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Developing an educational game for sustainable urban development

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Abstract. Implementing sustainable development, whether it is in the built environment or in other sectors, is a difficult challenge that requires the application of a variety of knowledge and skills. Approaches to deal with this challenge are complex as well, and they are difficult to communicate in traditional educational forms. Experiential learning environments, such as simulation games offer better opportunities to communicate complex lessons. DUBES is an approach that helps actors to develop sustainable urban renewal programs, and a simulation game has been designed in which actors can experience how the approach and the accompanying tools can help them to develop sustainable plans. The DUBES game has been played several times now and is in need of some fundamental revisions to improve the educational performance. This paper analyzes the game design and its improvement potential.

INTRODUCTION

DUBES, the Dutch acronym for sustainable decision-making, is an approach to manage sustainable urban renewal processes. Its aim is to make practitioners and/or students familiar with decision-making processes for sustainable urban renewal by explicitly taking into consideration the technical or *substantive complexity* of the sustainability concept and of the urban system and the social or *process complexity* of the multi-actor environment in which decision-making takes place. In urban renewal projects, actors often find it difficult to focus

on both complexities. The result is that sustainability ambitions in urban development processes are not formulated or not realized.

Emphasis on the process complexity may lead to negotiated nonsense instead of negotiated knowledge and to endless processes of interaction. Sustainability soon becomes an issue that can be exchanged for other issues for the sake of the process, or, sustainability remains only a goal in name, but never gets specified into priorities and decisions during the process. When emphasis is put on the substantive complexity, sustainability is given more priority. However, this often results in highly ambitious plans for which support is lacking, and the goals are not realized, or, sustainability goals are specified in a very early stage of decision-making, which leads to premature closures and sub optimized decisions, e.g. when the focus is on only one part of sustainability, such as energy performance or material use (e.g. Van Bueren and Priemus, 2002).

DUBES is an approach that helps actors in urban renewal processes to structure the process and substantive complexities of urban development projects. The approach has been developed in a consortium of Delft University of Technology, TNO Building and Construction and PRC Bouw since 2000. It combines a decision-support system (DSS) called MEDIA, which contains information on the various kinds of decisions that are involved in urban renewal, their interrelationships and their sustainability impacts, with a participatory planning or process management approach, in which actors with various interests and perceptions on sustainability negotiate how sustainable urban renewal could best be achieved.

DUBES thus represents an integrated approach to problem analysis and process management from which a variety of lessons can be learned. The multiple learning objectives included in the approach make the approach valuable, but at the same time difficult to communicate. During the development of the approach, gaming-simulation techniques got in focus. Simulation games represent dynamic models of real situations (Kriz, 2003: 496). In games, participants learn because it is necessary at that time. They experience an immediate relevance in what they are being taught. Parallel to the development of the DUBES approach, a simulation game was being constructed in which actors could experience DUBES and the lessons it has to offer.

Since 2001, the game has been played several times and has been improved on an incremental basis, especially in response to feedback and evaluations from participants. Now that DUBES and its components, MEDIA and the process design, are maturing, the time has come to reflect on the game and to see how its educational performance can be improved. In evaluations of the game, participants emphasize that DUBES is valuable approach, but they feel that they could learn more about the approach when the game is improved. Although gaming-simulation theories acknowledge that the educator is not in control of the learning process and the content of the lessons learned (Leigh and Spindler, 2004: 53), these theories also mention that the game design can facilitate learning by the players.

This paper explores how the game design can be improved to advance the educational performance of the game. The following section identifies the various design variables of the DUBES game, after which the results and challenges of the different versions of the design are discussed. The analysis shows that there are several flaws in the current design that are not very easy to solve, which can be traced back to three dilemmas in game design. These dilemmas form the agenda for further improvements of the game.

DESIGN VARIABLES OF DUBES

Gaming-simulation is a technique that has been applied to master an understanding of the complex world of policy and decision-making (Duke and Geurts 2004: 11). Urban studies have proved to be thankful objects of application. In the 1970s and 1980s, with the rise of the computer and during the rational planning heydays, the emphasis was put on simulating and modeling urban systems. From the late 1980s onwards, the rational planning model was under pressure and planners became aware of the role of actors who, with their 'irrational' behavior, thwarted the predictive power of the algorithms that simulated reality (Cecchini and Rizzi, 2001). Also in literature on game design, emphasis has turned to actor behavior and interactions in addition to simulation. Game design should combine a role-play and a simulation, including actors, rules and resources (Kriz, 2003: 496). Following these design principles, DUBES consists of the following design variables: a scenario, which consists of an urban renewal case and an assignment, a role-play of stakeholders who are involved in the renewal process, a DSS called MEDIA and a process design which helps players to structure interaction and decision-making. These design variables are shortly explained, followed by the educational goals of DUBES and a short comment on the applicability to other domains than urban renewal.

The scenario

The assignment in the game is to develop a program of requirements for the sustainable urban redevelopment of a neighborhood that is stuck in a down ward spiral of physical and social problems. The neighborhood to be used can be a real or fictitious one. The fictitious case is called *Greenward* and consists of an average Dutch neighborhood that has been built in the 1960s/1970s. The neighborhood is in urgent need of improvement. Because there is a good chance of getting financial support from the national government, the participants are asked to produce, in one day, a program of requirements for the renewal of Greenward. The municipality decided to involve the principal interested parties in drawing up the program of requirements. However, there is an important condition attached to eligibility for financing: the plans must make a clear contribution to the sustainability of Greenward.

The neighborhood, its problems and the assignment are described in the scenario that is sent out to participants prior to the game and to think about their position and interests in the assignment. It also contains a map and a photo collection that gives an impression of the architecture and the problems in the neighborhood.

The role-play

In each game, there are about eight to ten different roles. Between 20 and 40 people can take part in each simulation-game. Depending on the number of participants, there are two to three people performing the same role. Differences in role perceptions between players with the same role do not matter, since such differences are also present in the real world.

For the Greenward case, the following roles are distinguished: the project leader of housing association Our House, the project leader of the municipal building department, the responsible councilor, a residents' representative, a local environmentalist, the supplier for services such as energy and water, the municipal services department (responsible for

maintenance of the public spaces and for environmental affairs such as waste collection), and the local water board. The scenario contains an overview of the roles involved, including the formal responsibilities of each role. The role-play can be tuned to the group of participants and the lessons to be learned. When played with professionals, the roles can be tuned to their roles in real life, so that optimal use can be made of knowledge and expertise of the players. When played with students, a more elaborate role description is needed, since they lack a frame of reference from which they can play their role.

MEDIA, a DSS

MEDIA (Modeling Environment for Design Impact Assessment) is based upon Analysis of Interconnected Decision Areas (AIDA) developed during the 1970s at the Tavistock Institute of Human Relations (Morgan, 1971). In short, MEDIA operates as follows.

MEDIA includes about 200 decision areas for urban renewal projects. These were identified and validated through case studies and expert meetings. Furthermore, the debriefings of the gaming sessions with the participants were used to improve the set of decision areas continuously. Decision areas are grouped according to spatial level: region, city, quarter, block, building and room. They are also grouped by decision process stages (e.g., design, construction, maintenance, demolition) and by theme (e.g., water, energy, mobility, safety). These three ways of grouping decision areas are independent from each other, and each may be applied separately or in combination whenever this is opportune in the process.

Each decision option can have an impact on several variables. These variables typically model primitive attributes of a particular subsystem (e.g. a building) to which the decision pertains. The choice of insulation material, for example, will affect the energy required for heating the building, as well as the construction cost. Variables can also model system performance at a high abstraction level by aggregating the values of a range of primitive attributes into a single indicator. The energy efficiency of a block, for example, can be computed as the ratio between the total energy consumption and the total usable floor space for that block. The present version of MEDIA embodies a variety of knowledge from different disciplines and can calculate the (cumulative) effect of decision options on some 200 impact variables. If quantitative effects are difficult to assess, MEDIA allows users to define symbolic qualifiers (e.g. *People*, *Planet* and *Profit*) that can be attributed to certain options by the stakeholders themselves during their discussions.

Decision areas are 'interconnected' when the effects of certain combinations of options for these areas interact. The most recent version of MEDIA contains a *preclusions, promises & problems window,* which defines relations between decision areas and options. It shows which combinations are problematic or impossible (with state of the art technology) and which combinations are promising or necessary. If, for example, one decides for a central heating system for a neighborhood, decision areas related to heating of blocks and residences within that neighborhood become irrelevant. Combinations can be labeled (on a 7-point scale) as a *promise* if the interaction effects are beneficial, and as a *problem* if they are detrimental. In our example, the central heating option is problematic if the energy infrastructure for the neighborhood can transport only electricity and/or natural gas.

MEDIA now also contains a *design window*, in which users can specify alternative designs by adding and/or removing components at different spatial levels, and by checking different

decision options of the decision areas for each spatial level. MEDIA provides immediate feedback on the compatibility of the chosen options, based on the relations specified using the *preclusions, promises & problems window*. Players can use this window as a *reality check*, to see whether they develop a plan that is possible and feasible. It gives warnings, but does not prevent users to make apparently unrealistic combinations. The basic idea is that where there is a will, there is a way: design problems may be overcome by creative design and engineering.

Figure 1 contains some screen shots of the window with decision-areas, options and effects (left upper screen), the preclusions, problems and promises window (lower screen) and the design window (right upper screen).

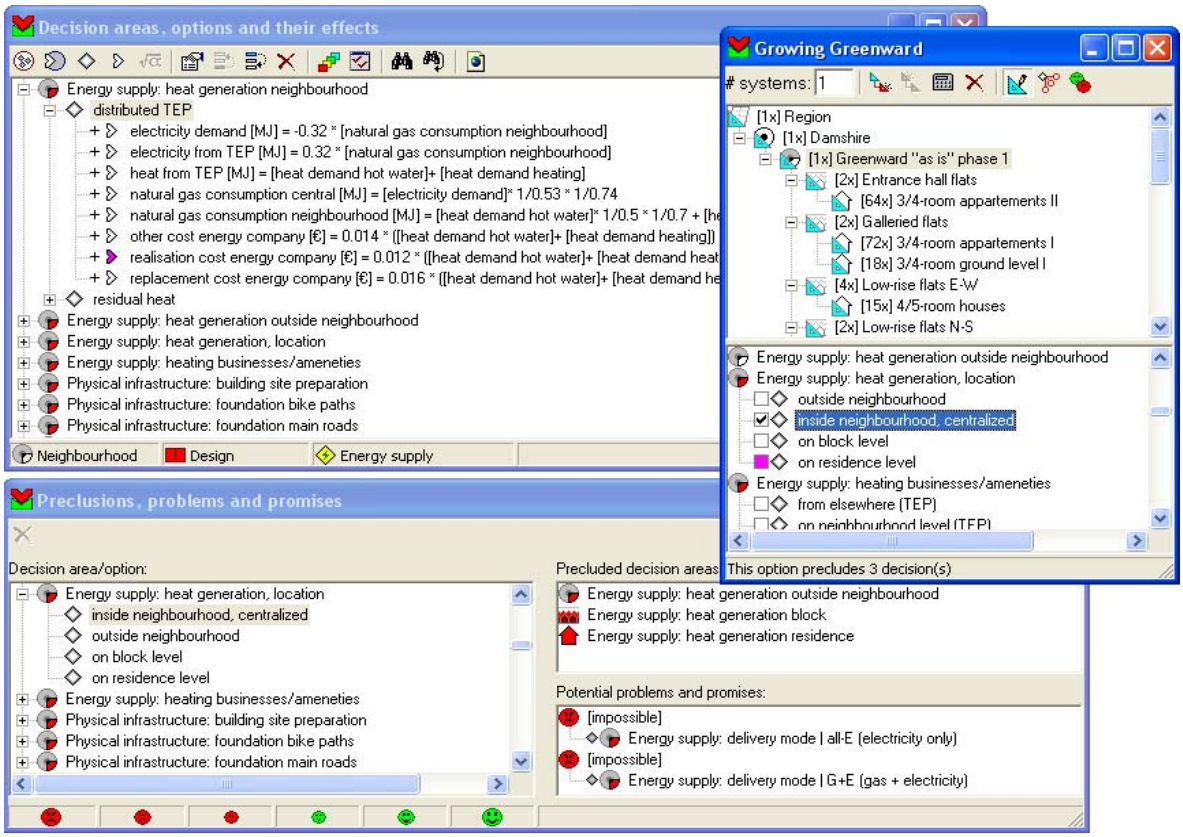

Figure 1: MEDIA screen shots

The process design

Although the process design has been modified during the various sessions played, the overall structure has remained the same. It consists of two main parts: a morning session in which the players explore the opportunities for sustainable urban renewal in Greenward as well as their own preferences and priorities, followed by an afternoon session during which the players define the requirements for the sustainable urban renewal of Greenward. Figure 2 presents an overview of the structure and program of the game as used in version 1.0.

In the agenda setting session, the information on decision-areas and options, grouped by spatial scale first, and then by theme, is provided in the *DUBES table* that is printed on poster format. This gives participants an idea of the kind of issues that are involved in urban renewal projects, and at the same time it gives them a first impression of the content of MEDIA and makes them familiar with the structure of MEDIA. During the afternoon, decision-making session, a *DUBES advisor* helps each group to use the software program.

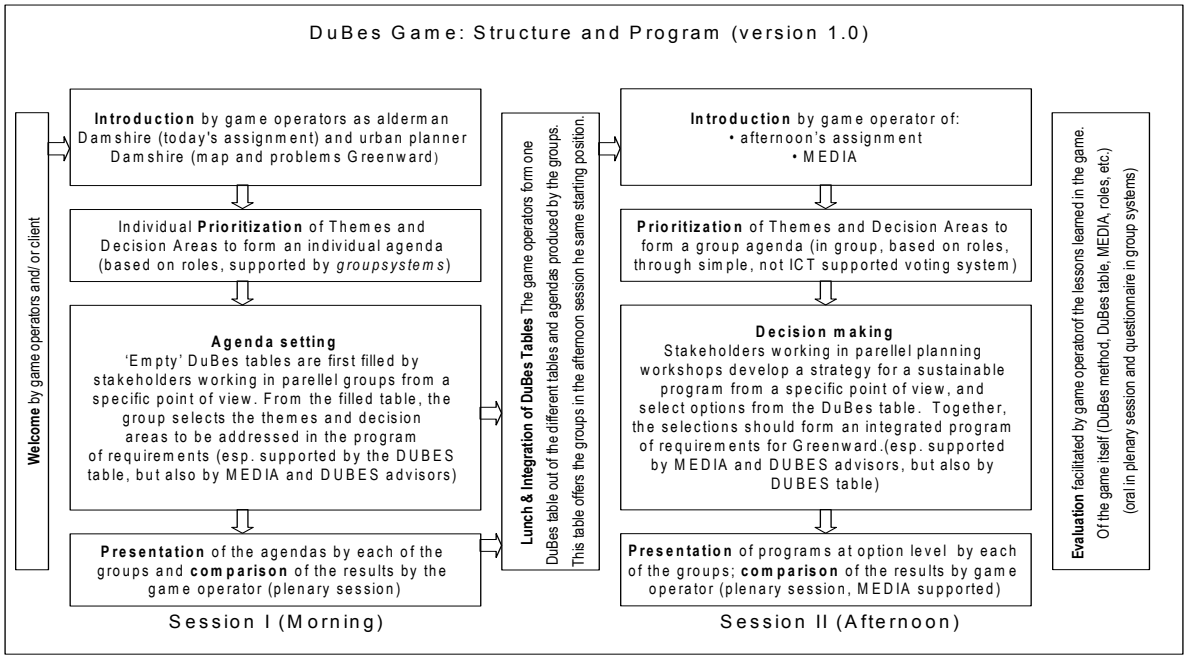

Figure 2: Process design

Educational goals

The DUBES approach is used to teach and train participants on a number of issues. Table 1 presents an overview.

Teaching and training about:	Substantive complexity		Process complexity
	Urban renewal	Sustainable development	
Types of questions addressed:	What is urban renewal? What alternatives/ opportunities exist and how are they interrelated? What kinds of stakeholders are or could be involved?	What is sustainable development? How can it be put into practice in urban renewal? How to assess whether decisions are sustainable? How is sustainability of interest to actors?	What variety of interests and disciplines is present in decision-making? How to manage different (competing) interests? How to cooperate with actors of different disciplines? How to make use of knowledge /DSS? How to balance between substantive & process complexity? How to formulate requirements?

Table 1: Overview of educational goals

Other applications

In its present form, the DUBES simulation-game can simulate a fictional neighborhood or a real renewal assignment. The method and the tools, however, are generic: in principle, the same tool and simulation-game can be adapted for other sustainable design projects, such as new construction projects or the development of a sustainable business park. When the simulation-game is played using the fictional renewal case, one can experiment with the DUBES method without involving direct interests. In that case, it is primarily an instructive means of exercising and training renewal managers in the DUBES method, but the concrete results are open-ended. When the simulation-game is used for the further development of a real renewal assignment, the participants in the DUBES achieve useful ideas and results for the real program of requirements. It is important to realize that the DUBES game delivers ideas and information *for* decision-making but that the real decisions can never be made *in* the DUBES (game) simulation.

THE GAME DESIGN VERSION 1.0 – 1.4

From 2001 to 2004, DUBES has been played several times, in different settings, with different groups of participants, and with different goals. Table 2 gives an overview of the various sessions played, including an impression of the improvements for each session.

Version	1.0	1.1	1.2	1.3	1.4
# sessions	1 (28 players)	1 (35 players)	4 (140 players)	1 (25 players)	5 (154 players)
Date	November 2001	December 2001	March 2003	October 2003	Feb/March 2004
Participants	Professionals	Professionals	Students	Professionals	Students
Case	Real case	Fictitious case	Fictitious case	Fictitious case	Fictitious case
Role play	Own role	Role exchange	Stylized roles	Stylized roles	Stylized roles
Process design (and tools used)	Part I: agenda setting from a specific point of view (DUBES table & MEDIA) Part II: integrated decision-making (MEDIA)	Part I: agenda setting from a specific point of view (DUBES table) Part II: integrated decision-making (MEDIA)	Part I: agenda setting from a specific point of view (DUBES table) Part II:integrated decision-making (MEDIA)	Part I: agenda setting from a specific point of view (DUBES table & MEDIA) Part II:integrated decision-making (MEDIA)	Part I: agenda setting (tables: DUBES & requirements) Part II: decision-making (MEDIA) (Voting and assessment)
Functions MEDIA	Informative	Informative	Informative, impact assessments, design window	Informative, impact assessments, design window	Informative, impact assessments, design window, reality check
Educational goals	Process complexity (esp. variety of interests), sustainability complexity	Process complexity	Process complexity, esp. interdisciplinary cooperation & role of knowledge	Process complexity, sustainability complexity	Process complexity, esp. interdisciplinary cooperation, role of DSS and formulating requirements.

Table 2: Overview of different DUBES versions

As table 2 shows, DUBES has been played in a variety of settings, with different participants, in different set ups. The differences between the versions are a combination of improvements resulting from previous sessions and fine-tuning to the knowledge and background of the players and their educational wishes and needs. A discussion of the results of the different sessions, as has been reported by the participants in evaluations and questionnaires, can be found in Van Bueren et al. (2002). For this paper it suffices to mention that the results of the game are promising: the approach offered participants a satisfying way of working, an overview of interests and opinions, a clearer picture of sustainability, cross-disciplinary discussions and useful outcomes (ibid.).

IMPROVEMENT POTENTIAL: FINDINGS AND DISCUSSION

The discussion in this paper will now focus on the improvement potential of the game design. To what extent has DUBES been able to offer an experiential learning environment, an environment in which players can learn to solve complex problems that are characterized by process complexity and substantive complexity?

Table 3 presents an overview of the strengths and weaknesses of the different components of the game as experienced by the participants during the various sessions. The information in this table is based on the debriefings with participants during the sessions and the questionnaires that they had to fill in during and at the end of the session.

Design variable	Strengths	Weaknesses / challenges
Scenario	Contains sufficient substantive and process complexity.	Make assignment more challenging by specifying targets or assessment criteria.
Role-play	Contains a variety of interests.	Esp. students need more information about interests/knowledge/expertise of the roles. Rules and resources should be specified.
MEDIA	Very informative, esp. the DUBES table is considered as a supportive tool.	MEDIA is experienced as a black box, due to: • Complex user-interface; indirect use through DUBES advisor. • Information overload. • Reality check is too loosely coupled to assignment, roles, rules and resources.
Process design	Experts experience process design as helpful tool to structure decision-making, especially separation of agenda setting from decision-making is valued positively (DUBES table prevents premature loss of information and closure).	Not all students are aware of help offered by the process design. Players (professionals and students) tend to get lost in details. Due to poor supportive role of MEDIA during part II, not all groups succeed to use this part for informed decision-making.
Overall design	For professionals: communicates substantive and process complexity to players, and players appreciate DUBES as a structured approach to tackle these. For students: communicates the complexity of decision-making.	For all participants: different complexities are understood, but game design should be improved when participants want to get a full understanding of how the approach and the various tools work and what they have to offer.

Table 3: Overview of strengths and weaknesses/challenges in the game design

Central lesson: tune game design to educational goals and participants

The table shows that despite the positive results of DUBES, substantial improvements can be made, which, in turn, can contribute to the educational performance of the game. Central message is that the lessons to be learned should be more explicitly specified in advance and tuned to the participants playing the game, and also the game design should be tuned to the group of players and the learning ambitions.

Participants remarked that the number of lessons transferred in the game is rather high. Professionals, who already have a full understanding of what urban renewal is about and who have been around in renewal processes, can grasp the essence of the suggested process managerial approach and have enough general knowledge of planning, housing and construction to see what the additional value of MEDIA is in terms of sustainability, irrespective of the way in which MEDIA is able to support decision-making in the game.

For the students that participated, the starting situation was entirely different. Most students lacked a frame of reference for two of the three main issues about which lessons were being learned. A mixed population of students from three different Master courses participated, and to some extent, they were able to fill in for the knowledge gaps of their fellow students. Students of Systems Engineering, Policy Analysis and Management had knowledge and understanding of process management, and already had some experience with gaming and simulation. It was often one of these students that took up the role of process manager, whether it was assigned to them or not, and made sure that the group fulfilled its task during the morning and afternoon sessions. Architecture students were familiar with planning processes and housing and construction and they could feed the group discussions with their knowledge. However, they were limited in number, which made it a heavy task for them. Students in Civil Engineering had very specified knowledge on the level of materials and construction and it was not always easy for them to see how their knowledge could contribute to the interaction process. Also, of the different groups of students, they were least familiar with group dynamics and cross-disciplinary cooperation, which made it quite a challenge for them to participate.

The lessons on process complexity seemed to have landed best amongst the players, whether they were students or professionals. Of course, with the different roles and interests present in the game, it is fairly obvious that drawing up a program of requirements results in a negotiation process, even though also this part should be improved in the future. Especially for students who have never been confronted with urban renewal or sustainable development, an improved design should be preferred, a design in which the roles become more focused on the achievement of ex ante specified results, results on which they are assessed during the game.

First improvements of the game design

In DUBES version 1.4, first improvements in this direction have been added. The role descriptions of students have become more prescriptive, i.e. the roles contain some goals that they want to achieve, and as a preparation for the game, students are asked to think about how they can achieve these goals, and who their potential allies and enemies are. During the game, an independent jury assessed whether they were successful in the negotiations. However, this

assessment was still of a highly qualitative nature, since not all goals were formulated in an assessable way. This not only was an obstacle for the jury, but it also hindered students who did not have strongly developed skills to play games, such as empathetic skills, diplomacy and sensitivity for what outcomes of the negotiations are acceptable for them and others. Also a more straightforward form of assessment was added: at the end of each session, students could vote on the agenda respectively program that they liked best. In this way, the students were extra challenged to pay attention to the potential support for their proposal, and they had to think of arguments that could convince the other students to vote for their proposal.

Students were also given an extra tool to formulate their proposals. In addition to the DUBES table, they received on poster format a table that helped them to formulate requirements. Students, but also professionals, have difficulty with formulating requirements. Often, concrete options are mentioned instead of requirements or requirements are formulated too vaguely and are therefore not able to give direction to the renewal plan. This extra tool was considered as helpful, which might also be useful when played with professionals.

To facilitate the substantive learning, a reality check was introduced in MEDIA. During the afternoon group discussions, the DUBES advisor put the formulated requirements in the design window in MEDIA. The preclusions, promises and problems window would then show whether the program would meet some basic demands, such as whether the proposed program remained within the available amount of square meters of the neighborhood, and whether it had enough water storing capacity, a crucial part of Dutch urban planning. In its current form, however, the reality check does not succeed in giving the required feedback to participants during the negotiations. Only when the entire design window had been filled, i.e. when all decisions had been made, the reality check could be performed, leaving the group with only little time left to revise the program. During the negotiations on specific parts of the program, MEDIA could not deliver information that was ready to use, unless it was operated by a professional in the field of sustainable construction and planning or when there was expert knowledge present in the group to quickly understand the information provided by MEDIA. However, in the sessions with professionals, each group often hosted experts in only a few specific areas, such as energy, water or material use. On the other decision areas the experts could not provide information.

Another effect of playing the game with professionals was that they started to evaluate and critically assess the contents of MEDIA, instead of using it as a decision support tool and it took a strong process manager to keep the groups on track. The result was that during the afternoon session, in which participants had to set priorities and make decisions, the supportive role of MEDIA was rather limited. Because of the pivotal role of MEDIA in this part, the process design scored rather weak as well.

GAME DESIGN CHOICES

The previous discussion of the weaknesses and challenges of DUBES shows that there are numerous opportunities to improve the DUBES game design, and the challenges already indicate possible directions for improvement. However, improving the game design is a resource intensive operation. For example, further improvement of MEDIA's interface is an enormous task, of which the results are uncertain. DUBES seems to be confronted with some fundamental design choices, which will be briefly discussed.

Instructive versus open game design

This is about finding a balance between pre-structuring the game for didactical reasons and keeping the design relatively unstructured to make optimal use of knowledge and creativity of the participants, and to stimulate participants to learn themselves (Leigh and Spindler, 2004). When dealing with such complex problems as sustainable urban renewal, every process is unique, in that it has its own participants, problems, opportunities and dynamics. By teaching players solutions rather than a structured way of managing interactions and knowledge development, the odds are high that players feel that the real world is different and that the lessons learned will not be of much help to them. A relatively open and unstructured game design would be preferred, provided that participants still learn the intended lessons. However, the game experiences show that participants, especially students, but also professionals, need more guidance in playing the game. The challenge is to provide this guidance, without letting the game evolve into a training of standard problems and solutions.

Learning about substance or process

This dilemma is about the balance between educating process complexity and educating substantive complexity of sustainable urban development projects. Professionals seem to have enough background knowledge and experiences with the different complexities involved to be able to play their role in the game and to learn substantive and process managerial lessons, provided that there is a large variety amongst participants in professional occupation, knowledge and experiences. For students, learning about three complexities at once seems to be a very difficult task, and they heavily rely on the tools offered in the game. However, in improving the game design, it is important that a combination of learning about both complexities is maintained. After all, it is this combination that is at the heart of DUBES. When one of the two would be left out, this would lead to unbalanced learning processes and during the game, students would fall into the trap of focusing on either process or on content, which would not likely result in a sustainable renewal program. Improvements may take place by reducing the complexities for participants during the game, however, it is important that both forms of complexities remain present in the game. Such reduction can, for example, take place by stronger structuring of the roles and the assignment, or, additional tools can be offered to participants, such as the requirements table, which helps the players to understand the situation they are in and what they can do.

Using negotiated knowledge or negotiating knowledge

The contested character of knowledge in decision-making processes in which multiple actors, perceptions, values and disciplines are involved is a central problem of decision-making for sustainability. MEDIA is a program that contains knowledge from various perspectives on a large number of decision areas that can be addressed in urban renewal. The information in the program is the result of the input of a large number of experts and has been improved in workshops with a variety of experts, and is therefore already of a negotiated character. Nevertheless, when the game was played, both experts and students started questioning the information in MEDIA. One of the crucial factors contributing to the distrust seems to be the lack of knowledge of the discussion that led to the information in MEDIA. The

value of negotiated knowledge thus seems to be limited for actors who have not been involved in the negotiations. The resulting improvement challenge is that the design should leave room for some discussion about MEDIA and its content, but this discussion should take place within the boundaries of the game. Already MEDIA offers the possibility to add, on limited scale, decision-areas and options. Another option may be to have MEDIA operated by players themselves, instead of by DUBES advisors. However, the players should keep in mind that MEDIA is just a supportive tool, not a prescriptive one.

CONCLUSIONS

The design choices that have been identified in the previous section set the agenda for further development of DUBES, of the game, the approach and the tools. With the improvements, it can become a powerful training instrument for a wide audience that succeeds in bringing sustainable development to the attention of students and professionals in a pleasant way. There is wide support amongst professionals for the DUBES approach, resulting in projects in which DUBES is applied to other areas, such as underground construction and the planning and construction of roads. Also teachers at universities and polytechnics and training firms and consultancies in the field of sustainable urban development and/or sustainable construction follow further developments with great interest. However, to fulfill the promises of DUBES and to keep actors interested, the DUBES team will have to make some fundamental improvements in the game design, as set out in this paper.

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