Translating insights from a causal loop diagram into a game

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This paper concerns a project of limited scope to study why innovations in health care often fail to be adopted and how this may be improved. The project consisted of two workshops with participants from different areas of health care. The objective was to identify factors influencing adoption of innovations, relating the factors to each other, and looking for measures to stimulate the adoption of innovations. During the first workshop, possible effects of innovations and prerequisites for adopting innovations were identified and prioritised. This resulted in draft causal loop diagrams. During the second workshop, refined diagrams were used to identify measures for stimulating the adoption of innovations. In addition, a game incorporating the results of the workshops was developed. The main causal mechanisms were translated into the game which can be played by people who work in health care to improve their understanding of some of the dynamics involved.

Key words: causal loop diagram, health care, innovations, game, group model building

Background

Concerned by a lack of adoption of innovations in health care, the Ministry of Health, Welfare and Sport in The Netherlands requested advice from the Dutch Council of Public Health and Health Care on measures to stimulate the adoption of innovations. Delft University of Technology was asked to contribute to this project. Two workshops were held with professionals and managers from different areas of health care. The workshops were aimed at determining factors influencing the adoption of innovations, relating the factors to each other, and identifying measures the Ministry can take to stimulate the adoption of innovations. In this sense, the workshops were an addition to the extensive scientific investigation of factors that can hinder or facilitate innovations in health care organisations by Fleuren *et al*. (2002). The findings from the workshops were reported to the Council of Public Health and Health Care, and were also translated into a board game that can be played by people who were not involved in the workshops, but who would like to learn more about the results.

In the next section, the set-up of the workshops will be explained. Following this, the results of the workshops will be discussed. The final section concerns the design of the game and some preliminary results of playing the game prototype.

Workshop design

The first workshop was a one day workshop aimed at identifying factors and relating these factors to each other. The second workshop was a half day workshop which was geared towards identifying measures that can stimulate the adoption of innovations. A variety of methods were used to achieve these results. These methods will be explained below. Nineteen participants attended the workshops. The workshop participants were from diverse

organisations in health care, such as patient organisations, hospital management, home care organisations, ICT suppliers, insurance companies, and health care professionals.

The first workshop consisted of three general parts: (1) identifying the effects of, and conditions for, the adoption of innovations, (2) brainstorming and prioritising the effects and conditions, and (3) mapping the relations between the factors in causal diagrams.

The identification of factors was carried out in a novel way using a role playing method, which we termed a 'gamelet' (Bots and van Daalen, 2005). Eliciting variables is often done using a brainstorming technique. However, because the identification activity had to be conducted at the beginning of the workshop and people did not know each other very well, a role playing method, which allowed participants to speak out freely as they took on their role, was developed. In addition, brainstorming does not include argumentation of the factors, whereas in the role playing exercise people had to put forward their arguments. In the gamelet, the participants were presented with a case description of an innovation that is still in a research or test phase, but may become a real possibility in the (near) future. These innovations were: operation robot, life shirt, online doctor, and hospital at home. The innovations ranged from more technically oriented innovations with organisational components to a purely organisational innovation. Each gamelet involved nine participants, so the group was split up into two smaller groups. A brief case description of one of the cases was handed out to the participants of a gamelet. The assignment was to play a meeting in which three of the participants were in favour of the innovation and three other participants had to be convinced of its merits. There were also three observers who wrote down all the factors and arguments mentioned at the meeting table. The observers were also asked to note any factors they thought of, but that were not mentioned. The meeting about one innovation lasted for 15 minutes. Afterwards there was a facilitator-led discussion about the possible effects of the innovation and conditions for adoption. A second case was then handed out to the participants and another gamelet was carried out. Following the meetings and discussions of all the cases, the effects derived from all the different cases were combined into one list, and the conditions pertaining to the different cases were also combined into one list. This way of identifying factors of importance to the issue proved very appealing to the participants. The ten participants who responded to a questionnaire on the workshops gave an average of score 4.3 (scale 1 = bad to 5 = excellent) to the gamelets, with everyone giving a score of either a 4 or a 5.

The lists of effects and conditions were then entered into the computer and presented to the participants in a Group Decision Room (Nunamaker *et al.*, 1997). This is a meeting room fitted with computers and specialised software allowing participants to, amongst other things, generate and prioritise ideas. Both lists were presented to the participants. Participants were asked to add factors to the lists that they thought were missing, e.g. possibly due to the specifics of the cases used in the gamelets. These completed lists were then presented on the screen and the participants were asked to electronically prioritise the lists in order to find the most important effects and conditions. The appreciation of this method by the participants showed substantial spread with participants either scoring this method very high or very low (mostly 2 or 5).

After identifying the most important factors to be included, first version causal diagrams of parts of the system were drawn. The first diagram showed the possible *effects of adoption of innovations*. This was drawn in conjunction with the group in a plenary session to illustrate the method. The other diagrams were drawn in three smaller groups. These diagrams

consisted of influences on *client commitment* towards adoption, on *commitment of professionals* towards adoption and on *management commitment*. These four parts were chosen because a preliminary analysis showed that there would be too many factors to fit into one diagram and these seemed to form reasonable submodels that would be approximately similar in size. The diagrams that were drawn up during the workshop were refined by the researchers between the first and the second workshop and were used as a starting point for the second workshop. The activity of drawing up the causal diagrams came much less natural to the participants than the first two activities. It was difficult for the participants to see what the contribution of this analysis would be. The method scored an average of 3.4 in the evaluation of the workshop. This time, there was no sharp division in opinions, but a range of scores.

During the second workshop, the way in which the causal diagrams had been refined was first explained to the participants. The participants then split up into two groups. Each group sat around a very large print out of one of the four refined causal diagrams. Using Nominal Group Technique (VanGundy, 1988), they were asked to identify measures that could influence the factors in the causal diagrams in a way that this would lead to an increased adoption of an innovation. The measures were written on post-it notes and stuck onto the causal diagrams next to the factors that they could influence. Each group discussed two out of the four diagrams. Then the groups switched places and the facilitator explained the measures that were identified by the other group for the other two diagrams. When all possible measures had been clarified, the participants were given small coloured stickers to stick onto the measures they thought were most important. This resulted in a prioritised list of measures, including the factors that were considered to be influenced by the measures. The participants gave an average of 4.1 as a score for the identification of measures using the causal diagrams (ranging from 3 to 5).

Workshop results

The first workshop resulted in a list of the most important effects of an innovation and a list of the most important conditions for an innovation to be adopted. The most important possible effects (positive or negative) of innovations which were identified were:

- effectiveness for client
- efficient care
- transparency
- client satisfaction
- costs
- client empowerment
- possibility for performance measurement
- changing role of medical personnel
- co-operation within organisation
- systematic collection of patient (experience) data

The most important conditions for an innovation to be adopted were:

- (scientific) justification of innovation, proven results
- presence of believer or promoter of innovation
- commitment of management / whole organisation
- presence of a culture of quality
- presence of implementation techniques
- presence of ways of measuring added benefits
- quality of leadership

- benefit to user
- organised client (patient) associations
- willingness to be held accountable / to be transparent

The initial causal diagrams from the first workshop were refined using the approximately 60 variables contained in the final prioritised lists. Although not all of these variables may have been equally relevant to the issue at hand, they were all used in order to make the diagrams recognisable for the participants. There are four different diagrams (factors influencing client commitment to the innovation, factors influencing the professional's commitment to the innovation, factors influencing management commitment to the innovation, effects of the innovation) which were drawn up separately. The interactions between the different parts are assumed to be as shown in Figure 1. The connections between the different parts do not originate directly from the workshops, but were inspired by Repenning (2002).

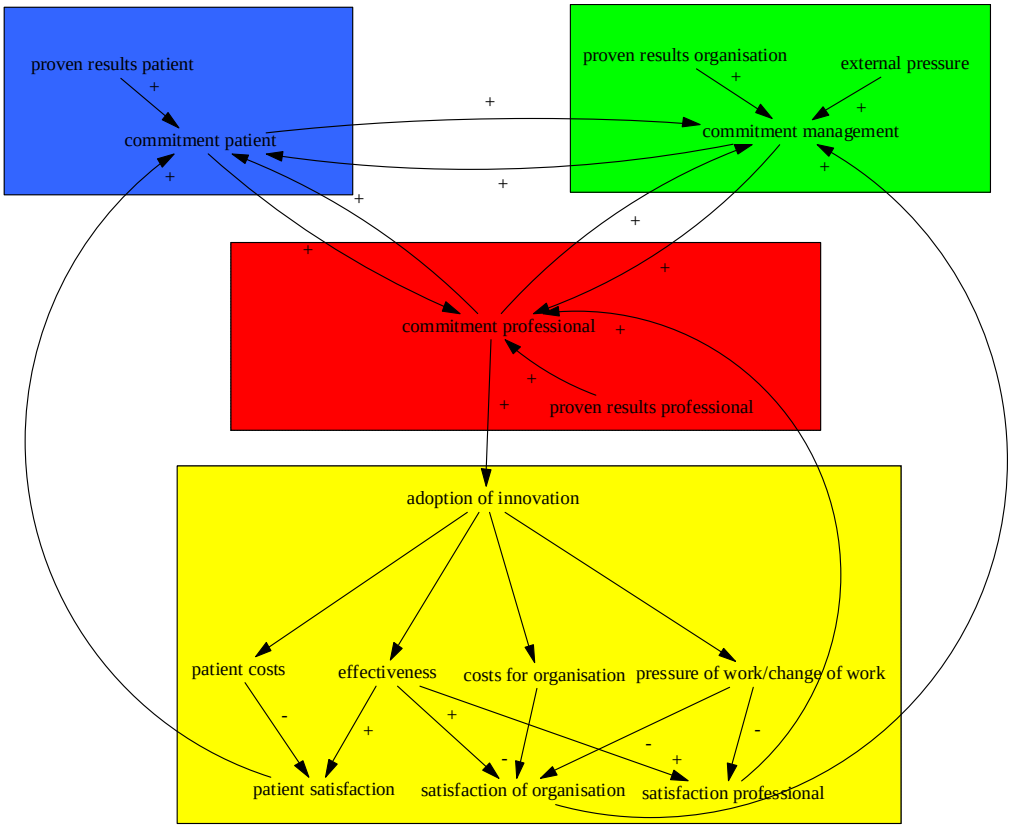

Figure 1. Schematic overview of main factors.

During the second workshop, measures that may stimulate the adoption of innovations were identified. This was done using the detailed causal diagrams drawn up after the first workshop. The most important categories of measures that were identified are related to increasing the visibility of proven results, financial measures, and accountability requirements. The measures which received the highest ranking in these categories are the following:

Visibility

- independent institute (research, communication, network)
- awareness programme (in organisation)
- broad think tanks; innovation platform for health care
- multidisciplinary innovation brigades (visiting organisations)

Financial measures

- output financing
- feeding back profits to sector (e.g. profits due to shorter patient recovery times)
- structural financing directly related to innovation

Accountability

- benchmark for culture of learning
- (require) external accountability

A schematic diagram of the influence of the measures at a very general level is shown in Figure 2.

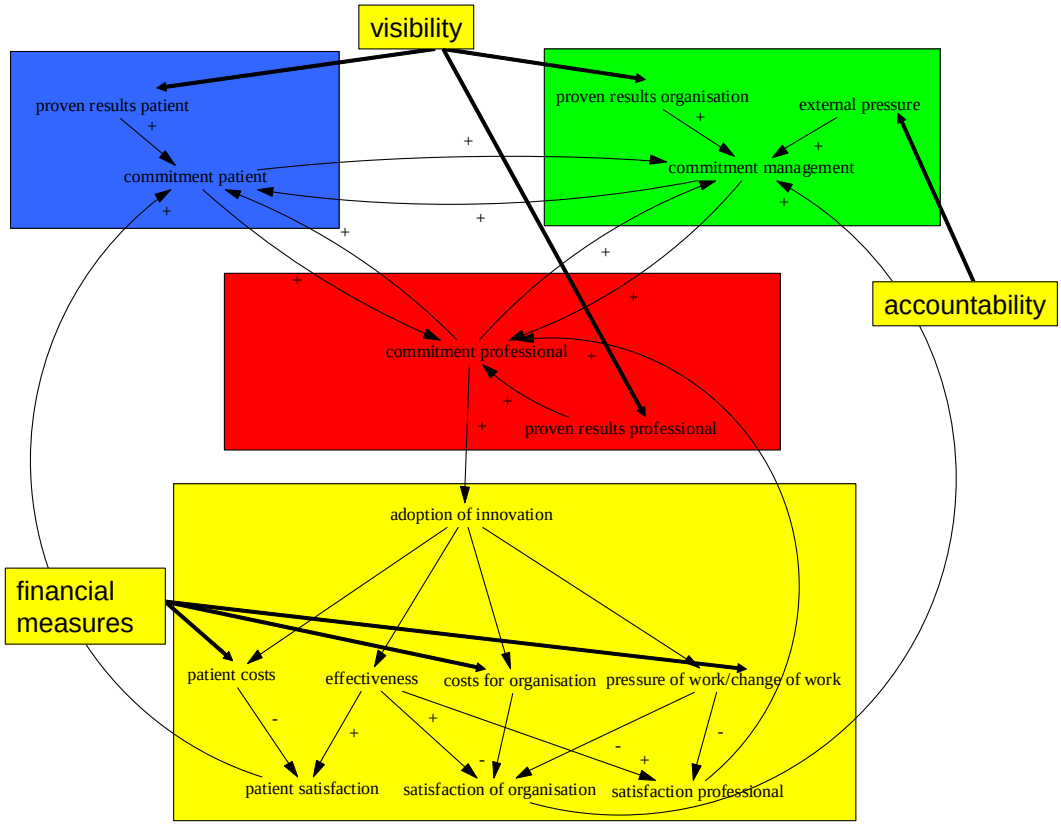

Figure 2. Overview of types of measures.

For the adoption and continued application of an innovation it is necessary that the reinforcement loop that has been described by Repenning (2002) comes into play and works in a positive way rather than in a negative way. Reinforcement loops for all the stakeholders can be seen in Figure 2 above. For each of the stakeholders (management, professionals, clients) the structure of the loop is the same and is shown schematically in Figure 3. Although the structure of the loop is the same, the effects of an innovation will be valued in a different way by each of the stakeholders. Their satisfaction with the same innovation can, and probably will, be different.

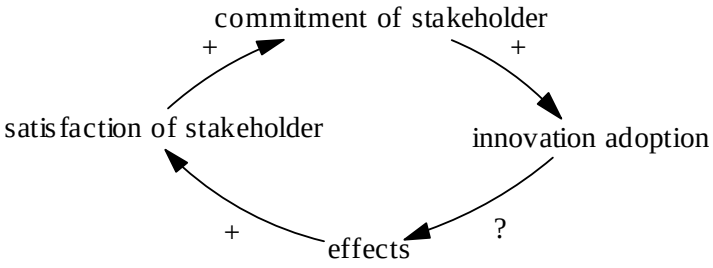

Figure 3. Schematic representation of feedback from effects to adoption.

If adoption of the innovation leads to positive effects with which a stakeholder is satisfied, this will lead to a higher commitment and continued application of the innovation. When the net effect of adoption of the innovation is negative for a certain stakeholder, this will lead to dissatisfaction and the innovation will no longer be supported. It is possible that negative effects of an innovation only become clear in the long term, after which non-adoption or rejection may occur (this effect is also mentioned by Homer, 1987). Another possibility is that it takes longer than expected before the positive effects of an innovation become visible and satisfaction and commitment will decrease (this effect is also mentioned by Repenning, 2002). Repenning also indicates that people initially are often sceptical about an innovation and it is necessary to take additional measures for the commitment to be directed in a positive way.

Translating the workshop results into a game

The game is aimed at people who were not involved in the workshops, but wish to learn more about the results. The game gives the players the experience of being involved in decisions on innovations with the objective of contributing to deeper learning than would occur by merely reading the workshop report. Figure 4 (Sterman, 1994) shows that feedback from the real world can cause changes in mental models. Sterman also indicates that for learning to occur, each link in these feedback loops must work effectively (double loop learning). Since it is difficult for people to obtain full information about the real process of adoption of innovations in health care, and it is not feasible to experiment in the actual situation, a virtual world (a game in this case) can contribute to the learning process (Sterman, 1994).

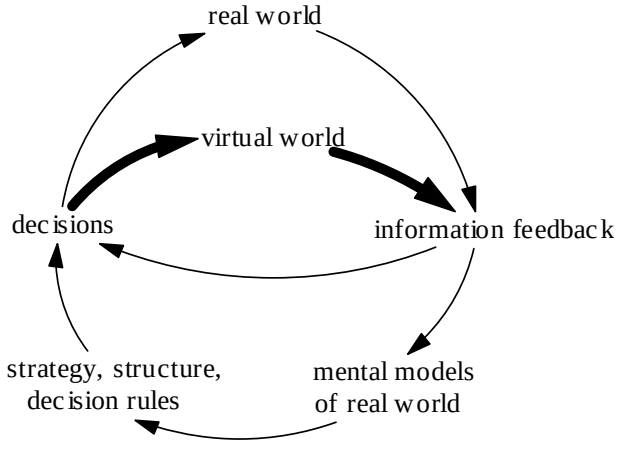

Figure 4. Introducing a virtual world (bold arrows) into the learning loop (adapted slightly from Sterman, 1994).

The general point of departure for the health care innovation game has been to develop a game which has correspondence with the diagram shown in Figure 2. The game is a role-

playing board game. There are three main stakeholders in the game (clients, professionals and management). The stakeholders are roles that are played by the players. A board contains positions for the three different players and the description of a specific innovation project can be placed on the board. The game is played by each of the players going through rounds of the commitment-adoption-commitment loop (Figure 3). This will result in a certain pattern of adoption of an innovation project over time. Afterwards, the players can see how well the innovations did over time, and discuss why these patterns are present. Reflection is necessary for the game to be effective in stimulating the learning process (Sterman, 1994).

Translating the main loop into the game dynamics
When translating a system dynamics model or causal loop diagrams into a game, links pertaining to decisions can be removed from the model, and these links can be replaced by human decisions that are to be made by the players. In this way, the players add the information feedbacks to the game. The main loop in this case was discussed above and is shown in Figure 3. This loop is similar for all three roles. In the game, the automatic connection between "satisfaction" and "commitment" is removed for each role. The players will receive information about the payoff of a certain innovation (i.e. satisfaction) and decide on their amount of support (commitment) for a certain project themselves. This support will then automatically determine the level of adoption of the innovation. The effects will be calculated and the satisfaction can then be calculated again. This allows players to choose their next amount of support based on their satisfaction. A number of rounds (i.e. iterations of the loop) are played in order to see the pattern of behaviour over time. The total amount of support a player can give in each round is limited. This reflects the limited innovation capacity of the stakeholder (how much change they can bring about).

Link between innovation and its effects
As can be seen in Figure 3, there is still a question mark between the adoption of the innovation and the effects. The game includes different projects. Each of these projects contains a description of the specific project and its specific outcomes. The outcomes are values of the most important effects that were identified during the first workshop: effectiveness, costs for client, costs for organisation, and work pressure/changing role. In order for the game to remain comprehensible, only these four effects have been included.

Link between effects and satisfaction
At the beginning of the game, each player chooses a utility function. They can say in which way they, of course from the perspective of their own role, value effects of an innovation. For example, client satisfaction may only be based on effectiveness and costs to the client. This would mean that for the client, the satisfaction related to an innovation would be calculated purely on the basis of outcomes on these two effects, whereas management would probably value all effects, but with differences in the weighing factors.

Link between satisfaction and commitment
As was stated above, the link between satisfaction and commitment is not one that can be calculated in the game. Players choose their own level of commitment towards an innovation.

In addition to choosing how to represent the main causal mechanisms, various other choices have to be made when designing a game (van Daalen *et al.*, 2004). The general choices that were made for the innovation game are summarised in Table 1.

Table 1. General design choices for the health care innovation game.

function	learning about adoption of innovations in health care
plot	stakeholders in an organisation have to take decisions about supporting (or not supporting) different innovation projects
goal of game/incentive	player's goal is to achieve the highest satisfaction score (most positive net effects)
roles	client, professional and management – three stakeholders together represent one project organisation
people playing	real stakeholders, but not necessarily playing their own role
rules	• rules for action: players have a limited amount of resources to support innovation projects and at the beginning of each round they place their support on one or more innovation project descriptions; based on the support the players have entered, there are calculation rules to calculate the implementation level and effects of an innovation • rules for interaction: players can freely negotiate about their preferences and try to convince the other players to support their preferred innovation project
physical system representation	• an organisation is represented as a table; the table has three set places for the three players • innovation project boards are placed on the table (in the organisation); these project boards can show the support for and progress of an innovation project • a specific innovation project is represented as a card with a description and indication of its effects; an innovation project can be placed in the middle of an innovation project board • support for a certain project is represented by tokens; the tokens can be placed on the project boards by the players
interaction environment representation	• no specific interaction environment within organisation, table at which players sit is also negotiation table • organisation has to provide a yearly progress report

Increasing the complexity

The basic workings of the game are discussed above. The game has been extended to make it more realistic, to incorporate the possibility of implementing measures and to include a diffusion loop (Repenning, 2002) whereby others observe the results of the innovation which can also increase commitment.

- There is always more than one innovation project on the table. Players have limited resources to support innovation projects. This means they will have to choose between different projects.
- More than one game is played in parallel. Each game represents one organisation. By playing various games in parallel, different organisations can be played. Each table plays innovation rounds at their own pace. So one organisation can innovate faster than others.
- There are three roles that don't have a place at a specific table, but are overarching for all games. These are: government, research institutes and health insurance companies. These players have measures available to influence the adoption of innovations. The measures are based on the measures that resulted from the second workshop. Research institutes can influence the visibility of innovations. When the research institutes see that a project is doing well in one organisation they can stimulate other organisations to initiate the project. Government can provide subsidies or set legislation. When costs of health care rise or fall, the health insurance player can increase or decrease client costs across all

tables. These three general players make decisions only at set times during the game, after the organisations have delivered their yearly progress reports.

As in the beer game (Sterman, 1992), players calculate their own results. For each of the links in the major loop, there is a calculation rule that the players use. Players keep track of their satisfaction (i.e. pay off) on each project and the group (representing one organisation) keeps track of the level of adoption of the different innovation projects. After the game, players can see which projects did well and which projects did not do well and analyse the reasons for this.

Results of working with the prototype

At present, the game is still in the prototype phase. The practical implementation of the game, including (calculation) rules, is shown in Appendix A. The aim is to use the game as part of the dissemination activities related to the release of the advisory report that the Council of Public Health and Health Care will present to the Minister of Health, Welfare and Sport. This report is due to for presentation prior to the summer of 2005.

The prototype game has been played a number of times with colleagues. In playing the prototype game, some properties of the system which were described above (relating to the behaviour of the loop) did indeed come to the fore.

- Players always start with the 'easy wins'. These are the small projects with only benefits. However, in the long run these advantages will be smaller than those of some of the larger projects with more complicated benefits and costs. This means that it is difficult to start projects that don't have only positive effects or need a lot of support to start with.
- When they have been playing the game for some time, the players suddenly realise that investing in projects that may not have only positive short term effects but that do have large benefits on the long run, would have given them much better results. Once they realise that it would have been better to start earlier with these types of projects, they are more prone to investing in these types of projects that follow.
- It was also found that players usually start with a large innovation project portfolio and then come to the conclusion that it would be better to concentrate on running a smaller number of projects at the same time, and to try to get those projects to maturity first, before starting new projects.
- A fourth finding was that after some time players see that they can make 'package deals' with other players in order to increase their own success.

Conclusions

This project incorporated a number of new ideas: the use of gamelets and translation of workshop results into a game. Gamelets were used for generating variables and elucidating arguments relating to these variables. The gamelets worked very well in identifying relevant variables. The elicitation of variables is often done shortly after the beginning of a workshop (see e.g. time-schedules for a typical one-day workshop by Andersen and Richardson, 1997) and people may not know each other very well. A gamelet allows participants to speak out more freely because they take on a role. It also makes participants look at the problem situation from different angles because they have to take on different roles, and includes argumentation of the factors. Participants were very positive about this way of identifying variables. The gamelet concept can be used as a way of structuring this task instead of using the Nominal Group Technique, for instance, or in addition to the Nominal Group Technique.

The second idea was that of translating the results of a group model building session into a game. The starting point of the game is the reinforcing loop from commitment to adoption and back to commitment. The general rule in designing the game was to replace a link representing a decision (a link which closes an information feedback loop) by a human decision (e.g. deciding how much support to give to a project in this game, or deciding on the orders in the beer game) and have the players of the game make the decision. The game is then played by going through the loop in rounds. Because this is a board game which does not involve any automatic computations, rules for what happens at each step (in the loop) and how the participants move from one step to the other (e.g. by calculating intermediate results) had to be derived. Although the game is still at a prototype phase, tests with the prototype indicate that the game can help participants in thinking about the consequences of supporting or not supporting innovations. The game also shows that players start with the easy wins, and hesitate to invest in projects that pay off only in the long run. Although the game was made for application to innovations in health care, it can be translated to other fields of application.

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Appendix A. Practical implementation of the game

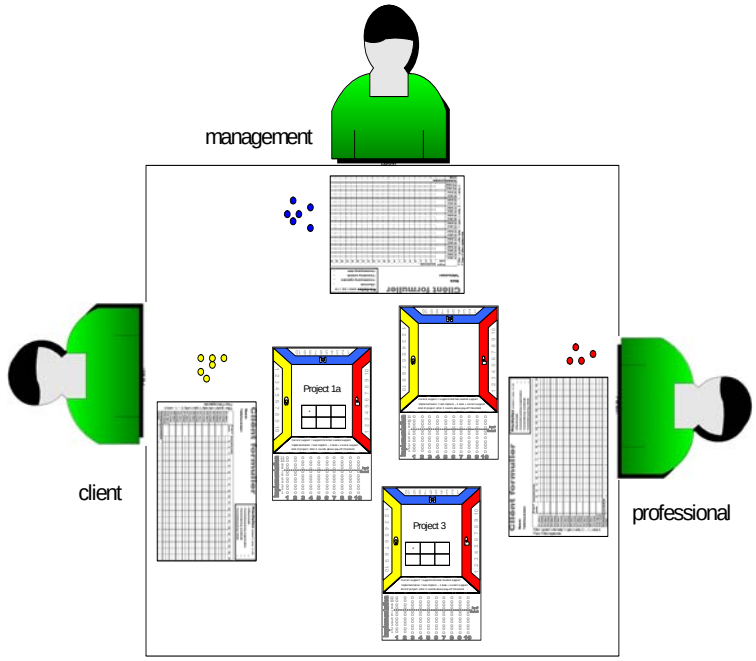
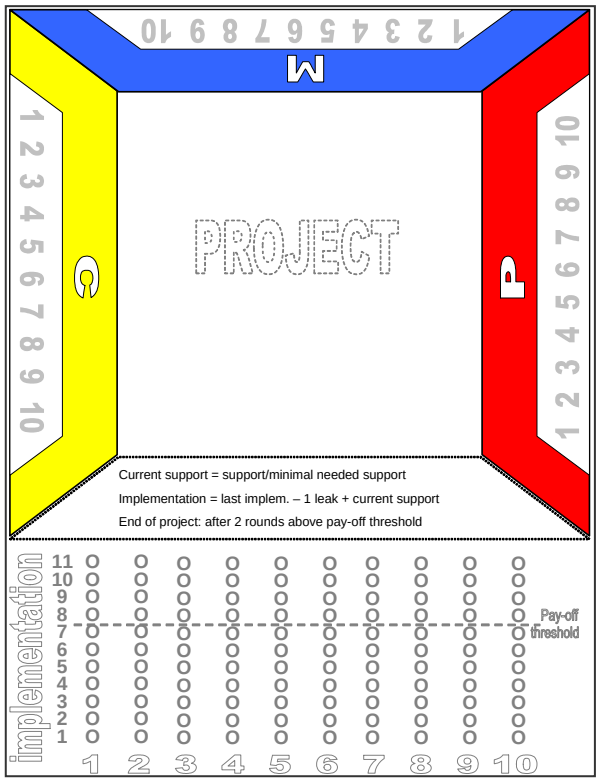
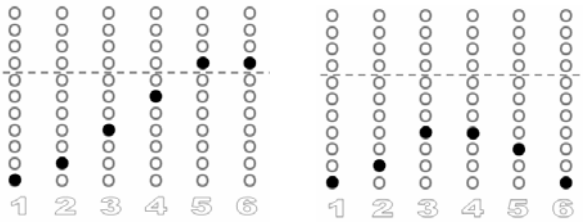


Figure A1 shows the configuration of one table, which represents a project organisation. Each stakeholder has a colour (clients: yellow, management: blue, professionals: red) and a set place at the table according to the project boards (see Figure A2). At start of the game, all players receive ten support tokens of their own colour. They also receive a sheet on which they write down their utility function and scores for each innovation round (as will be explained below). New projects can be started by placing them on an empty project board.

Figure A1. One project organisation per table.



The project board (Figure A2) has an area for a project card (see also Figure A3), space for each player to lay their support tokens, and an empty graph to enter the implementation level of the project in each project round. In this way, the support each stakeholder gives at a certain moment is visualised by the tokens, and the current and past states of the project are shown at the bottom of the board. In fact, the implementation level can be seen as a time graph (see two examples below).



The project board consists of an A-4 size paper copy (in colour). The circles are filled up (using pen) as the game progresses.

Figure A2. Project board.

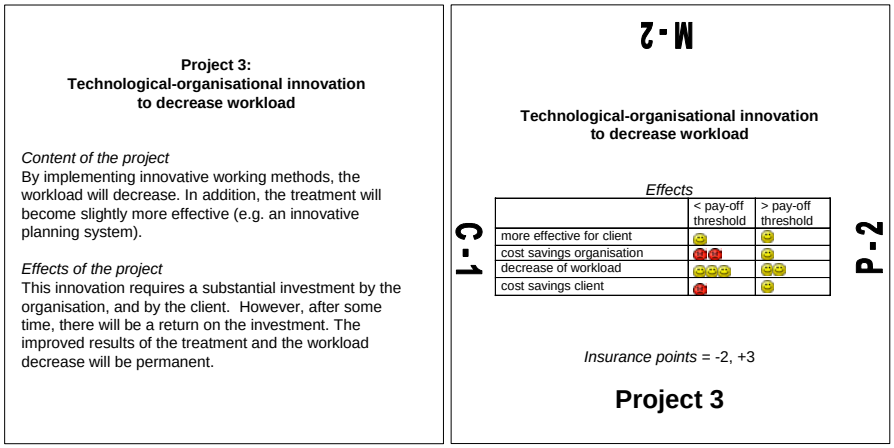


Figure A3. A sample project card.

A project card (example in Figure A3) shows a description of a project on one side. The other side shows the values of the four effects of the specific project represented by certain numbers of 'smileys' (and 'frownies' for negative effects). These effects change once the pay-off threshold has been reached. Project cards are reusable and are covered in plastic.

Calculation rules

Project implementation

Project implementation is calculated in each project round:

- Current support = support / support minimally needed (only whole numbers, rounded downwards)
- Implementation = previous implementation – 1 leak + current support

The implementation values are drawn in by colouring the circles on the project board, to provide the graph over time.

A project ends after two rounds of support above pay-off threshold. The support tokens for this project then fall free to be used for new projects, while the pay-off of the completed project becomes permanent.

Client, management and professional

At the start, each stakeholder defines his or her own utility function (i.e. priorities) for the four effects (Figure A4, top right hand corner). This means that they have to indicate the relative importance for each of the four effects (e.g. how important do they consider effectiveness in relation to decreasing workload, from the point of view of the role they are playing).

Each project round, players calculate the scores for their personal score sheet (Figure A4) where 'smileys' from the project card (Figure A3) count as +1 and 'frownies' as -1.

- Project Effect = (utility 1 × effectiveness count) + (utility 2 × cost for organisation count) + (utility 3 × workload count) + (utility 4 × cost for client count)
- Project Total = Project effect × implementation (*note:* project total indicates player satisfaction)

The players write down their own personal scores on their score sheet. The player with the highest score at the end of the game wins within the organisation and the organisation with the highest total score wins the game.

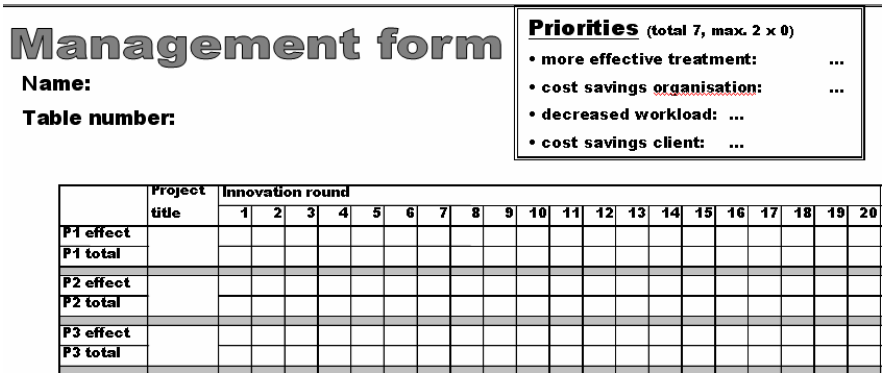


Figure A4. Form for each player to write down utility and scores.

Yearly reports
At set times, each organisation delivers a yearly report with scores for each project.

- Organisation project score = implementation × 'smiley count' per effect (not taking into account the utilities)

The players (or the facilitator, in case of few participants) with the role of government, the role of knowledge institute, and the role of insurance company receive these sheets.

Government
Government looks at how well organisations score on innovations and can take measures to stimulate certain innovations or organisations, e.g. to publish the scores of the different organisations for all the players at all tables to see (representing a benchmark).

- Σ Organisation project score per organisation and Σ Organisation project score per project

Knowledge institute
The knowledge institute can distribute additional support tokens to organisations to provide additional stimulation. The number of additional tokens is calculated on the basis of how well innovations are doing across all the organisations:

- Number of additional support tokens = Σ implementation of all projects in the game / 8

Insurance company
The insurance company calculates the total benefits (effectiveness, cost savings for organisation, and cost savings for clients; not the decreased work load) over the past year and redistributes this by way of points to the clients at all the tables. In this way, savings made by certain organisations will find their way back to all the clients of the insurance company and not just within the organisation.

- Insurance points for a project = Σ all effect 'smileys' except work load (because unlike costs for organisation, work load decrease does not reduce the overall health costs)
- Project total = Insurance points × implementation of project
- Decrease of insurance burden for client = Σ all project totals in the game / number of project organisations (= # tables)