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Gaming Simulation Validation: Matching Participants' Worldviews with Their Decisions

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Abstract. Gaming simulation is a successful approach to many issues where a holistic view is important. However, to use results from gaming simulations, the game has to be validated. This paper proposes a two-step approach for process validation of behavior for the gaming simulation by comparing decisions that players make in a game with the perceptions that affect their real-life decisions. Two case studies, where this approach was applied, are presented and the results are analyzed and discussed. A strong correlation between behavior during the games and in the real world was observed. This correlation indicates that gaming simulations in these cases are validated and represent the real system in an accurate manner. Thus, these cases show that the proposed approach works and can be used for validation of gaming simulations.

Key words: Gaming simulation, process validity, Q methodology, attribution theory

1 Introduction

Gaming simulation creates environments in which human participants can interact, allowing incorporation of multi-stakeholder perspectives with multidisciplinary and multi-scale problems [1]. It is used in many fields where there is a need for a holistic view of the system. However, these games require that a behavior of participants in the game is similar to their behavior in the real world [2]. Thus, one of the big challenges with the gaming simulation is its validation based on decisions that participants make [3–5].

There are opportunities to validate some gaming simulations using agent-based modeling and other approaches [6–8]. But it is still challenging to validate that the choices that participants make in the game will match choices that participants would make in real life [9, 10]. This is especially true for gaming simula-

tions where people bring in their own behavior and expertise, such as games related to case studies and field work.

This paper suggests process validation of behavior for the gaming simulation by comparing decisions that players make in a game with perceptions that affect their real-life decisions.

Process validation of behavior for a gaming simulation is important for several reasons. First, understanding the perceptions that participants have about the system helps to address better the needs in a game and to understand the situation from different angles. Second, learning about causes behind decisions in a game makes it easier to analyze the results of the game. And most importantly, validation based on an understanding of the perceptions and causes behind decisions helps to validate a game, which is important for a proper game design, the interpretation of the results, and in applying the lessons learned in a real system.

To achieve this validation, a two-step approach is proposed. Firstly, Q methodology is applied. The main purpose of this methodology is to research the subjectivity of viewpoints. Q methodology is used to systematically study opinion, beliefs, or attitudes to determine typical clusters of viewpoints that participants have regarding the topic. These clusters, or factors, represent participants who share common worldviews. Then, decisions or choices that all participants made in the game are considered and the causes behind these decisions are investigated. It is done using the attribution theory. This theory tries to understand what causes people to make certain decisions. A comparison of the nature of these causes with the factors from Q methodology allows determination of how well actions in the game correlate to actions that people most likely do in real situations, and allows validation of the game based on this correlation.

Two case studies related to service procurement are described in this paper. One case is focused on road maintenance procurement in Sweden, while the second case is from maintenance contracts within an airport in the Netherlands. For each case, Q methodology was applied and after game sessions, all decisions that players made were analyzed to determine their causes and were compared with factors of participants.

A strong correlation between participants' worldviews and their decisions in the game was observed. This correlation indicates that gaming simulations in these cases represent the real system in an accurate manner. It also shows that the use of the suggested two-step approach works for validation of gaming simulations based on decisions that participants make.

This paper starts with a brief description of the problem of validation in gaming simulations in section 2. After this, the approach is described with emphasis on each of the steps. Then two cases studies and their results are presented in chapter 4. It is followed by a discussion and conclusion about the approach.

2 Problem Statement

Gaming simulation is used to achieve a specific objective or a set of objectives. Hence, gaming simulation has to be useful. Robinson [11] suggests that effective simulation have to fulfill four requirements. The first requirement is validity. Validity is a perception from a perspective of the modeler that a model is sufficiently accurate. The second requirement is credibility. It is similar to the validity; however, it looks on accuracy from the perspective of the client. The third requirement for effective simulation is a utility. The utility is a perception that a model is useful to aid to decision- making process. The last requirement is feasibility, which is a perception that a model can be developed using available resources and data. However, a gaming simulation can be a measurement of usefulness for different types of games is different. However, different gaming simulations can have a different level of fulfilling these requirements to be successful.

Gaming simulations that rely on outcome data from the games, among other requirements have to have a high level of validation. Validation is a process of checking or proving the accuracy of the model's representation of the real system. In gaming simulations, validation is a process of checking how accurate the simulation model is. Since all simulations represent reality only in the context of the specific purpose or objective of the game, the validation is also keeping a specific purpose in mind [12]. Internal validity, roughly speaking, addresses the extent to which a simulation functions in an intended manner.

The validity of gaming simulation is based on four criteria [3, 4]. These criteria are 1) psychological reality when providing a game environment that is realistic to the players, 2) structural validity when structures in the game are similar to the structures in the real system, 3) process validity when processes in the game are similar to the processes in the real system, and 4) predictive validity when the game can have outcomes that are similar to those of a system in the past or predict how a system will change in the future.

Process validity is usually addressed based on debriefing, questionnaires, and/or self-validation to an extent that is satisfying for the organization [10, 13]. However, these approaches do not give a full picture of how much a participant's behavior in a game is similar to his or her behavior in a real system and, thus, how well requirements for process validity are satisfied.

To properly investigate how well a gaming simulation is valid based on choices and decisions of participants, we need to know how accurate the causes behind choices and decisions are in the game compared to causes in the real world [14]. Hence, validation based on behavior or behavioral validation is performed by comparing attributions during the game with perceptions of individuals.

Such validation provides empirical evidence of how well behavior in a game is comparable with the real system. It also gives an understanding of what elements of the gaming simulation work properly to achieve the objectives and purposes of the game.

3 Proposed Approach

To be able to evaluate game’s external validation an approach is developed that is based on the behavior of participants during the game and their perceptions in real life. Because perceptions of reality directly affect the choices that a person makes, it is possible to observe such effects in games also.

In order to do so, the first step is to learn how participants perceive the real system. This can be done by grouping participants based on their worldviews regarding the research object of the game using Q methodology [15], as is described in subsection 3.1. This methodology looks at how participants rank different statements regarding a specific topic and then groups the results based on the correlations between the answers of different participants. Later, the observed correlations are analyzed and replies are clustered into factors based on similarity of opinions. People in common groups (factors) share common beliefs or attitudes toward a specific topic; the factors show a set of important values and principles for participants in this group.

Fig. 1. The Flow of the Proposed Approach

When the factors are known based on analysis of Q methodology and the game is finished, all decisions in the game are analyzed to see what type of behavior pattern causes them to make such decisions, because not all decisions are caused by the participant's worldview. The analysis is done with attribution theory [16]. This theory is described in subsection 3.2. It is applied because it helps to understand what decisions are really coming from the beliefs and ideas of a participant and which decisions are situational and are affected by the game itself, other situations, or organizations. It is important to identify what causes are internal and what are external because only internal decisions, which come from perceptions and ideas of a participant affect process validity. Observing the decisions of all participants during the entire game, models in attribution theory allow determination of what causes are internal and what causes are external.

Once decisions with internal causes are found, they are evaluated using factors with corresponding sets of values and principles as identified with Q methodology. Next, these results are compared with the group to which the game's participants who made these decisions belong. This comparison shows the level of validity of the game. If the ratio of the internal causes matching with the perceptions of the participant is higher, then the behavioral validation and the game's validation are higher too.

3.1 Q Methodology

Q methodology aims to study how people perceive the world regarding specific topics [15]. This methodology is used in cases where there are different opinions to group these opinions into factors. This allows analysis of these factors for better investigation of how participants perceive the system. It also allows some patterns to be found that determine the choices and decisions that these participants would make in real cases.

The basic process of Q methodology has several steps, starting with developing a set of statements on the topic of research to the final interpretation of the found groups, as seen in Figure 2.

The concurrence is a broad set of different opinions, ideas, and beliefs about the system. Typically it is based on literature and interviews with key stakeholders. It also might include some hypotheses or feedback about a design of the gaming simulation.

Once the concurrence is defined and includes all the important elements, it needs to be reduced to a set of 30-50 statements, which is the typical number of

statements for Q methodology [15]. It is important too that the final set of statements includes the whole spectrum of opinions.

Fig. 2. Process of Q Methodology

When the final statements are selected, a response grid needs to be defined. This grid contains several columns, usually ranging from ‘strongly disagree’ to ‘strongly agree.’ Each column has a predefined number of placeholders where participants can sort the statements. The response grid typically has a bell-shaped normal distribution as seen in the example in Figure 3. Participants are asked to fill in this grid, and such forced distribution helps to achieve better results during the analysis.

[illegible]

Fig. 3. Example of Q Response Grid

After the statements are known and a response grid is defined, Q-sorting starts. During Q-sorting participants are asked to read and sort all statements based on how much they agree with each of the statements. After sorting, participants are asked about their choices regarding the most left and most right piles because they represent extremes in opinions and thus, contribute more to the grouping process.

When all the sorts are done, they are analyzed based on how each sort correlates with other sorts. The sorts that are similar are clustered into factors, and the centroids in these clusters are used for interpretation.

When these centroid factors are found, the patterns in the sorting are examined, and together with the comments from the sorting, are used to form the final descriptions of the factors.

3.2 Attribution Theory

Attribution theory deals with how the social perceiver uses information to arrive at causal explanations for events. It examines what information is gathered and how it is combined to form a causal judgment [16]. Based on this theory, behavior has causes.

These causes can be internal or external. Internal, or dispositional, attributions are related to the person's inner factors, such as perceptions, traits, and skills. External, or situational, attributions are caused by some factors relative to the situation, something that is outside of the person's immediate control.

One of the central models within the attribution theory is Harold Kelley's covariation model [17]. His model is based on three types of causal information: 1) distinctiveness that deals with the extent to which we act differently in different situations, 2) consensus that refers to the extent to which we act in a similar way to other people in similar situations, and 3) consistency that considers the extent to which we act similarly over time. Each type can have high value, where causes can be explained by external attribution, or low value, where causes can be explained by internal attribution.

For example, if in the gaming simulation one participant chooses to use different variable values for different scenarios, then distinctiveness is high, and it can be explained by external attribution, such as values that are related to the context of the scenario or some instructions. However, if another participant chooses to use the same values for different scenarios, then distinctiveness is low, and it is explained by internal attribution – the participant relies on personal experience or knowledge and his or her own perceptions.

Fig. 4. Process of Attribution Theory

In a similar way, if all teams make the same decision for the same case or scenario, the consensus is high and it is caused by external attribution. But if one team chooses to make a unique decision, then the consensus for this team is low.

Also, if a team uses the same strategy over a prolonged period of time, such as several rounds or turns, then consistency is high, while changes in the strategy over time would show that consistency is low.

Choices with low distinctiveness, consensus, or consistency have internal causes and should be in line with the perceptions of participants.

4 Results

Two case studies related to service procurement are described in this paper. Both cases represent complex reality where process validation is important to interpret results in a proper manner. One case is focused on road maintenance procurement in Sweden, while the second case is from maintenance contracts within

an airport in the Netherlands. The aim of both case studies is to determine how procurement can promote innovation without losing its purpose. For each case, Q methodology was applied and games were designed and played, in which participants needed to create new procurement contracts based on standard procurement procedures from their organizations.

4.1 Road Maintenance Procurement in Sweden

Road maintenance in Sweden is the responsibility of the Swedish Road Administration, who procures services from private companies. All maintenance procurement contracts are highly standardized across all of Sweden, and they contain a large number of technical specifications and regulations on how maintenance has to be carried out. A contract is typically signed for four years with the opportunity to prolong it for up to two more years. Every project receives around 3-5 tenders, and the tender with the lowest cost is awarded.

However, maintenance contracts are seen as a type of contract with the lowest amount of innovation and that raises many concerns for the Swedish Road Administration. The main issues usually mentioned for this are the high standardization level, the low attractiveness of the contracts, and the low transparency about the amount of work.

In order to test some policies and ideas on how the situation can be improved, a gaming simulation was used. The objective was to create environments where procurement specialists from the Swedish Road Administration could experiment with procurement documents to see how changes will affect the outcomes of the contracts.

Participants were instructed to make any changes they wished in the documents, in order to produce a request for tenders that could exist in reality with the aim to decrease costs by 40% within the next 20 years. The game had two rounds, where participants continued to work with the same area of roads during the game.

4.1.1 Findings from Q Methodology

Prior to the game, Q methodology was performed. Twenty-one people who worked with maintenance procurement from the Swedish Road Administration and private construction companies were selected to participate in Q methodology to find clusters of perceptions. Each person was asked to sort 43 statements regarding maintenance procurement. Based on their replies, Q methodology identified three groups: factor 1 (Administration-oriented), factor 2 (Business-

oriented), and factor 3 (Service quality-oriented). Each factor represents a set of attributes and values based on how participants in these factors perceive the road maintenance project procurement.

Participants within factor 1 looked at project procurement from the administration point of view. They are concerned with market structures, organizations, and structures within organizations, the experience of stakeholders, and cooperation between companies in the market. They check that all processes are running smoothly and all management is done properly.

Participants within factor 2 looked at individual contracts and related aspects rather than the administration aspects. They wanted to have contracts with the lowest costs. They were interested in procurement, finance models, innovation, and incentives.

Participants in factor 3 emphasized statements about service quality, such as the environment, quality, road characteristics, and work process. They looked not as much at the management processes, but rather into the goals of the project and how well the final work was performed.

4.1.2 Teams and Their Strategies

Nine people participated in the session, and they were divided into four teams: three teams of two and one team with three people.

Team A mainly focused on using incentives as a bonus that entrepreneurs can get paid when they come up with an innovation.

Team B chose to customize documents to the local conditions and to stimulate the market of the European Union to dare them to bid more.

Team C made the contract to be procured based on the most economically advantageous tender in terms of the criteria of innovation, the environment, service, and safety. Small changes were made to the appendix such as removing some report forms.

Team D tried to achieve innovation in order to get increased productivity, efficiency, and so on. They were trying to get incentives for the contractors to try new materials, new methods, and new ways of working in order to get even better.

4.1.3 Internal Decisions

All teams started with typical documents for procurement and then they could make changes. Each change was a decision, and it was recorded and analyzed based on distinctiveness, consensus, and consistency.

Team A had made two changes in the first round and four changes in the second round. Two changes were the same in both rounds, which indicated that consistency was high and the causes were external. One change was the same as other teams', which had a high value for consensus, meaning that the cause was external. Three other changes were internal changes. The first change was about relocating some specifications to different files. This change was purely administrative, so it correlated to factor 1 from Q methodology. The second change was to separate contractor fees from other fees. This change was also administrative, and it correlated to factor 1 too. The third change was to reward contractors for extra high-quality work. This change had aspects of business because it provided business incentives and aspects from service because the change intended to improve service quality. Therefore the third change correlated to factors 2 and 3 from Q methodology.

Team B had a total of 18 changes, but only eight of them were internal. Five changes were administration-oriented (coordinate work with municipalities, make communication during the procurement process more flexible, refer more to international standards instead of local ones, translate documentation into English, increase visibility of the request for tender), one change was business-oriented (some of the attachments were rewritten to make cost calculations easier), one change was between administration-oriented and service quality-oriented (some changes from the technical specification to the functional specifications) and one change was between administration-oriented and business-oriented (contract can be divided into lots).

Team C made six changes with three internal causes. One change was administration-oriented (removed some attachments describing administrative work), one change was business-oriented (changed the award criteria) and one change was service quality-oriented (rewrote some of the requirements on how service work has to be performed).

Team D had 15 changes with seven internal ones. Five changes were administration-oriented (split the contract into two contracts based on geography, changed the start date of the contract, accepted contracts in other languages, made it a recurrent procurement, and removed some of the qualification questions regarding administrative experience), one was business-oriented (accepted alternative solutions), and one change was between administration-oriented and business-oriented (changed the type of procurement to a competitive dialogue).

4.1.4 Validation

After the gaming simulation, each participant was asked to complete a Q sort to determine the group to which he or she belongs. While the majority of partici-

pants had one defined factor, one participant had a high correlation with two factors.

Team A had one person who belonged to factor 1 (administration-oriented) and the second person to factor 2 (business-oriented). Team B had two people belonging to the administration-oriented factor. Team C had one person who belonged to the administration-oriented factor; while the second one had attributes from the business-oriented and service quality-oriented factors. Team D had two people who were administration-oriented and one who was business-oriented.

Table 1. Distribution of factors between participants and committed changes for each team

Team name	Participants			Changes		
	administration oriented	business oriented	service quality oriented	administration oriented	business oriented	service quality oriented
A	50%	50%		67%	17%	17%
B	100%			75%	19%	6%
C	50%	25%	25%	33%	33%	33%
D	67%	33%		79%	21%	

The standard error of the estimate is a measure of the accuracy of the predictions made. Based on this, 82% of the causes of the changes that participants made matched the results from Q methodology.

4.2 Airport Management

Schiphol airport is the main international airport of the Netherlands. Its work is governed by Schiphol Group. This group makes sure that all activities are carried out properly, from serving passengers and airlines to handling agents and logistics service providers to having a range of shops, catering facilities, and services to taking care of buildings and equipment.

Most of this work and services are procured according to European and Dutch public procurement acts. However, it has some issues with daily interaction, because airport staff are sometimes too involved in the work of contractors, particularly in making technical judgments themselves about e.g. the condition of an asset and the work needed on it. The goal of Schiphol Group is to shift this attitude toward a more distant relationship and to make the working relationship more of a partnership.

This change is mainly seen to be done through a procurement process, where some conditions and specifications need to be adjusted in order to make it true. However, it is unclear what parts need to be changed and to what extent to make

it happen. Also, it is important to find a way to change how the employees of the Schiphol Group perceive their jobs and how to interact on a daily basis with contractors.

Gaming simulation was chosen to investigate deeper these changes. Although the entire solution was based on a series of games, the first game in this project was about procurement for safety clothing maintenance.

Participants were instructed to modify an existing contract in order to make it cheaper and in line with the new vision, where the awarded contractor is a strategic partner, rather than merely an aide.

4.2.1 Findings from Q Methodology

Prior to the game session, all participants were asked to participate in Q sorting. For this study, 26 statements were selected about different opinions regarding procurement policies and efficiency in the airport, as well as the relationships between different parties. Nineteen participants sorted these statements based on how much they agreed or disagreed with each statement, and based on their answers, three factors were found based on clustering of their replies and agreement level.

The first factor included people whose opinions were about more freedom for companies. This factor sees procurement merely as guidelines to help contractors do their job. They want contractors to have more freedom and focus more on functions that need to be done rather than some specific descriptions.

The second factor focused on imperfections in current procurement practices. Their opinions were that the current system is not effective and has many issues, and they would like to see changes in these practices.

The third factor sees the airport and Schiphol Group as one with authority. They want contractors to listen to the airport since they merely work for Schiphol Group. Because of that companies need to do what the airport tells them to do.

4.2.2 Teams and Their Strategies

Twelve people only came to participate in the gaming session. They were divided into six teams, each group including two participants.

Team A focused on the clear definition of the goals and ambitions and connected them with the incentives. At the same time, they removed some of the less relevant parts from the contract, so it would be more attractive and open to bidders.

Team B decided to make many changes in the way procurement is done. In this, they tried to keep a balance between protecting the interests of Schiphol Group and making the request for tenders more appealing.

Team C aimed mainly to protect the interests of the airport. They added more specifications and criteria for bidders. They also made more references to the standards that currently exist in the airport.

Team D decided to keep the main contract with the specifications without changes, but instead focused on the way procurement is done. They changed some legal, economic, financial, and technical information related to the bidding process. They also changed the procedure with different award criteria and object of the contract.

Team E tried to switch from technical specification to functional, making it easier for contractors to be more creative and have more liberties as long as a contractor will deliver the services on time.

Team F decided to make the criteria stricter for potential bidders and to include technical information about the service.

4.2.3 Internal Decisions

Each team had three forms to fill in, which is the typical procedure for real procurement projects. Each team needed to make all necessary changes in the forms to achieve the goals of the gaming simulation.

Since there was only one round of the game, all the decisions of participants were analyzed only based on the extent to which these decisions were similar to the decisions of other participants (consensus). The total number of all changes and also the number of internal decisions that correlated with each of the factors can be seen in Table 2.

Table 2. Total changes and internal changes based on their correlation with factors for each team

Team	Total changes	Correlation with Factor 1	Correlation with Factor 2	Correlation with Factor 3
A	19	1	3	5
B	19	0	6	4
C	9	0	0	3
D	12	0	3	4
E	15	5	1	0
F	21	0	2	9

4.2.4 Validation

Once the internal decisions were analyzed, they were compared with the results from Q methodology.

Team A had one person who belonged to factor 3, while the second one had attributes from both factor 1 and factor 2. Team B had one person who belonged to factor 2 and the second person to factor 3. Team C had two people who belonged to factor 3. Team D had one person who belonged to factor 2 and the second person to factor 3. Team E had two people who belonged to factor 2. Team F had two people who belonged to factor 3.

Table 3. Distribution of factors between participants and changes made for each team

Team name	Participants			Changes		
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
A	25%	25%	50%	11%	33%	56%
B	0%	50%	50%	0%	60%	40%
C	0%	0%	100%	0%	0%	100%
D	0%	50%	50%	0%	43%	57%
E	100%	0%	0%	83%	17%	0%
F	0%	0%	100%	0%	18%	82%

The standard error of the estimate in this gaming simulation is 10.6%, meaning that almost 90% of all decisions matched the patterns found based on participants' perceptions prior to the game.

5. Discussion

Two gaming simulations in this paper focused on the procurement process in the administrative sector. In both games people brought in their own behavior and expertise. Hence, it is important to validate gaming simulation. Both games had similar rules and objectives, although they focused on different types of work and had different focuses and purposes. Because of focus differences and different cultures, participants in the games had different sets of perceptions.

The first case about road maintenance procurement revealed perceptions that were related to the organizational structure of work. It helped to see that the game played had a poor balance between participants that belonged to different factors. A game session with more participants that were business- or service-oriented could lead to other results. The second case had perceptions that were more focused on relations between stakeholders and the role of procurement in forming these relationships. Perceptions in both cases helped to steer the debriefing session and analyze the results from the games.

At the same time, it was observed in both cases that many choices were based on the policies and guidelines of the corresponding organizations, even when participants were told that they had freedom in their decision-making. Although participants chose to follow company guidelines partially because companies have best practices, in many cases participants were scared to take risky decisions even when they knew that there were problems related to such choices.

Finally, this approach showed that both cases have a high level of validity based on the standard error of the estimate. This validity makes it possible to measure and compare how well behavior in each game, or even in each team, correlated with reality. It gives more information for analysis of the game outputs. It also helps to improve game design and be aware of potential bottlenecks in the design; and it helps with the process validation criterion.

This proposed approach can be used for design or policy games where participants have their own roles in the game or other types of gaming simulations where participants have enough freedom to make a number of decisions based on their own experience. It is preferable to have a game 1) that is played by several teams or players to evaluate consensus, 2) that has several rounds to evaluate distinctiveness, and 3) that gives a choice between different strategy plans to evaluate consistency. However, these criteria are not mandatory, and in the provided cases, not all of them were implemented.

It is possible that the approach will have some limitations when players participate in the game individually rather than in teams. In this case, it is possible to evaluate each participant not merely based on his or her dominant factor, but rather based on correlations with all factors. Also, it is hard to say how much each participant contributed to the general results when they were working in teams. This means that in a team of two participants that belong to different factors, and where one of the participants is not actively taking part in the game, it would be unreasonable to expect that the changes will be split into equal halves between those two factors. This can explain why the standard error of the estimate is quite high.

6. Conclusions

This paper proposes an approach for process validation of gaming simulation. It is based on a comparison between the causes behind choices that players make in the game and their perceptions about the topic in real life.

This approach was applied to validate two games and the results were described. A strong correlation between the worldviews of participants and their decisions in the game was observed. This correlation indicates that gaming simulations in these cases are validated and represent the real system in an accurate manner.

From our results, a combination of Q methodology and attribution theory appears a promising method for constructing a validity assessment of a gaming simulation.

This approach can be applied in games where participants play their own roles and can make multiple choices. Such games can be, but not limited to, policy games, design games, planning games, political games, etc. The results from this approach can help to see deeper reasons behind the choices that participants make for analysis of the results and real applications.

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