groupthink bias. To make participants aware of groupthink bias, we designed the game to include (a) roles designed to strengthen the bias, such as having one person deliberately hold back, (b) unequal information provided to participants, and (c) arguments suggesting the first decision was wrong to encourage reflection on previous team decisions.

During the game, we could clearly observe that the groups fell into the bias trap, increasing their awareness of groupthink bias. The following statements highlight this:

- Collective rationalization: here, participants first stated things like “Yeah, that was easy” (Group 1, referring to Decision 1) and later had to admit that, e.g., “I have not even looked at the alternatives that are not available” and “we have probably made the wrong decision” (Group 1, Player 1);
- Direct pressure: “However, I said I could live with it {...} because time has run out{...}” (Group 2, Player 2);
- Self-censorship: “The group members were cautious for a long time. Only at the end did one person ask the relevant group member: ‘What do you think?’ This helped the group make the right decision at the last moment” (Group 1).
- Illusion of unanimity: “Yes, we were very harmonious” (Group 2, Player 1).

These statements show that the groupthink bias was addressed within the game. A questionnaire, afterward asked players to name a real-life situation where groupthink influenced their decisions. A similar question was asked to non-players. The answers from the game players were precise and mentioned various symptoms of bias, such as the illusion of unanimity, self-censorship, and direct pressure on dissenters. Feedback from non-players showed that they indicated a moderate level of perception in advance, but it was recognizable that only half of the people could provide a clear example. The examples from non-players mainly focused on self-censorship.

Authority bias. To draw attention to the authority bias, we used the role concept. The manifestation of authority bias depends on how people take on roles. For instance, one group followed the authoritarian role, as exemplified by the statement: *“I trust you”* (Group 3). In two other groups, the authority bias was not observed. It seems, however, that the bias is well-known to both game players and non-players: in the questionnaire, six out of ten players identified authority bias as the most relevant in group decision-making, but also non-players were able to give clear arguments and examples for this bias, e.g., “*The authority bias strongly influences group decisions by weighing opinions. If input comes from an authoritarian person, it is perceived differently than from a reserved person, as people often do not want to confront this person*” (Questionnaire). Another participant noted that they remained silent during a disagreement because a dominant team member had already expressed a strong opinion, mirroring real project situations where authority figures unintentionally suppress alternative views.

Sunflower bias: The game was designed to highlight the concept of sunflower bias by simulating an intervention from an authority figure, a queen. The goal was to learn to assess the queen's opinion critically and recognize that her argument was irrelevant using in-game clues.

Feedback varied among groups. Except for one group, all groups fell into the trap. Group 1 articulated their skepticism with statements such as, *"I do not know the Queen's background; if she has been in power for a long time, or if she is a good one".* Group 2 failed to recognize the bias during the discussion and saw the queen more as a customer. Other groups identified and discussed the bias during the debriefing. Time pressure seemed to play an important role for those groups who fell into the trap: *"If we had time, it would have been worth discussing, but we had the order to go in this direction"* (Group 3). Additionally, there was a frequent mix-up in understanding and identifying authority and sunflower biases, underscoring the need for clearer differentiation between the two biases.

Social loafing. Awareness of social loafing was raised by giving one player a fun game to distract them from discussion within the group.

All groups overcame the bias by including that player in the discussion. Two groups lost time because the player did not participate in the discussion. In the debriefing, they pointed out that they were unsuccessful without this player and drew parallels to real-life projects with examples. One group also reflected on the reasons for social loafing: *"Maybe you once put forward an idea and it was not taken into account, and then you automatically stopped expressing your opinion in this way"* (Group 5, Player 3). In the questionnaire, the answers from the players differed; some provided concrete examples of the influence of social loafing, while others were unrelated to group decision-making – thus, a sustainable learning effect was not clearly proven. However, in contrast, the examples from non-players were mostly neither clear nor concrete.

All in all, the feedback in the questionnaire shows that the authority bias is perceived as the most important. This finding was unexpected and contradicted the existing literature, which had anticipated a greater focus on groupthink bias.

The analysis of the questionnaires shows that not all biases were addressed equally well in the game. Groupthink and authority biases were consistently acknowledged, with participants providing detailed, real-world examples of their effects. In contrast, awareness of sunflower bias and social loafing varied among groups, with some participants failing to identify these biases or their consequences. This discrepancy suggests that not all biases are equally amenable to the same game design elements, indicating that each may require different debiasing methods. Participants frequently highlighted authority bias, citing examples such as repeated interference by authority figures in flat agile structures and unchallenged group decisions resulting from directive leadership. These scenarios align with the literature and reinforce the study's findings on the influence of authority bias in decision-making.

The game's evaluation indicated that participants could effectively recognize groupthink and authority bias during gameplay and in the post-game questionnaire. They offered detailed, real-world examples and demonstrated an understanding of how these biases influence group decision-making. However, they struggled to identify the interplay between these biases or how one might reinforce another, as suggested by the literature. For instance, authority bias can aggravate social loafing when participants feel that their contributions are undervalued, and sunflower bias can promote groupthink by suppressing dissenting opinions. This gap highlights a potential area for improvement in the game's design.

In addition to checking the ability to recognize biases and their consequences, we also collected participants' ideas and insights regarding mitigation strategies. We observed that apart from sunflower bias, where hardly any mitigation strategies were contributed, the participants mentioned strategies that are also largely in line with the corresponding literature. For instance, the "devil's advocate" and paying attention to a team's diversity were mentioned as mitigating strategies for groupthink bias, in line with [17], [22]. To address social loafing, participants suggested providing team feedback and possibly reducing team size, in line with, e.g., [30].

Regarding authority bias, participants mentioned cultural and leadership changes as possible mitigation strategies, confirming suggestions by [17] and [76].

Overall, participant feedback revealed that the game was well-received and effective as a training method. This finding is consistent with the existing literature [77]–[79], which suggests that collaborative games can help mitigate biases and improve group decision-making. This feedback contributed to the various characteristics implemented in the game. While the game has raised awareness of bias, its long-term effects on decision-making remain unknown. Participants who played the game provided more concrete and nuanced examples of biases than non-players, indicating a greater likelihood of recognizing and addressing biases in practice. Improving the game to highlight interdependencies among biases and tailoring elements to address specific biases could further enhance its effectiveness.

8 Conclusion and Contributions

The evaluation confirmed that the collaborative serious game effectively raised awareness of cognitive biases, particularly groupthink and authority bias, while engaging participants through a fantasy storyline and role-playing elements. Participants recognized symptoms of groupthink, such as self-censorship and the illusion of unanimity, and identified authority bias through real-world examples, demonstrating the game's relevance to decision-making processes. Awareness of sunflower bias and social loafing, however, varied, with some participants failing to identify these biases or their consequences, indicating the need for more tailored game elements and clearer emphasis on interdependencies among biases. Players demonstrated a deeper understanding of biases than non-players and proposed more specific mitigation strategies, although the game's long-term impact on decision-making remains unclear.

The role-playing feature revealed deviations from expectations based on previous work. Participants found it challenging to adopt roles that diverged from their personalities within the game's short duration, while roles aligned with participants' traits proved more effective, contradicting literature assumptions that diverse role alignment improves bias recognition [29], [71]. Delayed reflective debriefing proved more effective than immediate feedback, challenging established serious games principles [72]. Additionally, the fantasy storyline outperformed realistic scenarios, opposing findings that realistic settings ensure better learning transfer [72]. Overall, the study contributes to the literature on bias mitigation and serious game design by addressing the lack of specific training tools integrating cognitive biases, project management, and group decision-making, and by demonstrating how a collaborative adventure role-playing game can enhance awareness of cognitive biases in a project environment. It provides empirical insights into effective game design, highlighting the importance of personality-aligned roles and tailored bias representation.

The article has several limitations. The evaluation was based on a small sample from a single corporate context, limiting generalizability. Future research should refine role concepts to enable more flexible and personalized adoption, integrate additional biases, and assess lasting behavior change by expanding application to diverse organizational contexts and broader training programs. The study adhered to established quality criteria for qualitative research [76]. Credibility was ensured by involving participants from real-world project teams and designing the game around practical decision-making challenges. Dependability and confirmability were supported through the structured use of Jaccard's framework and systematic feedback analysis. Transferability is facilitated by detailed documentation of the game's design and evaluation, offering a foundation for further research and application in diverse organizational contexts.

Specifically, the game can be applied in any organizational setting that involves collaborative decision-making, where hierarchies have a certain influence, and where time pressure or the complexity of decisions increases participants' reliance on heuristics.

In terms of design knowledge, we expect that some of our findings can guide the future development of games in several ways: above all, we think that the concept of personality-aligned

roles may be interesting to investigate further because sometimes the advantages of participants feeling a strong sense of identification with their role may outweigh the advantages of, e.g., increased role diversity. Similarly, the advantages of delayed reflective briefing may be taken up in future game development, especially in situations where long(er)-term consequences of decisions need to be recognized. Finally, the effectiveness of a fantasy setting as compared to a real one may also hold in other settings: future work may consider whether realistic examples are really needed for effective transfer or can even be harmful because they, e.g., increase defensiveness or stop participants from abstracting to underlying principles of group decision-making.

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Appendix

Table A. Game Characteristics (The table refers to the same list of references as the main body of the article)

Decision-making Requirements	Characteristic type	Characteristic	Interrelated/contradictory characteristics	Comment
The game raises the perception of social and authority biases and supports overcoming these biases to enhance group decision-making.	Learning characteristics	1. By incorporating clear learning objectives [68]	Related to numbers 2 and 3.	By defining clear objectives, the game can raise the perception of the biases.
	Learning characteristics	2. By demonstrating the effects of this bias [69]		The effects and consequences of the biases should be demonstrated in the game.
	Learning characteristics	3. By focusing on tactical and operational decisions [60], [70]	Related to number 1, since the type of decision is part of the learning objectives	
	Learning characteristics	4. By incorporating experiential learning theory [35]		
	Learning characteristics	5. By providing a feedback and reflection system [43]	There are contradictory characteristics: 5.1 Feedback should be given immediately after the task	The characteristics and different suggestions should be elaborated in the suggestion phase
			5.2 Feedback should be at the end in order not to disturb the game flow	
	Game characteristics	6. By implementing a role concept	There are different contradictory characteristics: 6.1 The participants take on predefined roles [73]	The characteristics and different suggestions should be elaborated in the suggestion phase
			6.2 The participants define the roles themselves before the game [73]	
			6.3 Players take their roles [29]	
	Game Characteristics	7. By having a time limit [26]		The time pressure is intended to simulate quick decisions.
	Game Characteristics	8. By developing a digital game that engages motivation ([77], [78]	Interrelated: 8.1 The game provides a user-friendly interface [68]	
			8.2 By implementing fun learning activities [79].	
	Game Characteristics	9. By having engaging content and a compelling storyline to maintain interest [51]	9.2 The game has an imaginative and compelling storyline	
			9.3 The game re-samples real-world and domain-specific scenarios	
	Game Characteristics	10. By providing collaborative elements [47]		More detail should be specified for the collaborative elements, such as the game's space, information handling, actions and rules, and team composition.