

Exploring the Potential of a Serious Game Framework in Developing Systems-Thinking Skills

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ABSTRACT

Effective decision-making within veterinary practice demands a comprehensive understanding of interconnected animal, public, and environmental health systems. To foster systems thinking, participatory modeling and serious games are gaining prominence. Serious games combine play, instruction, and problem-based learning to facilitate skill acquisition. This study investigates the potential of a multiplayer serious game framework as a participatory method to cultivate systems thinking skills in a Master of Veterinary Medicine program.

The research focuses on the Territory Game, designed to encourage engagement and creativity, assessing its role in fostering systems thinking among veterinary students. Integrated into a master's course, the game immerses students in complex decision-making scenarios, aiding their navigation of real-world intricacies. Qualitative analysis of discussions and responses provides insights.

Results indicate that serious game-based learning within a participatory structure enhances participants' grasp of decision-making complexities. The game's simulated environment promotes a broader perspective and consideration of diverse factors in choices. Additionally, the game framework exhibits potential to enhance group participation, autonomy, time management, and inclusivity for reserved individuals.

However, the study acknowledges that teaching methods like participatory modeling might not universally fit all contexts and could require instructor support. The framework's effectiveness is influenced by educational constraints, engagement levels, learning styles, and expertise.

Nonetheless, the Territory Game framework shows promise in deepening understanding of complex veterinary decisions and fostering critical systems thinking skills essential for effective decision-making. Future research should explore its adaptability, scalability, and long-term impact across diverse educational settings.

Key words: veterinary education, serious game, systems thinking, participatory approaches, systems design learning, instructional design, problem-based learning

INTRODUCTION

As an interdisciplinary field, the veterinary profession demands a nuanced approach to decision-making that takes into account a multitude of interconnected factors. The provision of comprehensive care to animals requires consideration not only of their medical factors such as medical history, physical state, and behavior, but also the preferences of their owners, ethical considerations, and the wider impact on animal, public, and environmental health.¹ Moreover, veterinary professionals must navigate the business aspects of their practice while ensuring that the provision of high-quality care is financially sustainable. In light of these multifaceted responsibilities, it is imperative that veterinary and other health professionals adopt a systems-thinking approach when making decisions. This will enable them to consider the broader context and interconnectedness of various factors, ultimately ensuring the best possible outcomes for animal welfare, public health, and the environment.^{1,2}

In their work on systems thinking, Arnold and Wade (2015) identified it as a set of skills that enable professionals to identify and understand systems, predict their behaviors, and plan changes that produce desired effects.³ Systems thinking

is a powerful methodology that is based on the principles of systems theory. It is particularly useful in addressing complex problems where the intricate interplay and interdependence between different components of the system pose challenges in fully comprehending or describing the situation. However, mastering systems thinking is no easy feat. It involves a shift from "linear" thinking, which focuses on well-defined cause and effect relationships, mostly in isolation from a context and in short sequences, to a more complex and nuanced way of structuring and approaching situations marked by uncertainty. To reach this, learners will also require a continuous feedback loop of learning and adaptation.

A significant aspect of systems thinking is integrating diverse perspectives and information from different sources to achieve collective intelligence, which is essential for effective problem-solving.⁴ However, this integration can be challenging because individuals may have biases, assumptions, and preconceptions that hinder them from truly understanding and considering the viewpoints of others.⁵ Moreover, individuals from different backgrounds, experiences, and cultures may have different communication styles, ways of thinking, and values, which can lead to misunderstandings and conflicts.⁶ Additionally, it

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can be challenging to create a safe and inclusive environment where everyone feels comfortable sharing their opinions and ideas, especially if there are power dynamics or hierarchies at play.

Despite the challenges, the benefits of systems thinking cannot be overstated. Veterinarians trained in systems thinking are expected to better understand the significance of perspectives when approaching situations and better manage teams and project design. They will identify relevant elements, analyze their relationships and interactions, recognize patterns, and conduct analysis across various levels. By taking a comprehensive and iterative approach, systems thinking helps appraise the problem's dynamics from multiple perspectives and gain a more nuanced understanding of the situation at hand. This holistic perspective enables veterinary professionals and other health professionals to make informed decisions that lead to positive outcomes for animal welfare, public health, and the environment.⁷

Participative Learning Contexts

The acquisition of systems thinking skills is linked to the integration of various perspectives through participation. Therefore, an educational environment aimed at developing these skills should include group activities or projects designed to foster complex attitudinal and intellectual changes resulting from such activities.⁸ To achieve this type of learning, the learning environment must offer relevant tasks, appropriate instructional sequencing, feedback, and encourage active student engagement.⁹ A recent study demonstrated the use of these participatory contexts in action research among community members in Nigeria to foster collective reflection, engagement and learning in addressing complex challenges related to water sanitation and hygiene.¹⁰

Active involvement is essential for successful teaching, which should not simply involve the transmission of information from the teacher to the student. Rather, students should have opportunities to experience, create, and apply new knowledge based on their efforts. Participatory approaches prioritize learner-centeredness and emphasize learning through the process of solving unstructured problems.¹¹ Examples of such contexts include team-based learning, flipped classrooms, and problem-based learning, which facilitate constructive dialogue, exchange of ideas and opinions, and a broadening of understanding of complex problems.¹²

These contexts provide an ideal environment for fostering systems thinking skills, leading to better, more sustainable solutions. For instance, problem-based learning employs a self-directed learning (SDL) model that emphasizes student groups taking ownership of their own learning as a team while working collaboratively under the guidance of a facilitator.¹³ In such contexts, the facilitator plays a critical role in guiding the learning process and helping participants understand emerging knowledge created from autonomous learning.

Effective learning is dependent on active student involvement and collaboration. However, traditional teaching methods can often restrict opportunities for learners to seek assistance from their peers, resulting in a surface-level understanding of the learning objectives. Encouraging active student involvement can be challenging if the facilitator is perceived as a traditional teacher who simply imparts information. This may limit opportunities for learners to seek assistance from their peers and gain a deeper understanding of the learning goals. To address this challenge, serious games can be used

as a learning tool that combines instruction, play, and learning, making them effective tools for promoting autonomy and learner-centeredness within an educational context.

Serious games are designed as systems in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome.¹⁴ This participatory nature provides an environment where different perspectives can be shared, creating a collaborative and engaging learning experience. Serious games can also be designed in such a way that students require collaboration and interaction with their peers to advance, further increasing active student involvement.¹⁵ By designing to reduce the need for a facilitator, serious games have a potential to encourage autonomous learning and increase active student involvement, making the learning process more engaging and effective.

Objectives of the Research

The goal of this research is to investigate the potential of serious games as a participatory framework to facilitate the development of systems thinking. The game used in a mandatory veterinary education course was found to have a constructivist nature that could foster systems thinking over time. This realization prompted a desire to explore the framework further and define it better for application in other settings. Our primary research question explores the adaptability of the original game to encourage a holistic approach to learning complex concepts. Given the game's constructivist framework and the diverse student groups involved, we opted for a qualitative research approach to better comprehend the effects of the framework in each group based on their team dynamics and learning styles.

The study is motivated by a desire to expand the objectives of a mandatory veterinary education course, which currently uses the game in the paraclinical category. We aim to inspire students to think more comprehensively and reflect more deeply on complex situations by broadening the game's scope beyond its original purpose of teaching financial concepts and veterinary management. The game presents an opportunity to stimulate a profound understanding of complex issues and promote a systems thinking approach to learning. Furthermore, this research seeks to investigate the instructional design of the framework and how it promotes collective intelligence. Ultimately, we aim to provide valuable insights into the potential of participatory learning contexts, such as serious games, to facilitate the development of systems thinking and promote a more meaningful, connected approach to learning that transcends disciplinary boundaries.

MATERIALS AND METHODS

Territory Game Description and Integration into a Course

The Faculty of Veterinary Medicine at the University of Liège in Belgium has incorporated a serious game into a course on professional veterinary management. The game, called the Territory Game, was originally created by VetAgro Sup in France and is based on principles of prospective participatory approaches.¹⁶ The game is designed to encourage group dynamics and collaboration, with the aim of promoting learning through expressing oneself, exploring perspectives, and being creative.

Traditionally, the game involves a 2-hour problem-solving exercise in which participants are presented with a simulated scenario and must apply their knowledge of economics and

finance. The game comprises a problem situation, a blank map, and a set of cards with information about a specific region in France. The facilitator explains the objectives of the game and distributes the cards, each containing information about various themes such as other veterinary establishments in the area, types of animal species predominant, weather, transportation, and recreational facilities. Participants work together as a group to co-construct a map of the region based on the information they have selected, and then decide on a prospective location to set up a profitable veterinary activity. The participants prepare a business plan, which they present and defend at the end of the week.

The Territory Game is played in the presence of a facilitator, who guides the group in achieving the game objectives.¹⁶ However, for the purpose of the study, the facilitator was replaced by organizational roles and written instructions to further increase the level of autonomy and decision-making of the participants during the learning activity.

The course on professional veterinary management provides participants with the opportunity to learn how to apply accounting and financial management concepts in practical settings, and to reflect on professional strategies and career decisions. The course emphasizes the importance of evaluating the feasibility of a project from both professional and personal perspectives, taking into account factors such as expenses, income, break-even point, personal expectations, and family needs.

The integration of the Territory Game into the course serves to enhance the learning experience by providing a fun and interactive environment for participants to project themselves into the near future, test their skills, and identify room for improvement.

Adaptation of the Territory Game

Due to pandemic control measures in 2019, the traditional game was adapted to an online hybrid format and has since

then been conducted in this manner. To achieve this, all game materials were adapted to an online format. Table II in the annex displays the original materials alongside their online equivalents. Originally, the game materials consisted of blank paper for the map, printed information cards detailing the territory, and markers for drawing. The online adaptation utilized the university's Learning Content Management Systems (LCMS) for storing and accessing the information cards in pdf format. Google Slides replaced the blank map, and icons in jpeg format were used to create the map, organized by the themes of each information card. The students were also encouraged to search their own image choices in a bid to be more creative with their map creation. Figure 1 provides an image of the Google Slides page showing the map and the images that could be copied and pasted on it.

Google Slides was ideal for designing the map as it supports simultaneous use by multiple participants and is already familiar to most. For communication among the participants during the pandemic, the video-conferencing system built in the university's LCMS was used. However, for the study, the students were placed in a hybrid setting where they were present physically but accessed the game in its online version. In addition, the facilitator was replaced by the creation of written instructions and the introduction of organizational roles to each participant.

The instructions were placed in a sequential order as a presentation on Google Slides. A total of 13 slides represented each stage of the gaming process accompanied by pictorial guidelines explaining the learning activity in increasing levels of complexity. The organizational roles were incorporated into the instructions as a means of structuring the session and were introduced to the participants from the beginning. Each group member was assigned these roles randomly. The random assignment of roles was facilitated through a Google Form in which participants selected a number between one and

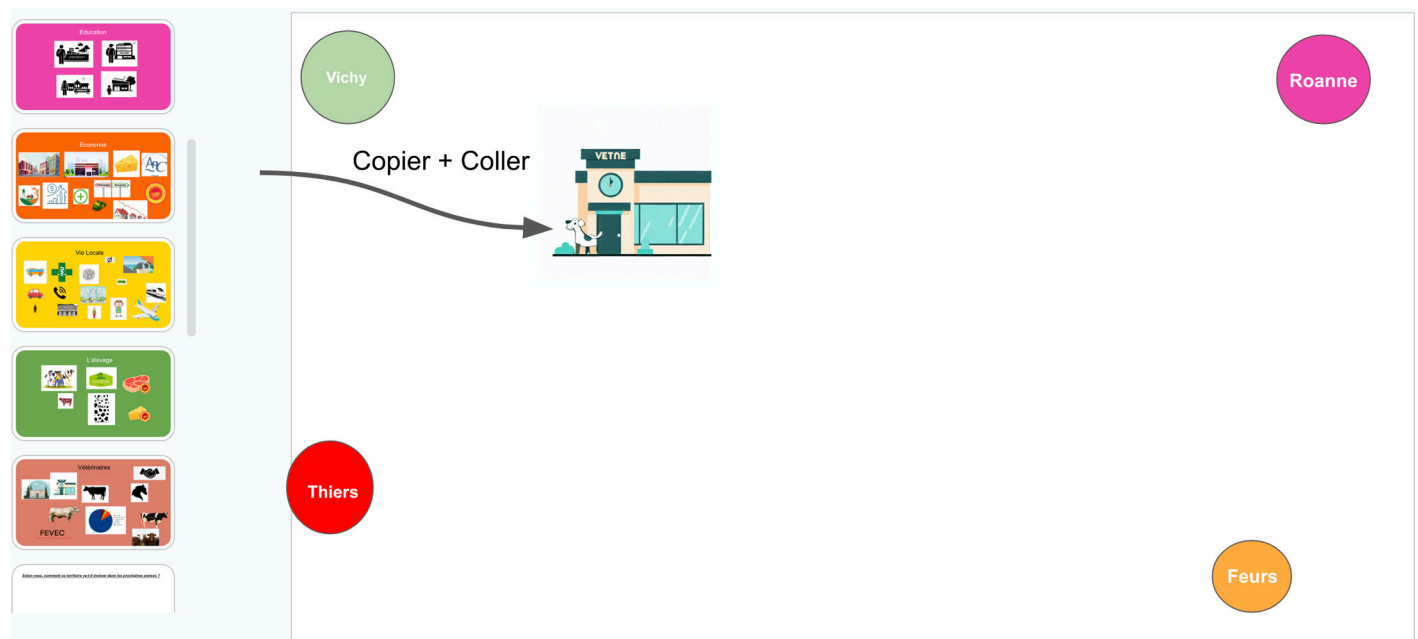


Figure 1: The adapted map layout in Google Slides

Note: Participants used color-coded slides with categorized icons to create themed maps based on the information cards they received. They could easily copy and paste icons onto a blank slide to visually represent their collective map. They were also encouraged to include their own images to personalize the map and bring their shared vision to life.

six, with each number corresponding to a pre-defined role: timekeeper, decider, narrator, moderator, observer, and scribe. Each role was accompanied by a set of instructions. These roles were inspired by the three broad categories of the nine team roles of Belbin:¹⁷ thought-oriented roles, action-oriented roles, and people-oriented roles. The thought-oriented roles are defined as roles that concentrate mainly in the production of ideas and the innovators in a certain team. The people-oriented roles are made for the communicators who maintain balance in the team and act as leading figures. While action-oriented roles are those that provide more hands-on abilities, i.e., those that act for the team and carry out decisions made. Table I in the annex presents the roles in detail, highlighting their connection to the categories of Belbin team roles, and the instructions given for each.

Ethical approval

The Faculty of Medicine, University of Liège's ethical committee (Comité d'éthique Hospitalo-Facultaire Universitaire de Liège) granted permission to conduct the study, referenced as 2023/30. The study adhered to the university's ethical guidelines. The study was deemed not worthy of ethical authorization during the study period and was therefore waived by the Ethical board. All participants were presented with the rationale and the aim of the study and voluntarily consented to participate by means of a verbal consent.

Sampling Strategy

A total of 156 master students from the Faculty of Veterinary Medicine participated in the Territory Game course over a span of eight months, from February to May and September to December 2022. The course was structured with 11 student groups, each consisting of 10–12 participants. These groups were divided into 22 subgroups, with an estimated 5–6 participants per subgroup, based on the course structure.

Data Collection

Two methods were employed for data collection. Firstly, participants engaged in individual written responses during the game at 40-minute intervals. They used a Google Slides text box to answer six questions, enabling personal reflection on the game's technical aspects, skill development, and the impact of organizational roles on autonomous learning.

Initially, the expectation was for each participant within a subgroup to respond individually in writing. However, in some cases, the entire group provided a collective response, with team members contributing to an overall response in the Google Slides text box. Out of the 21 participating subgroups, 10 presented a single grouped response to each question, while the remaining 11 subgroups had individual responses from each student for each question.

Secondly, we conducted a focus group discussion using the same six questions after the game had been played. The focus group discussion (FGD) facilitated reflections at the group level, capturing interactions and dialogue among the students. We recorded the FGD using a mobile phone's audio recording function.

The questions asked during both the individual responses, and the group discussions were:

1. What did you think of the attributed roles?
2. What were the effects of the roles on the group?
3. How was the game without a facilitator? Is it possible to do it without one?

Table 1: The roles created for the Territory Game, their instructions, and links to Belbin team role categories

Roles	Instructions per role	Belbin categories
Timekeeper	Your role is to keep track of time during the meeting to ensure that the team does not spend too much time on one topic. It is essential to ensure that the team adheres to the allotted time for each agenda item.	Roles oriented towards people
Decider	If decisions are not made quickly, he/she calls for a decision vote by yes or no, the majority decides. (Only the decision-maker can do this)	Roles oriented towards action
Narrator	Your role is to read the game instructions, summarize discussions, and decisions made during the game for the rest of the team. You will need to ensure that everyone understands the instructions and ensure that all opinions are heard.	Roles oriented towards people
Observer	Your role is to observe each team member during the game and take notes on who is keeping track of time, reading the game instructions, clarifying arguments, and ensuring that everyone is heard. You will need to make sure that each decision is based on sound reasoning.	Roles oriented towards reflection.
Moderator	Manage the placement of icons to create the map. Ensure that everyone follows what is placed on the maps.	Roles oriented towards action
Scribe	Take note of the main decisions made. Keep track of modifications made to the visual model. This information will be used to defend the map and the business plan.	Roles oriented towards reflection.

Table 2: Conversion of materials needed for the Territory Game

Modifications to the Territory Game	
List of materials	Virtual modifications
Cards	Scanned PDFs of cards available on E-campus
Blank paper for co-construction of map	Blank slides on Google Slides® software
Markers and Post-it's for drawing	Icons and images from the web to represent drawings
Replacement of facilitator	Creation and random distribution of organizational roles using Google forms ®

4. What type of competencies did the game help to develop?
5. How did the game impact your confidence? In what way?
6. Please rate your experience on a scale of 1–5.

Data Analysis

The written data were analyzed by reviewing the responses from each student subgroup and categorizing them under the corresponding questions in an Excel sheet. This systematic arrangement facilitated easy comparison and analysis of the written responses. Individual responses, which varied in detail and elaboration, were carefully reviewed, and organized.

Following Braun and Clarke's thematic analysis framework, sub-themes were created by grouping similar excerpts of text together, and codes were assigned to these sub-themes. Different colors were used to represent codes for similar verbatim texts, facilitating the coding process. A thorough review of the coding process by the second author ensured its accuracy and consistency.

The focus group data, with its potential for providing in-depth information and capturing nuanced experiences, was given particular attention. Discussions and interactions within the focus groups were analyzed to identify recurring themes, shared perspectives, and unique insights. These valuable insights were then integrated with the individual responses from the written questions.

To ensure accuracy, the original recordings of the focus group sessions were transcribed, translated from French to English by the first author, and validated by the second author, a native French speaker. The transcribed focus group data was then organized under each question, aligning it with the written responses. Additionally, direct observations made by the first author during the game sessions and focus group discussion were included as an additional tab in the Excel sheets. These observations provided further context and interpretation of the findings in relation to the main themes identified.

To ensure a comprehensive understanding of both individual and group experiences, each theme that emerged from the data was interpreted following a literature review, thus enhancing the triangulation of data. By incorporating the richer insights from the focus group data along with the written responses and direct observations, the study aimed to provide a more nuanced analysis and a deeper exploration of the research question at hand.

RESULTS

Out of the 156 students that partook in the study, 88 students responded individually to the written responses, which represent 56.4% of the individual respondents. The focus group discussion and written responses was conducted following Braun and Clarke's thematic analysis (2013) and three main themes emerged.

Fun through Self-Directed Game-Based Learning

Participants across all groups generally found the game to be interesting and thought-provoking when playing the game. The game's instructions and the roles played a part in guiding the learning process and created an avenue for participants to communicate and co-construct a shared understanding. A group shared their enthusiasm for the game saying *we thought it was theoretical at first, but since it was a game and we could experience it, we were able to apply concretely what we learnt*. Furthermore, the immersive and integrative context of the game-based learning environment was also emphasized where a group

added that *the context of gaming is good because we were immersed in the experience. It also helps us to project ourselves in the future*.

The substitution of the facilitator with written instructions was also found by most participants to increase autonomy. A participant pointed out how the instructions in place of the facilitator improved the motivation and attention in the game stating that *yes, the game can be played without a facilitator. The motivation levels were quite good, the instructions were clear and over time, I understood what the game was about. It was also interactive and based on making tough choices. I think that it brings people together and made them talk in a particular context they all understand*. Furthermore, one participant raised an observation in favor of autonomous learning insinuating that if the facilitator plays a more active role, it might hinder peer-learning efforts. He highlighted that *the facilitator was not needed because even though we were lost at first, games require that the players experience it so we could manage it ourselves. This gave us the possibility to be autonomous*.

However, some participants reinforced the importance of the facilitator in introducing the course before the start of the game. This was corroborated by a participant stating that *I think that your presence (as facilitator) is important to start the game and to introduce the game. Once the game starts, then we don't need a facilitator*.

Team Dynamics and Role-Playing

The allocation of organizational roles had various impacts on the structure of the organization, team confidence, and the dynamics within the group. Numerous participants highlighted the organizational qualities of the roles in structuring the game session stating that *without the assignment of specific roles for all players, the game might be too messy or too long*; and was completed by a fellow participant who emphasized how *the roles helped to organize the session in a way as we didn't have to ask the question "who is doing what."*

Additionally, some participants felt that randomly assigning roles helped them understand their strengths and weaknesses and pushed them to take on responsibilities they were not usually comfortable with. This observation was supported by a participant stating that *the randomization of roles was good because it regrouped the personalities in the group. It helped us to get out of our comfort zone. There were questions on self confidence in the group and the roles helped to break these barriers*.

Role allocation also influenced the team dynamic in the way the roles were being used by different participant groups. Three distinct patterns were observed:

1. Some teams used the organizational roles to the letter and stated how the roles helped them with time management and a quick immersion into the game context as highlighted by a participant who stated that *thanks to the roles, we didn't waste time and were able to focus on the objectives*.
2. Other teams flexibly distributed the roles among their members. This was corroborated by participants who stated how they *adapted the roles sometimes, and some people took the roles of others because we are used to working as a group and attributing not very defined roles to each other, so it was interesting to see how these roles were more defined*.
3. The final pattern was teams that prioritized the game apart from the roles and reverted to existing team dynamics. Corroborating this, a participant expressed that *at the beginning, about 30 minutes into the game, the roles were maintained for a while, but after that everyone was involved in the game and did not respect their roles*.

Managing Complexity as One of the Most Challenging Endeavors

The reflections of most participants revolved around the complexities of decision-making and emphasized the crucial importance of taking into account multiple perspectives. The game highlighted the intricacies involved in making tough choices, with one participant boldly admitting that *the game showed us that these complexities are there, and they should be addressed*.

The process of decision-making was brought to the forefront, with participants recognizing the importance of prioritizing choices collectively rather than basing on individual wants. As one participant stated, *even in the choice of activity to choose for the clinic, our process of decision-making was guided by looking at the opportunities in the area and comparing that with the others*. Participants also expressed their realization of the difficulties that arise in dealing with complex situations, with one participant personally admitting, *I realized that it is very difficult to make a choice because of the complexities*. This newfound appreciation for the complexities of decision-making and the importance of considering different perspectives was further demonstrated by another participant who found the game intriguing because *I had to go through different types of information and actually take into consideration all perspectives*.

The result also suggested an impact of the gaming experience on the participants' confidence due to the level of reflection necessary before making a decision in front of complexity. Thus, one participant stated that *there were more things to take into consideration. So, the game has shown us that we were very ignorant of a lot of things. Therefore, I'm less confident in myself because now I know the number of things I need to take into consideration*.

DISCUSSION

The aim of this research was twofold: first, to explore how the instructional design of the Territory Game into the course could facilitate the cultivation of systems-thinking by leveraging collective intelligence to assess and analyze diverse sources of information and make decisions in the face of complex problems; and secondly, to present a framework for potential application in fostering systems-thinking, while also shedding light on its advantages and limitations.

From Individual Reasoning to Collective Intelligence

An individual's understanding of a system is based on their mental model of it, which is influenced by their knowledge of the context, structure, and dynamics of the system in question. This knowledge can impact the decisions made about the management of the system.¹⁸ To effectively integrate different contexts and perspectives, it is necessary for knowledge to be shared and communicated among all relevant actors, who may be directly or indirectly connected to the problem at hand. Participation and proper communication are crucial for this integration to occur.

Participatory modeling is a decision-making process that involves the integration of mental models and has been suggested as a methodology in developing systems-thinking skills.¹⁸ It is a transdisciplinary process that facilitates the knowledge co-creation to support decision-making and adaptive management. Its transdisciplinary nature bridges the gap between science and practice and promotes social learning and collective intelligence through participation.¹⁸ This approach is based on the idea that *the systems reality is a recurrent participatory process*, as extracted from Hodgson's (2019) book on

systems-thinking for a turbulent world. The phrase, depicted in Figure 2 as a recreation of the original diagram in the book, suggests that reality can be understood as a system that is constantly changing and evolving, and that this process involves the active participation of individuals or other components within the system. It is an approach to understanding how we come to know, understand, and process knowledge, which combines several different concepts from the fields of philosophy and cognitive science. *The pattern that connects* is a concept introduced by the philosopher Gregory Bateson, which refers to the idea that everything in the world is interconnected and can be seen as part of larger patterns. *The matrix that embodies* is a term coined by the cybernetician Heinz von Foerster, which refers to the idea that our experience of the world is shaped by the structures or matrices that underlie it.¹⁹ We go from a process of patterning where knowledge is reconfigured to produce a new and emerging pattern through the participation of multiple actors.

The Territory Games learning process was designed following a constructivist logic, which is aligned with systems-thinking. The incorporation of the game into the course proved to be a useful approach to gamifying constructivism in learning. According to constructivism, learning is an active process that involves learners constructing their knowledge based on their experiences and interactions with themselves and their environment.²¹ Inspired by Hodgson's (2020) patterning model, the authors created a game-based learning framework (Figure 3) that may help us describe how the course nurtured several transversal skills through a participatory approach, with six stages, namely individualization, visualization, integration, production, consultation, and evaluation.

The first three stages (individual, visualization, integration) focused on collaborative self-directed learning (SDL), which allowed the participants, as a group, to identify, reorganize, and visually represent shared information without any assistance from a facilitator. This process helped the participants collectively gain a deeper understanding of the intricate systems of the territory and collaboratively develop a shared understanding of the key components and relationships within it. SDL has been shown to be associated with moderate knowledge and skills strengthening in health education,²² compared to traditional methods of learning. The importance of appropriate instructional support in guiding SDL has also been recognized.²³ This is because SDL places an additional layer of stress on learners in a pure discovery mode with which they have to cope in addition to learning about the topic.²⁴ Learners have also been found to get lost or distracted from their primary goal, and experience disorientation.²⁵ In the literature, various types of instructional support have been proposed to facilitate SDL. One effective method is providing feedback, which can assist learners in tracking their progress, identifying areas for improvement, and remaining motivated.²⁶ Feedback can be delivered through different means, including teacher feedback, peer feedback, or self-reflection, and via various mediums such as written comments, verbal discussions, or online tools. Another essential type of support is scaffolding, which offers learners the necessary structure and guidance to accomplish intricate tasks.²⁷ Scaffolding can be carried out through different approaches such as providing prompts, modeling, or breaking down tasks into manageable steps. Scaffolding can be particularly beneficial to learners who may feel disoriented or uncertain. In the case of the game used in this study, the set of instructions and the integration

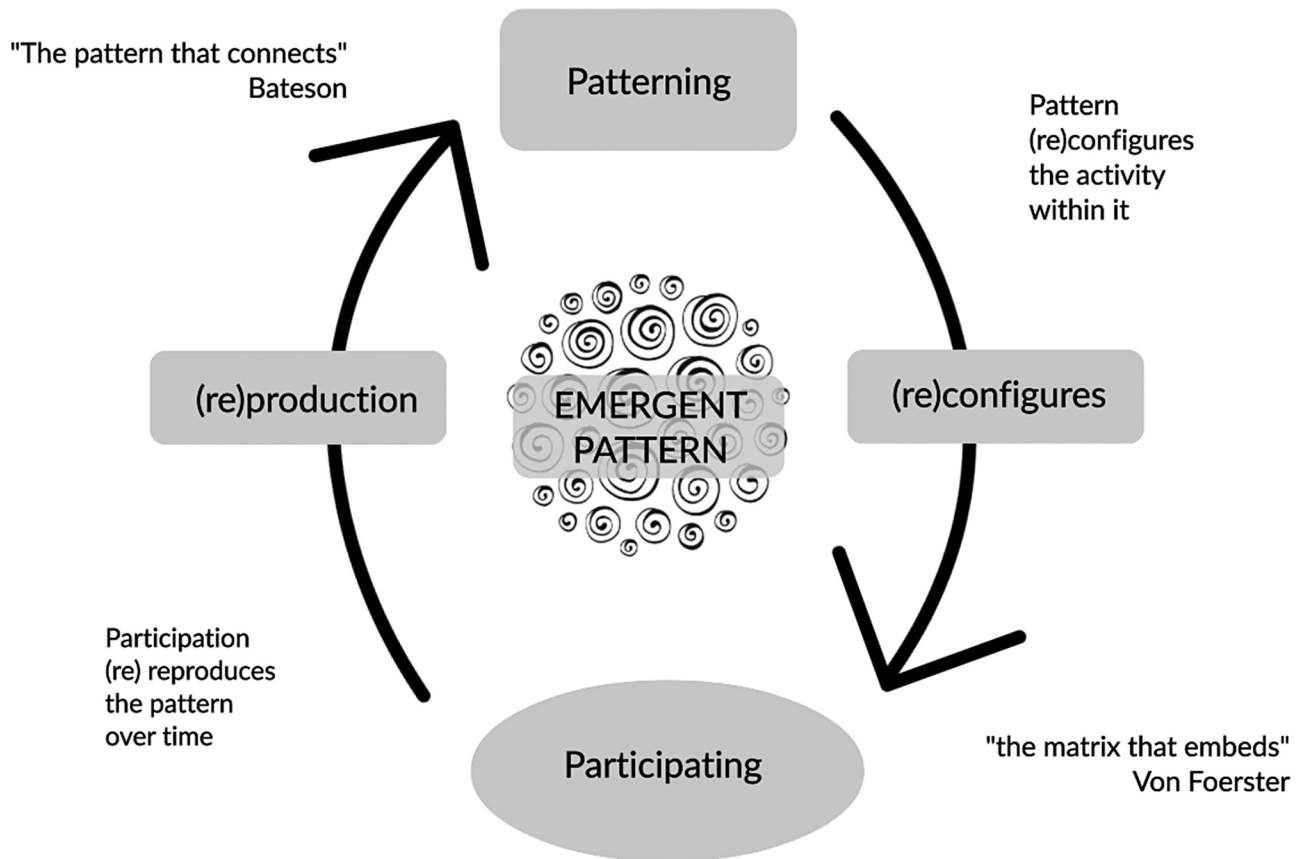


Figure 2: The participatory modeling approach for systems-thinking

Note: This framework suggests that knowledge of the world cannot be fully explained by either representations (mental models or maps of the world) or mechanisms (physical processes in the brain or the world), but must consider the larger patterns, structures, and interactions that shape our experience. This is because knowledge is not simply something that is passively absorbed from the world but is actively constructed through people's interactions with it.

Source: Systems-thinking for a turbulent world by Anthony Hodgson and Bill Sharpe.²⁰

of roles into gameplay acted as scaffolding techniques for the students.

The next three stages of the process (production, consultation, and evaluation) were focused on facilitating learning to support the participants in producing and collaboratively revising emerging knowledge co-created by their collective intelligence. In this regard, a facilitator is essential to guide the participant groups through a deeper understanding of the underlying patterns and structures that drive the system they are studying. It was important that smaller groups were used during the course to ensure each member had a crucial role to play in the team. The organizational roles were an attempt to further reinforce each member's commitment and resulted in creating a feeling of participation and ownership for some groups. A recent study highlights the significance of both peer-to-peer and facilitated learning in health education, particularly when conducted in small groups of learners. It suggests that these approaches are more efficient in promoting effective learning outcomes,²⁸ emphasizing the importance of dividing the classes into small teams for the purpose of the game.

The notion of group or peer learning that is essential in this participatory framework is consistent with constructivist learning theory, which highlights the significance of social interaction in the learning process.²⁹ By working collectively to

reconfigure and reproduce the knowledge of the system they are studying, the participants can become more conscious of the need for a more robust and nuanced understanding of the underlying patterns and structures that drive the system so that more informed and sustainable decisions can be made.

Through the emphasis on collaborative self-directed learning (SDL) during the initial three stages of the Territory Game process, participants were able to actively participate in and co-create their understanding of the system being studied. This was achieved through meaningful collaboration and constructive dialogue. The final three stages facilitated learning to support the participants in producing and collaboratively revising emerging knowledge based on their collective intelligence.

The role of a facilitator cannot be understated in the game achieving its learning outcomes. In fact, in a recent study, it was found that appropriate pedagogy and meaningful content integration, with a facilitator, were crucial in promoting participant learning outcomes, especially in a game-based learning environment.³⁰ The facilitated debriefing exercise at the end of the game placed teams in a position where different interpretations and perspectives of the game could be discussed and compared. This provided a valuable opportunity for student teams to reflect on their experiences and interact with members of other teams, leading to a more meaningful and impactful learning experience overall.

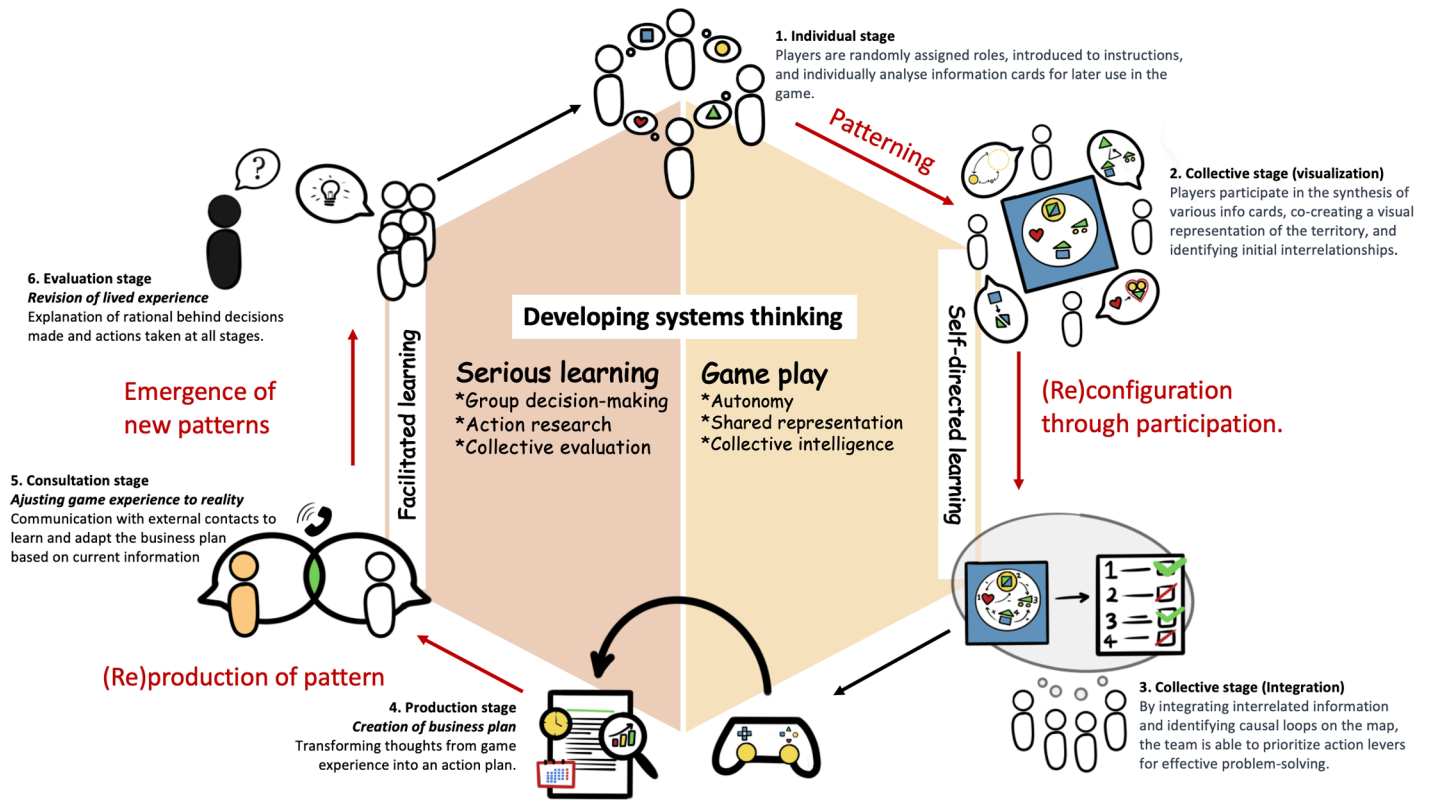


Figure 3: Participative framework of the Territory Game

Note: The diagram outlines six stages for developing systems-thinking using the Territory Game, inspired by Hodgson and Sharpe's (2020) pattern framework. The first three stages involve collaborative self-directed learning to identify, reorganize, and visually represent shared information. In the final three stages, learning is facilitated to support participants in producing and collaboratively revising emerging knowledge based on their collective intelligence.

Team dynamics can be complex and are not static, which means that teams need to be adaptable to meet the changing needs of their tasks, team composition, and individual differences such as motivation, skills, and personality. One model that has been widely used to better understand team dynamics is the Belbin team roles model. This model has been extensively researched, with studies demonstrating its positive impact on team effectiveness and productivity.^{17,31,32} However, some studies have raised concerns about the model's reliability and validity, suggesting that it may oversimplify the complexity of team dynamics.³³

In the context of gaming experiences, the importance of context and flexibility in the use of organizational roles was highlighted. While role-playing has been shown to increase participant engagement and enhance skills such as communication, problem-solving, self-awareness, and teamwork, the evidence on the benefits of role-playing and serious gaming compared to traditional instruction is inconclusive.³⁴ Therefore, teams should be encouraged to adapt their roles and responsibilities to better fit their needs and goals, requiring open communication and mutual respect among team members, as well as a willingness to experiment and learn from each other.

Overall, the Territory Game helped learners to become conscious of the importance of an open mindset and realistic thinking when handling complexity. They became more aware that even though a given action looks sound in one actor's view, it is always important to take into account what is feasible in the real world and considering that all actions are interconnected.

Limitations

While the constructivist learning framework utilized in this study offers advantages in promoting deep understanding and systems thinking, it is important to acknowledge potential limitations of the current proposal.

Firstly, as all teaching methods, the framework may not accommodate all learners' styles and preferences, as some students may prefer traditional instructional approaches or individual learning.³⁵ The effectiveness of the framework can vary depending on the specific learning needs and preferences of the students.

Second, facilitators responsible for guiding and supporting participants may encounter a learning curve when implementing the framework. Inexperienced or untrained facilitators might struggle to provide adequate support, leading to suboptimal learning experiences for the participants. It is important to emphasize the significance of teachers' understanding of constructivist theory, principles, and pedagogy to ensure effective teaching and learning.³⁶

Third, the design of the framework also presents challenges in assessing and evaluating student performance and learning outcomes. Traditional assessment methods may not align well with the collaborative and constructivist nature of the framework, necessitating the development of alternative assessment approaches that accurately capture the intended learning outcomes.

Fourth, the technical requirements associated with implementing the Territory Games framework may also pose a

challenge. The reliance on digital devices, software, or online platforms can be limiting if there is a restricted access to those resources or if technical issues happen during gameplay, potentially hindering the framework's smooth implementation and effectiveness.

Fifth, the implementation of the Territory Games framework can be demanding in terms of time and resources. Developing the game, training facilitators, and organizing collaborative activities require investments. Institutions with limited resources or time constraints may face challenges in adopting and sustaining the framework within their educational programs.

Lastly, the success of the framework relies heavily on participants' buy-in and active engagement. If students do not fully comprehend the purpose or value of the game-based learning approach, or lack motivation to actively participate, the effectiveness of the framework may be compromised. Ensuring participants are fully engaged and committed to the game-based learning process is crucial for achieving optimal outcomes.

Areas for Future Research

The study highlights several areas for future research in relation to the Territory Games framework. Understanding the individual learning needs and preferences of students in the constructivist and collaborative learning environment is crucial. Exploring strategies to accommodate diverse learning styles and preferences will optimize the framework's effectiveness and promote inclusivity in education.

Additionally, research should prioritize the development of effective training strategies and support systems for facilitators who implement the framework. Identifying the specific competencies and knowledge required for facilitators to guide and support participants will enhance the framework's benefits. This entails creating training programs, guidelines, and resources to establish an optimal learning environment.

To align with the collaborative and constructivist nature of the Territory Games framework, it is essential to explore alternative assessment approaches. Innovative methods like performance-based assessments or self-reflection tools can provide a comprehensive understanding of students' progress and achievements within the framework.

Lastly, ongoing research efforts should focus on refining and customizing the Territory Games framework to suit various educational contexts, age groups, and cultural backgrounds. This involves exploring customization options and adaptations that address specific learning objectives and challenges, facilitating a more tailored and effective implementation.

Implications and Applications for Veterinary Education

The Territory Games framework has several implications and applications for veterinary education.

1. **Enhancing systems thinking:** The framework promotes a comprehensive understanding of complex systems, which is crucial in veterinary education. It enables students to analyze the interdependencies and interactions within the veterinary field, including animal health, public health, and environmental factors. By applying systems thinking skills, students can develop a holistic approach to problem-solving and decision-making in veterinary practice.
2. **Fostering collaboration and teamwork:** The collaborative nature of the framework encourages students to work together, fostering teamwork, and effective communication

skills. In veterinary education, collaboration is essential as veterinarians often work in interdisciplinary teams to address animal health issues. The Territory Games framework equips students with the necessary skills to collaborate, negotiate, and make collective decisions, preparing them for real-world veterinary practice.

3. **Engaging and interactive learning:** The game-based approach of the Territory Games framework makes learning more engaging and interactive for veterinary students. It offers a dynamic and immersive learning experience that can increase student motivation and active participation. By integrating gamification elements, the framework can create a stimulating environment that promotes knowledge retention and application.
4. **Developing critical thinking and problem-solving skills:** The Territory Games framework encourages students to think critically and analyze complex veterinary scenarios. It challenges them to evaluate information, make evidence-based decisions, and anticipate the consequences of their actions. These critical thinking and problem-solving skills are essential for veterinary professionals to diagnose and treat animal health issues effectively.
5. **Promoting lifelong learning:** The Territory Games framework cultivates a culture of continuous learning among veterinary students. By engaging in active and self-directed learning experiences, students develop the skills and motivation to pursue lifelong learning beyond their formal education. This is crucial in a rapidly evolving field like veterinary medicine, where ongoing professional development is necessary to stay updated with advancements and new research.

CONCLUSION

The Territory Game, as a serious game, has demonstrated its potential in facilitating comprehensive thinking and systemic decision-making in health education. Its six-stage process aligns with constructivist learning theory and promotes active participation and social interaction among learners. By actively engaging with complex systems and collaborating with others, participants develop a more thorough understanding of underlying structures, leading to sustainable decision-making in complex situations. However, it is important to acknowledge the limitations of the framework. Not all learners may thrive in the constructivist and collaborative learning environment it offers. Technical requirements and limited access to resources can pose challenges, and facilitator training and support are crucial for effective implementation. Additionally, alternative assessment methods need to be explored to accurately measure learning outcomes.

Educators and institutions should carefully consider the benefits and limitations of the Territory Games framework when deciding to adopt and adapt it. By addressing individual learning needs, overcoming technical challenges, and providing adequate support, the framework's potential can be maximized. Future research should focus on refining the framework for different contexts and disciplines, aiming to strike a balance between its strengths and limitations. Ultimately, the Territory Games approach has the potential to enhance veterinary education and promote deep learning and critical thinking in various subject areas.

DATA ACCESS STATEMENT

The original data generated by this study is available on reasonable request addressed to the corresponding author.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in this work.

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