A CONCEPTUAL MODELLING FRAMEWORK FOR STAKEHOLDER PARTICIPATION IN SIMULATION STUDIES

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ABSTRACT:
This paper describes a framework and tools that enable stakeholder participation in the development of conceptual models in simulation studies. The suggested framework utilises tools from soft systems methodology, a problem structuring approach, but it is also influenced by group model building in system dynamics. Its aim is to support the simulation modeller in developing a conceptual model with the stakeholders, which in turn, could lead to a more successful simulation study. The motivation for this study comes from health care where evidence suggests that one factor inhibiting implementation of simulation study results is the limited participation of the stakeholders. We focus on conceptual modelling, which is about understanding the problematic situation and deciding what and how to model. Our framework is generic and applicable in domains other than health care.

Keywords: conceptual modelling, stakeholder participation, framework, modelling process.

1. INTRODUCTION
This paper explores the use of participative modelling to assist with the development of conceptual models in discrete-event simulation. Conceptual modelling is understanding the problematic situation and deciding what and how to model. We describe our approach including the suggested framework and tools, which can be used to assist modellers and healthcare practitioners involved in a simulation study.

Discrete-event simulation (DES) has been widely used in healthcare modelling. Over the past forty years it has become a popular decision making tool to support the improvement of healthcare provision of service and cost reductions (Jun et al. 1999, Jacobson et al. 2006). The ability to explore alternative scenarios through the use of a computer model rather than experimenting with the actual system of interest makes the use of simulation modelling appealing to healthcare practitioners. Despite the marked increase in the use of simulation in health care over the last forty years, only a limited number of studies have been reported as successful or had an impact on policy making. The findings of healthcare simulation models rarely find a way towards implementation (Fone et al. 2003). One of the main reasons leading to incomplete simulation studies is reported to be the inefficient communication between the simulation experts and the stakeholder team (Lehaney and Hlupic 1995). Hence, the premise of our work is that user participation in key stages of a simulation study can potentially lead to successful simulation studies, where stakeholders are involved in the process and take responsibility for the implementation of the simulation study findings.

A number of studies have already been reported in the literature, attempting to introduce a participative approach to simulation modelling, most of which happen to be in healthcare (Lehaney and Hlupic 1995; Lehaney and Paul 1996; Lehaney et al. 1999). These studies provide an account of specific simulation studies using softer approaches, such as Soft Systems Methodology (SSM), as a structured approach to initiate debate and to enable understanding (Checkland 1999).

However, a formal step-by-step guidance that can assist modellers and practitioners in developing simulation models has yet to be developed. Baldwin et al (2004) propose a Modelling Approach that is Participatory Iterative for Understanding (MAPIU), that aims to enhance stakeholder understanding and communication in health care simulation studies. The focus of the MAPIU study is mainly on project management, providing useful guidance in terms of the
activities followed regarding the initialization of the study, processing of information, the modelling component and communication between project participants. The study highlights important aspects that one needs to be aware of when developing a simulation study such as roles in the stakeholder team, power and politics in the stakeholder organization, types of communication, etc., but does not specifically provide a toolkit for the development of conceptual models. Van der Zee (2007), on the other hand, suggests the development of a participative modelling framework for simulation in manufacturing, taking an engineering approach.

In this paper we put forward a framework and tools, consisting of two facilitated workshops that guide the development of conceptual models in a structured and participative way. The outcome of this process is an agreeable and feasible conceptual model. The proposed framework takes forward already existing work that suggest the development of conceptual models using SSM (Kotiadis 2007, Pidd 2007). The framework adapts a range of tools from SSM but is also influenced in its approach by Group Model Building (GMB) in systems dynamics. GMB consists of a relatively structured approach to developing system dynamics models, that incorporates active stakeholder (called client) participation throughout the modelling process, (Andersen et al. 2007). The framework has been independently applied by various system dynamicists. Indeed, Andersen et al. (2007) and Rouwette and Vennix (2009) identify six streams of group model building, which may have not been referred to as GMB interventions, but have in common stakeholder participation. These are: the reference group approach, the Strategic Forum, the stepwise approach, modelling as learning, strategy dynamics and the ‘standard method’ of Hines. This is probably a reflection of modellers’ preferences, personal approach and skills in practicing GMB. Despite the plethora of research on GMB in system dynamics, there does not exist a generic framework followed during GMB interventions (Rouwette et al. 2002).

In brief, GMB interventions have as a main objective knowledge enhancement within the team, by eliciting and sharing mental models. Vennix (1999) maintains that stakeholder involvement serves three main reasons: it captures stakeholder’s mental models and the associated knowledge about the situation, increases the chances of implementation of model results and enhances stakeholder’s learning process. In the next sections, we reflect on GMB in terms of stakeholder participation and the techniques used for knowledge elicitation.

2. GROUP MODEL BUILDING IN SYSTEM DYNAMICS

In this section, we review the literature on Group Model Building (GMB) with the view to determining potential contributions towards DES modelling. GMB is considered to be a flexible approach to system dynamics modelling, where one can start the process from scratch or develop preliminary models, which are further discussed in individual interviews or group sessions through the development of small or large models (Rouwette and Vennix 2009). Since its beginnings in the 1990s, group model building has been associated with system dynamics modelling. For more information on system dynamics modelling the reader is referred to Forrester (1961) and Sterman (2000).

The field of GMB matured with the ideas and the work done at Radboud University at Nijmegen (Netherlands) and at SUNY at Albany (USA). Most interventions take the form of 2-4 workshops, involving a backward cycle between stages to provide the stakeholder with feedback and reports from the sessions (Rouwette, Vennix et al. 2002).

The rest of the paper is structured as follows. In the following section, we explore the literature on group model building, identifying potential tools to utilise in discrete event simulation. Next, our proposed approach and tools are presented, followed by a discussion and reflections on the suggested framework.

2.1. The approach to stakeholder participation

We review GMB in terms of the approach taken to stakeholder participation, as the means of developing a basis of interaction between the stakeholders and the modelling team. GMB has been independently applied by various system dynamicists. Indeed, Andersen et al. (2007) and Rouwette and Vennix (2009) identify six streams of group model building, which may have not been referred to as GMB interventions, but have in common stakeholder participation. These are: the reference group approach, the Strategic Forum, the stepwise approach, modelling as learning, strategy dynamics and the ‘standard method’ of Hines. This is probably a reflection of modellers’ preferences, personal approach and skills in practicing GMB. Despite the plethora of research on GMB in system dynamics, there does not exist a generic framework followed during GMB interventions (Rouwette et al. 2002).

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stages: pre-meeting activities, the actual group meetings/sessions and follow-up activities, which require the implementation of different tasks. The actual group modelling session in particular refers to the activities carried out during the day, where simulation models are built in interaction with the stakeholder, such as agreeing meetings and participants, the modelling procedure, facilitation aspects and logistics. Andersen and Richardson (1997) provide so-called “scripted techniques” in the form of activities and tips to be followed during a group model building session. They strongly suggest setting a detailed structure of the modelling session, including a public general agenda (which is distributed to the stakeholder team) and the team agenda, which includes detailed and smaller tasks (used only by the modelling team). Advice is provided for the facilitator as well as a number of scripted techniques for defining the problem, conceptualizing the structure of the model, eliciting the systems’ feedback structure, supporting equation structuring, etc. (Andersen and Richardson 1997). Some useful insights can be gained from these scripted techniques, however, most of them concern technical aspects of system dynamics modelling and are not readily transferrable to discrete-event simulation modelling.

2.2. Techniques for knowledge elicitation

Knowledge elicitation is another aspect referred to in the Group Model Building literature. The main underlying premise is that people hold different views on whether there is a problem and if they agree there is one, what the problem is (Vennix 2001). Therefore, understanding the cognitive tasks involved during the modelling process and choosing the correct techniques is considered important. In a review of the techniques used for knowledge elicitation in GMB Vennix et al. (1992), identify that a variety of techniques for knowledge elicitation is used in group modelling sessions. In an attempt to provide a guide for system dynamics modellers the same authors maintain that different cognitive tasks require different knowledge elicitation methods. They identify three types of cognitive tasks involved in system dynamics modelling:

- Elicitation of information. This type of thinking is often involved in the phases of problem definition or model conceptualization. Some reported techniques used include interviews, cognitive mapping (Eden 1988), brainstorming and workbooks (the latter is a type of questionnaire where materials and the structure of the system are presented alongside with questions for individual participants to comment on, for more information go to (Vennix 2001)).
- Exploring courses of action or convergent thinking. These types of activities are less developed. It involves mainly problem solving processes, such as discussions about alternative problem formulations, model structures and suggestions for different policy options.
- Evaluation. It involves an evaluation of various aspects regarding the model, such as: data inputs, validity of model output, performance of suggested policies, choosing between alternative structural formulations or choosing between different policies for investigation. Evaluation is made using either judgment (assessment of a topic or issue on some scale) or choice (selecting one or more topic/issue). A number of techniques that can be used to help reaching consensus have been referred to such as: Nominal Group Technique (Delbecq et al. 1975), Delphi (Dalkey and Helmer 1963) and Social Judgment Analysis (Rohrbaugh 1979).

2.3. Reflections on group model building

Given the extensive literature pertaining to system dynamics modelling, it is surprising, that in discrete-event simulation modelling very little has been reported on the development of conceptual models involving stakeholders. Whilst stakeholder participation is considered a prerequisite for the success of a simulation study, rarely modellers report on the extent and the way the stakeholders are involved in the DES study. Several reasons could explain the limited knowledge developed regarding stakeholder involvement in DES modelling. Firstly, it can be argued that stakeholders are little or not at all familiar with the simulation modelling software and the related technical aspects. Hence, attempting to develop models in meetings with stakeholders would not prove beneficial. Secondly, a participatory modelling framework does not exist, which can assist and guide the simulation modeller to methodically involve the stakeholder during the model building process. Furthermore, conceptual modelling has been generally considered an art rather than a science (Robinson 2006), making the process less explicable for the modellers themselves let alone explaining the process and steps involved to the stakeholders.

Indeed conceptual modelling is the least understood stage in a simulation study although more recently the topic has gained the increased attention of the simulation modelling community (Kotiadis and Robinson 2008). A special issue on
conceptual modelling was recently published in the Journal of Simulation (Robinson 2007a). Some efforts have been made to standardise the representation of conceptual models. Onggo (2009) for example, proposes a multi-faceted conceptual model for the representation of necessary components for an effective communication of mental models between stakeholders, domain experts and modellers. The development of a standardised process for building conceptual models can aid in surpassing the aforementioned difficulties. Van der Zee and Van der Vorst (2007) suggest the development of domain-specific frameworks for the development of conceptual models. They provide guidance in developing conceptual models in manufacturing simulation, taking into account the specific structure of manufacturing systems based on engineering principles. In the next section the PartiSim approach is explained.

3. THE PROPOSED PARTISIM APPROACH

The PartiSim approach stands for Participative Simulation in Healthcare. It consists of a framework and relevant tools. The framework is based on the typical stages of a simulation study as suggested in simulation literature (Robinson 2004, Law 2007) (Figure 1). The novelty of this approach is that it embeds stakeholder participation in the form of workshops as part of the specific stages of the study. These stages are represented in bold in Figure 1. The suggested framework consists of six main stages:

1) Initiate the study;
2) Define the system (conceptual modelling – part 1);
3) Specify study objectives (conceptual modelling – part 2);
4) Develop the simulation model;
5) Experimentation and
6) Implementation.

The focus of this paper is on the conceptual modelling stage of a simulation study. Hence we concentrate mainly on stages 1 to 3 (and briefly stage 4) of the PartiSim framework. Stages 5 and 6 are not covered. The PartiSim framework supports the development of conceptual models in the main activities involved: understand the problem situation, determine modelling objectives, identify model inputs and outputs and determine model content (Robinson 2007b). Next, we proceed with the description of the PartiSim stages for the development of conceptual models.

![Figure 1: The PartiSim modelling framework and stages](image)

3.1. Stage 1: The initiation of the study

The first stage involves the initial activities involved in preparation for the simulation study. There might not be a specific starting point for this stage, however there will be a vague recognition that a simulation study is required, the simulation analyst (a modeller or a modelling team) has been commissioned and a project team is starting to be identified. Two are the main tasks that the modelling team should pursue at this stage: to gain an understanding of the situation of interest and to identify the project team. Some preliminary outputs are developed, with the view
to using these in facilitated workshops in the next stages of the PartiSim modelling process.

The main reason for developing preliminary outputs is to ease the group processes during the actual PartiSim workshops. Starting with a blank piece of paper might be time-consuming and unproductive. It is also believed that using preliminary outputs helps instigate discussions in facilitated workshops. From his experience in GMB interventions, Vennix (2001) reports that putting in front of the group an initial model can stimulate discussions.

These preliminary outputs are dependent on the modelling team’s exposure to the situation of interest and the level of contact with the various stakeholders. Even though the effort made at this stage is left to the modelling team’s judgment, it is advised that some preliminary outputs are developed. This depends on the specific type of study as well as the time the stakeholder team is willing to spend with the modelling team at this stage. Some suggested preliminary outputs are: problem definition using SSM root definition(s) or a simple statement of the situation; simulation study objectives; purposeful activity diagram; process flow diagram; performance measurement model (Kotiadiis, 2007). A more detailed description is provided in the following sections (3.2 and 3.3).

3.2. Stage 2: Structuring the situation of interest

The second stage in the PartiSim framework takes the form of a facilitated workshop (Workshop 1), where a prior selected group of the stakeholder team has been chosen to participate. In these workshops the efficient management (facilitation) of the group is crucial. This in turn can enhance stakeholder participation and the chances of deriving the desirable workshop outcomes. The aim of this workshop is to reach to a common understanding of the situation of interest. This is the very first workshop where all PartiSim group members get together in the workshop room. The first workshop can range from half a day to a whole day. It can be also combined with workshop 2 (section 3.3.) in a full day session if it is difficult to get the stakeholders together for workshops on different days. A schedule for the activities planned for the day should be also set up in advance and agreed with the project champion (a key stakeholder that is enthusiastic about the project and serves as the link between the project team and the stakeholders) and preferably a public and a detailed team agenda based on Andersen and Richardson (1997). The detailed agenda should include smaller tasks that can be completed in small time slots (i.e. 15 minutes), in order to keep the group alert and focused (Andersen and Richardson 1997).

In the first workshop, the situation of interest is explored utilizing tools borrowed from SSM. Indeed, Pidd (2007) and Kotiadiis and Robinson (2008) suggest that SSM tools can be used to aid conceptual modelling. The former suggests the use of root definitions to support problem understanding, whereas the latter consider developing rich pictures, analyses One, Two and Three and purposeful activity models to move from a system description to a conceptual model. The key outputs produced in the second stage are: the CATWOE and root definitions and the Care System Model.

3.2.1. CATWOE and root definitions

A good starting point to initiate discussion is to consider what the core purpose of the system of interest is. This coincides with the definition of the transformation process carried out in the system. Next, the transformation process is further defined in terms of the CATWOE, which serves as a mnemonic of six core aspects that characterize the system studied. For further information on the CATWOE elements the reader is referred to Pidd (2007) and Checkland and Scholes (1999).

After having discussed each CATWOE element separately, the views and ideas discussed are put together in a root definition. The root definition, conveys the core purpose of the system of interest in the form of, do X by using Y to achieve Z (Checkland and Scholes 1999). It can specify the views about the current or the future system as visualized by the modelling team (as a preliminary output) and subsequently as visualised by participating stakeholders. During the workshops, discussions about the CATWOE elements and root definitions can raise a variety of views and issues, which may happen to be unknown to some other participants. The discussions and issues raised most often will depend on the group dynamics. However, the group facilitator needs to be aware of this and ensure that all members participate in the discussions. Group work techniques (Vennix 2001) need to be utilized to ensure a productive discussion emerges. This discussion ensures that at a first instance a common and agreeable understanding of the situation of interest is achieved by all workshop participants and the high level objectives to be undertaken by the study are discussed.
3.2.2. Care System Model (CSM)

The next step involves developing a care system model (CSM) structured in three parts. A CSM is a simplified description of the system, representing the main activities that bring about the transformation process already identified in the CATWOE and root definition (section 3.2.1). The CSM is based on the purposeful activity model in SSM, but adapted to fit healthcare situations. The process of building a CSM consists of collecting the verbs that describe the activities that take place in the system, as named in the root definition and structuring these based on the logical dependencies involved (Rosenhead and Mingers 2001). We believe that three separate parts should be included in the CSM, clinical, managerial and research activities that support that care system. For merely illustrative purposes, an example of a CSM is shown in Figure 2, where the relevant activities are entered in each part of the diagram. The reader should however realize that the activities included in a CSM depend on the situation at hand.

The clinical activities consider the care system from an operational perspective, with regards to the flow of services and/or patients through the care system. These are usually transformed into a computer simulation model (in stage 4) because these represent a more concrete representation of the processes occurring in the system of interest. The managerial activities refer to the activities required to design and support the management of that system at a strategic level, but it can also include the administrative tasks involved. The research activities consist of activities that support the clinical research studies, which often are an additional requirement in healthcare settings.

At the end of the facilitated workshop, participants are asked to compare the system representation in the CSM to the “real world” situation. The main aim is to identify activities that are not taking place or activities that need improvement. This coincides with the third methodological cycle in (Checkland and Scholes 1999), where for each activity in the PAM the team considers whether a) this activity exist in reality, and if so b) how is it perceived as well as c) what changes might be considered as both desirable and feasible. The discussion involved here serves as a means of validating the models developed so far, as well as to discuss the study objectives. Comparing this PartiSim modelling section to the third methodological cycle in SSM, it is clear that in the latter the actions for intervention in the system are specifically revealed based on the task of comparing the SSM models developed with the real world, whereas the PartiSim framework provides further opportunities for discussions on this aspect at later modelling stages.

3.2.3. Summary of the second stage

The second stage of the PartiSim framework involves a facilitated workshop environment where the stakeholder team and the modelling team debate the current situation. The preliminary outputs (section 3.1) developed during the first stage by the modelling team now are revisited and restructured. This is now possible due to the change in perceptions and the learning occurred during the group discussions. A benefit of using SSM in this stage is that it provides useful tools that “make[s] the thinking process coherent and capable of being shared” (Checkland and Scholes 1999, pp. 67). After the completion of workshop 1, a backward cycle follows where the modelling team reports...
back to the stakeholder team the CATWOE and root definition and the CSM for reflections.

3.3. Stage 3: Specify simulation objectives (Workshop 2)

The third stage of the PartiSim framework is again performed in a facilitated workshop environment with the aim to further establish the simulation study objectives and to identify model contents and its inputs and outputs. The simulation study objectives are extracted using the performance measurement model (or 3 Es) as explained in (Kotiadis 2007) (sections 3.3.1 and 3.3.2). Some discussion regarding the simulation study objectives may have already been made in stage 2 (Workshop 1), at this stage the discussion builds on the understanding developed so far, by focusing on the definition of the criteria used to judge the performance of the system (Checkland 1999). Based on the objectives agreed the model contents are agreed by developing the communicative model (section 3.3.3).

3.3.1. Performance measurement model (PMM)

The second workshop starts with the task of developing the PMM model as specified in (Kotiadis 2007), based on the three performance measures (3Es) of SSM (Checkland and Scholes 1999). The aim of the first part of workshop 3 is to facilitate participant discussions on the three performance measures. From these discussions a number of activities that are used for performance measurement (evaluating) the system will emerge. The modelling group should have been able to develop a preliminary PMM based on the information extracted from the prior meetings and the literature. This can be further modified in light of the knowledge gained during the Workshop 1. In this stage the preliminary PMM is further refined based on participants’ collective views.

For further information on how to construct a PMM the reader is referred to Kotiadis (2007). The PMM is appended at the bottom of the CSM already developed in Workshop 1. As a result of developing the PMM a number of actions in the form of improvements or changes to the system of interest are suggested.

3.3.2. Simulation study objectives

In the second part of Workshop 2, the suggested improvements/ actions to be taken in the system of interest are further considered in order to reach to agreeable and feasible simulation study objectives. The recommended steps, based on Kotiadis (2007) are as follows:

- The modelling team selects from the PMM model the actions/changes to be undertaken, that can be explored in a potential simulation model.
- The actions/changes selected are then considered in a round-table discussion, where further potential changes may be discussed. These are further grouped in a logical order to specify simulation study objectives, which are agreed among participants.
- Based on the objectives agreed the team is required to identify the inputs and expected model outputs.
- Optionally, after the workshop an iteration of modelling objectives between the stakeholders and the modelling team is suggested.

The discussions involved result in establishing simulation study objectives and also model inputs, in the form of experimental factors to be tested and expected model outputs, in the form of model results.

3.3.3. Developing a communicative model

In the third step of the PartiSim framework, further model abstraction takes place, where the team moves from the CSM to deciding the simulation model contents, which are visually represented in a communicative model, called herein Patient Flow Diagram (PFD). The latter is further transformed into a computer simulation model in stage 4 of the PartiSim study. The PFD, equivalent to process flow diagrams in discrete-event simulation, is suggested it is considered to be a simple approach (Robinson 2004) and it can therefore be more comprehensible for participants with little or no knowledge of simulation modelling. Queues and activities are the basis of DES models (and most DES software) so using process flow diagrams is a reasonable approach to expressing the communicative model. To the authors’ opinions there is a more straightforward connection between a CSM and a process flow diagram. The clinical activities depict the care system at an operational level and hence can be more relevant to the sequence of activities/process (represented in boxes) and queues (represented in circles) in the PFD. It is hence, easier to move back and forth between these two models, allowing iterations between different PartiSim stages.

3.3.4. Summary of stage 3

Workshop 2 uses the PMM model to elicit the simulation study objectives, model inputs and outputs and its contents. The novelty that the PartiSim framework brings along with the third stage is involving stakeholder participation in establishing the simulation study objectives. The
first 3 stages can result in the development of a conceptual model, which has been collectively agreed by all participants and more importantly stakeholders. However, to ensure full acceptance of the outcomes accrued so far it is suggested that these materials are fed back to the team to comment on. During this stage some data inputs may be revealed, however specifications for data requirements should be discussed and formally agreed. This will be crucial for the execution of stage 4, where the conceptual model is converted into a computer model. The modeller(s) develop the code of the simulation model, working closely with other project members. It is essential that open routes of communication with the stakeholders are maintained during stage 4.

4. DISCUSSION AND CONCLUDING REMARKS

This paper suggests a structured approach to conceptual modelling involving stakeholder participation in the development of a simulation study. The stages involved in the PartiSim framework suggested are based on the conceptual modelling process specified in (Robinson 2004). The processes followed in this framework and due to the workshops involved, may at first sight depict a linear process (Figure 1). It should, however, be mentioned that the process involves iterations between stages and one needs to be aware of this when applying the framework. For example, moving back and forward between the PAM, the process flow diagram and the computer model, or the root definitions and the PAM, can effectively result in a commonly agreed and feasible model. When implementing the PartiSim framework on needs to be continuously seeking for reflections on previously developed outputs, involving especially the stakeholder team.

The PartiSim approach aims to develop a tool that supports the effective and efficient participation of healthcare practitioners in a simulation modelling study. We will now reflect on two aspects of the PartiSim approach: stakeholder participation and knowledge elicitation.

4.1. Stakeholder participation

One of the main contributions of the PartiSim approach is bringing stakeholder participation in the simulation study, by structuring the process in stages, which include facilitated workshops. A similar approach is taken in GMB (Vennix 2001), which is mainly focused on facilitating stakeholder participation in system dynamics modelling studies. Despite being geared towards system dynamics modelling, the knowledge developed in group model building can inform the development of participatory modelling in DES. Considering that DES and system dynamics are both simulation techniques widely used in healthcare modelling it is believed that an exchange of knowledge and insights is beneficial.

In both group model building and in the PartiSim approach, facilitated workshops are considered to be a creative environment for the extraction of useful information (in the form of mental models) towards the development of conceptual modelling. Workshops play an important role, not only in providing the stakeholder team the possibility to express their views about the situation of interest, but also in reaching to a consensus on the views expressed. The main contribution of the PartiSim approach is to provide a structured approach to stakeholder participation based on the typical stages of a DES study. By identifying the absolutely necessary modelling stages that require stakeholder participation it assists not only in efficiently utilising the stakeholder’s time, but also in developing a robust framework that can be adopted in different simulation studies. The PartiSim approach suggests using in total four workshops, where the first two focus on conceptual modelling.

GMB interventions are structured in three general stages: pre-meeting activities, actual group modelling sessions and the follow-up activities. The activities involved in each stage are identified in (Andersen et al. 1997), but the number of workshops required is not specifically indicated. One can consider relevant the view taken in GMB that it is not possible to specify in advance the number of workshops required. As has already been mentioned due to the different approaches taken in GMB, there is not a pre-specified and accepted framework to drive GMB interventions. We believe that the strength of the PartiSim approach is that it provides a structured approach to modelling that can assist the modeller and particularly less experienced modellers to plan and run a simulation study effectively. The suggested framework relies on a number of tools which can enable the completion of the study in the stages and workshops already specified.

4.2. Knowledge elicitation

The knowledge already developed in SSM and GMB has provided useful insights for the development of the PartiSim approach, especially in terms of developing an agreeable and feasible conceptual model. Obviously, the tools used are relevant to models created in each approach. For example, the questionnaires and workbooks used in GMB are designed around the causal relationships between variables in order to derive the causal
structure (Vennix and Gubbels 1992), which is the basic structure of system dynamics, but not DES. The tools used in SSM are more suitable for problems with softer connotations and the conceptual models developed serve as the source for the decisions made. The contribution of the PartiSim approach is that it combines and adapts a number of knowledge elicitation techniques from SSM and GMB. The tools obtained from SSM are: CATWOE and root definitions, purposeful activity models and the three performance measures. Some tools from GMB that could be beneficial in a PartiSim study are: some scripted techniques for the modelling sessions (Andersen and Richardson 1997), knowledge elicitation techniques (the nominal group technique, social judgment analysis, brainstorming, workbooks, etc.).

The PartiSim framework represents a structured, but flexible approach for the development of a discrete-event simulation study, one can choose and/or mix and match the suggested tools according to the project, the stakeholder team or the modelling skills available. The suggested framework is considered to be more beneficial for less experienced modellers, who are advised to follow more closely the steps specified in section 3. The main elements, part of conceptual modelling, developed using this framework are: gaining an understanding of the problem situation (stage 1 and 2), determining modelling objectives (stage 2 and 3), identifying model inputs and outputs (stage 3), determining model content (stage 3), and collecting data inputs (stage 3 and stage 4).

The main contribution of this paper is that it provides a generic participative framework for developing conceptual models involving stakeholder participation. Stakeholder participation is deemed to be crucial and it can significantly enhance healthcare simulation study outcomes and its prospects for implementation. The authors have already applied previous versions of the PartiSim framework and are also planning to apply it to other healthcare studies, but are also hoping that more modellers will report on the results of using the framework in their studies. The PartiSim approach can be used to develop conceptual models, not only in healthcare, but in other domains. A similar framework is being developed to assist experimentation and implementation of simulation studies.

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