

2.3 Quality of Business Process Models

Although we have described above the quality aspects of different types of system representations, many of which are also relevant for process models, we will herein present the relevant work that particularly examines the quality of (business) process models. First, however, we examine the aspect of the quality of business processes.

2.3.1 *Quality of Business Processes*

As discussed in Chap. 1, a good business process is one that optimizes one or more of the following:

- Time,
- Quality,
- Cost,
- Flexibility,
- Resource usage,
- Unwanted side effects,
- Operations according to regulations.

The aspects that are to be emphasized also influence the quality evaluation of the supporting business process models, e.g., that the models particularly include the representation of the information needed to evaluate these aspects. It is not possible to optimize according to all these dimensions simultaneously; thus, as part of the goal of the business and, secondarily, as a goal of the model of a future improved situation reflecting the business, one must select what type of improvement to focus on. This improvement strategy is often linked to the overall image that the organization attempts to establish for its products and services; thus, there is no standard answer on how to optimize. Because different patterns of improvement optimize different dimensions, one must select which patterns apply in which cases.

Based on Andersen Consulting (1997), Dumas et al. (2013), Rosemann and Recker (2015), and Willoch (1994), a number of enhancement patterns and heuristics can be identified. We will here structure these according to the seven Rs described in Chap. 1 and use examples from the conference organizing domain on each heuristic. In doing so, it should be clear that different optimizations are good based on different goals. We will also observe that improvements in practice are often a combination of different Rs, as also illustrated in the first case from the healthcare sector presented in Chap. 1. As for the conference domain, Fortnow (2011) lists a number of reasons for having conferences:

1. To rate publications and researchers.
2. To disseminate new research results and ideas.

3. To network, gossip, and recruit.
4. To discuss controversial issues in the community.

In most fields, items 2, 3, and partly 4 are most important, although also the first is relevant, in particular in the IT area.

Rethinking (Why is the process there at all)

Rethinking is about clarifying and challenging the rationale and assumptions behind processes and their outcomes. This area is different from the other six because challenging an assumption does not necessarily lead to a solution. However, it does allow for more creative thinking. The other six areas can then be used to generate new process designs that address the new goals.

This area is a reminder to ask essential questions, such as the following:

- What is the root cause of the problem? Example: A conference may have a problem with obtaining detailed reviews on papers and thus have a limited basis for choosing the papers to be accepted. A root cause of this problem may be that the reviewers receive too many papers to review in a limited amount of time or the papers do not fit the interest and expertise of the program committee members. This issue relates not to the actual review process, but possibly to the process of organizing the program committee (with too few people familiar with the area of the conference).
- What are the reasons for doing it in this manner? Oftentimes, the exercise of articulating *why* the organization does the things it does quickly reveals reasons that are unknown, not compelling, easily changeable, or no longer valid; additionally, the reasons may be valid, but not relevant because the desired outcome can be achieved in some other manner. Once the reasons are articulated, they can be probed and challenged and either discarded or accepted as explicit constraints to innovation efforts. Example: A conference may have as a focus to publish the best technical papers and reject paper with novel ideas that are yet not fully validated. However, if one only focuses on the good technical papers, then one obtains fewer submissions because, instead, researchers will have these papers published in journals. Additionally, allowing papers with novel ideas that are evaluated according to slightly different criteria may make attending the conference more worthwhile because conferences are regarded as good places to discuss new ideas.
- Is this process sufficiently valuable to continue? Should the process be fixed or eliminated? Example: If the interest in a conference is reduced with fewer papers submitted and fewer people participating, one may do things to increase interest or perhaps instead join forces with another conference (as an accompanying event/workshop), piggybacking on the interest and organizational efforts of the other event.

To be able to reason about this, the *goal* of the process model should be captured in some manner as part of or related to the main process model.

Reconfiguring the Process (What)

Reconfiguring focuses on what work is being done. Some heuristics for this area with examples are described below.

Eliminating an activity, e.g., eliminating intermediaries and non-value-adding work: When submitting a paper, one should also enter certain metadata, e.g., keywords according to a predefined classification. Rather than checking this after submission, one can automate the control of this in the user interface of the conference system.

Inserting a new activity: When using a conference system, one has user identification through, e.g., the username and password. Even if login to the system is then introduced as an extra step when, for instance, entering a review, it ensures that the right person enters the assigned review (and not, e.g., the author himself).

Consolidating activity: If a process consists of sequential tasks performed by many different people with special competences, two problems often arise:

1. The tasks take up too much specialist time.
2. It is difficult to track the status of the process because there are many persons involved.

One solution to this problem is to give one person or a group the main responsibility for the process. This person or persons can execute smaller tasks between the specialist tasks. In this manner, the specialists can release time for other more important duties, and the customer has one contact point where he or she can have all of the desirable information. The role of a PC chair in controlling the overall review process is an example of such a strategy.

Dividing a practice into two subsequent practices (decoupling horizontally): A task can be divided into two subsequent tasks, e.g., because the different parts are better undertaken by different persons. When writing a paper, one typically conducts a language check at the end. If the main author is not good at writing in English, one may choose to have another person (or organization, e.g., a professional proofreading company) conduct the language check.

Buffering: Instead of requesting information from an external source, one should buffer it and subscribe to updates. Instead of starting from scratch when organizing a program committee, one maintains a database of potential PC member candidates, inviting a selection of these to the program committee. If one needs more PC members (e.g., due to more submitted papers than expected), one has a reserve of additional potential PC members and reviewers readily available.

Dividing a practice into two parallel elements (decoupling vertically): When writing a paper, one may accelerate the process by having different people write different parts in parallel. For example, one might write the background part in parallel to someone else writing the contribution part.

Integrating two subsequent practices: When a final version of a paper is to be delivered, one also has to provide a copyright transfer form. Although, logically, there are two different processes that can be done sequentially, one can ensure that both are done simultaneously, e.g., when using a paper submission tool.

Reducing reconciliation by putting quality at the source: One should also mandate that the submission of original papers is done according to the final format and length limitations by sharing these guidelines with people who want to submit a paper. Although it is not strictly necessary to enforce these guidelines before papers are accepted, having done so will mean fewer problems for the authors of accepted papers in terms of getting a (possibly much too long) paper in the right format and length and simultaneously address comments by reviewers.

Specializing the process according to the case type: In a conference, one may want to have different processes for different paper types, e.g., having more reviewers for certain types of papers.

Having specific ways of treating exceptions: Business processes should be designed for typical cases, addressing exceptions outside the normal flow. In a conference, one should be able to address cases of plagiarism but not have this ability as part of the normal flow. If plagiarism becomes a large problem, then one may include a system to check for plagiarism as a standard part of the review process (which is often done in journals).

Reducing the number of inputs and outputs in a process: High numbers of input and output flows between different departments and groups within an organization increase organizational complexity. The chances of misunderstandings and errors are high, and the many parallel flows can also delay the process execution. A large number of input flows can result in a bottleneck. For example, when developing and submitting the final version of a paper, one needs the information on acceptance/rejection, the comments to be addressed, a description of the format/length of the final paper, and information on a copyright transfer form. In some cases, the last may not be ready when the acceptance is ready to be sent. Because the main work to be performed is updating the paper, one can send the acceptance and comments as soon as they are available, whereas the copyright transfer form, which basically has to be signed, can be sent later (although before the deadline for the submission of the final version of the paper). A process with many outputs can similarly act as a bottleneck if everything has to be ready before anything can proceed. For example, one may send out rejection letters later than acceptance letters because the timing issue (from the perspective of the organizers of the conference) is not as acute for a rejection (for the author, rejection information may actually be more time-critical because it may enable them to rework the rejected paper to submit it to another venue).

Making a previously obligatory activity optional: A conference may require that all accepted papers should include a description of the changes the authors have made when delivering the final paper. A change in this situation would be to only do so in the case of borderline and shepherd papers.

Borrowing and improving on best practices from other industries: In recent years, many companies have improved their processes by benchmarking across industry lines. For example:

- In a large conference, one may provide guidance for which session to attend by using recommendations similar to what is done in the recommender systems of Amazon, Netflix, etc.
- A mobile phone company learns delivery management techniques from a leading pizza delivery company.
- An office equipment company improves its warehouse productivity by analyzing the methods employed by a US-based catalog retailer.
- An international manufacturer obtains ideas for cost-cutting and improving customer service from a computer parts wholesaler and a major auto company.
- A medical center, realizing that patients judge their hospital experience not only based on the quality of care but also based on how much time, hassle, and paperwork are involved, uses an international hotel operator to help redesign its admitting process.
- An airline uses the best practices of an Indianapolis 500 pit crew to help develop faster turnaround in its maintenance processes.

Reassigning (Who)

Reassigning is concerned with the following question: Who does the work? Today, there are a large number of possible answers to this question. In nearly every industry, organizations are turning to suppliers, customers, strategic partners, outsourcing partners, subsidiaries, temporary workers, and others to do work previously done in-house.

Pulling instead of pushing: Instead of the papers being distributed to the reviewers, the reviewers select (or bid for) the papers themselves. The papers that no one selects are then distributed to those having selected the fewest papers.

Letting workers perform as many steps as possible for a single case: To avoid too many handovers between people, this idea can be good. In a two-level structure, a program board (PB) member should facilitate the discussion among the reviewers of the proposed verdict of the paper, present this verdict in the PB meeting, and perform the necessary shepherding of the paper if needed.

Having a flexible assignment: One should assign work such that maximal flexibility is preserved for the near future. If a PC member has indicated skills in very few areas, then papers should be assigned to him first because it will most likely be easier to assign later papers to people who have indicated a larger variety of knowledge areas.

Dividing responsibilities: One should avoid shared responsibilities for tasks by people from different functional units. Although the program chair is responsible for the selection of papers, one may have a separate proceedings chair from the conference organizer responsible for communication in relation to the final proceedings with the publisher because he has to address monetary aspects (whereas the PC chair is often with another organization than the main conference organizer).

Assigning a case manager: One person is made responsible for handling each type of case. An example of such a policy would be when a program board member is responsible for following up one paper.

Customer team: One should compose a work team across different departments that will completely address the handling of specific cases. One could imagine that the general chair, proceedings chair, and publisher compose a joint team to ensure the smooth production of the proceedings.

Minimizing the number of partners in a task: One could imagine, for instance, that all of the people on the organizing committee of a conference work at the same place (and at the same place as the conference is being held).

Involving extra resources: If more papers than expected are submitted, one should attempt to recruit more program committee members or reviewers to avoid a workload that is too large for each reviewer.

Empowering the worker: One should give workers most of the decision-making authority. In many conferences with a two-level structure, one can follow this principle by removing the extra layer and inviting all PC members to participate in the final selection of papers instead of a separate program board.

Outsourcing the activity: Instead of having the organizing committee do all of the participant handling, one involves a professional conference organizing company that, for a fixed fee per participant, will do all of the participant handling, including payments and reimbursements and agreements with hotels.

Using a trusted third party: This action is related to that above. For example, rather than arranging for payment services oneself, the conference organizer uses standard payment and banking services.

Having customers and supplier share information: When registering for a conference, information on who else will attend can be made available. By giving access to this information (which needs to be accepted by the participant), one can make the conference more attractive and make it easier for conference participants to plan who they would particularly like to talk to during the conference.

Having the customer perform the activity: A publisher may have had a process for checking the final manuscript in detail before publication. By providing a good template and mandating that the conference proceedings editor ensure adherence to its standard use (and return manuscripts with too many errors), they may have to do less work themselves.

Integrating the business processes of customers and suppliers: When a paper is published, the paper is to be registered in the national publication database. If the publisher makes it possible to directly import all of the publication information into this national system, then the reporting work of the author will be eased.

Facilitating interfacing: One should improve coordination by having a standardized interface between customers and partners. When organizing a conference, one mandates a certain paper format (e.g., Springer LNCS), even in conferences not being published by Springer, because it is a well-known format with available style guides and templates.

Making the organization perform an activity that the customer is currently performing: Although the formatting of references was previously done by the author, this is by Springer done by them, to ensure that papers and citations are correctly referenced and thus correctly indexed.

Resequencing (When)

This heuristic centers on the question of when work is done: sequencing, timing, and interdependencies. When activities have been performed in a certain manner for many years, it is easy to assume that some steps simply must be performed before others. However, there may be fewer real dependencies than what is written in the procedures. Varying the timing and sequence of work can be a powerful lever for designing not only a faster process but also a process that enables greater customization, lower cost, and fewer errors. Once process performance requirements are known, one should check whether resequencing the work can help achieve them.

Using predicting to increase efficiency: One should use statistics from submissions to earlier conferences to estimate at an early time how many papers one will end up with. If the number seems to indicate fewer submissions than usual, one should intensify the marketing activities to attract more papers.

Changing the decision moment: Earlier decisions will make it easier to continue the process and make it more efficient. Later decisions will provide time to evaluate and choose between the alternatives and therefore provide more flexibility. For example, one should use a knockout approach. If a paper is clearly not relevant for the conference, then the program committee chair removes this paper (“desk reject”) from the papers to be reviewed and thus decreases the number of reviewing tasks.

Increasing flexibility with postponement: When one receives all of the reviews of a paper, one possibility would be to decide on the acceptance/rejection of this paper immediately. By waiting until all of the reviews are received on all of the papers, it is possible to view the selection of the overall program and perhaps accept a somewhat weaker paper because it fits with some other accepted papers in a session.

Minimizing the number of interconnections and dependencies: In many conferences, one has one call for papers and then decides on the paper sessions based on the overall accepted papers. If one places great focus on having not only good papers but also coherent sessions, then the selection of papers may end up depending on too many other reviews. In some conferences, one has predefined tracks with separate submissions from the start, which makes the selection within the session independent of what is done in other tracks.

Changing the number of alternatives: A number of alternatives that are too large can result in complexity and inefficiency. If the selection of alternatives is too small, then one risks that none of the solutions are appropriate for the special case. For example, a conference may have ten different paper types. In this case, one may end up with ten parallel decision processes that must then be coordinated. If the conference has only one paper type, then it may end up with only standard technical papers and not include other types of papers (e.g., novel ideas and experience papers) at all.

Resequencing the work: Typically, in a conference, the papers are first published at the conference. A different model could consist of having the papers published

well ahead of the conference so that participants can have the time to read the papers and prepare for the conference upfront.

Reorganizing partial processes: It may be possible to organize sequential partial processes in parallel. If it is possible, in most cases, doing so will decrease the execution time of a process. For instance, in the case of a conference, reviews are performed by several people in parallel and not sequentially.

Another possibility is merging two or more partial processes or dividing one partial process into various smaller processes. Merging can be an effective tool for improvement if the processes are tightly bound. Desirable consequences of merging and dividing partial processes include the better use of resources and faster process accomplishment.

A thorough analysis of the partial processes and their internal dependency can also uncover parts that are useless for the entire process. These parts are only a waste of time and resources and should therefore be eliminated (cf. the discussion on lean principles in Chap. 1).

Relocating (Where)

This heuristic focuses on the question of where work is done; it concerns location, distance, and physical infrastructure. There may be some correlation with the heuristics for reassigning. The idea is to minimize distance and maximize communication between the people involved in a process, thereby reducing the costs associated with travel time, handoffs, late error detection, rework, and quality problems.

Moving the activity closer to the customer or supplier: When deciding on the conference location, oftentimes, one criterion is that it is close to one of the universities where some main researchers within the community reside, making it more likely that it will attract more participants.

Moving the activity closer to related activities to improve communication: When deciding on the venue of a conference, oftentimes, one possibility is to have it at a hotel because all of the participants also need accommodation and food. Thus, a total package with one supplier of conference facilities, lunches, accommodation, and potentially a conference dinner can be negotiated.

Decreasing time by reducing travel time and distance: Another criterion for conference location can be that it is at a place that is convenient to travel to for most participants. An extreme variant of this would be to have a virtual conference where everyone participates remotely. Although this would be good from a resource usage point of view, only parts of goals of the conference can be achieved in such setting.

Creating a geographically virtual organization: Before the arrival of general e-mail services and the Internet made arranging such an organization easier, the organizing of a scientific conference is a good example.

Centralization: One should treat geographically dispersed resources as though they were centralized. When everyone uses the same review systems, the international program committee can work as though it was centralized.

Reducing (How often)

This set of heuristics concerns frequencies, volumes, the amount of resources, information and quality levels, and determining how much of each is actually necessary and appropriate. Despite its name, the heuristic of reducing encourages designers to explore what type of process improvements is possible if the frequency of activities varies up or down. Depending on the process outcomes desired, either direction may be the direction to go in.

Consolidating multiple practices into one: Subscription models consolidate the invoicing of individual services to larger, regular payments and consolidate at the end of the year based on actual use. One can also consider other methods of bundling payments. For example, in connection with a conference, one may have several subactivities that one can pay for individually. Being able to pay them in one transaction will typically make this task easier and entail fewer errors.

Individualizing: Breaking up a practice into multiple instances. In a conference, one may shepherd (some of) the accepted papers. Rather than sending out the reviews to all of the accepted papers from the program chair, the shepherds send out a personalized message for the papers he shepherds, starting the scientific discourse to ensure that the necessary changes and improvements are performed. Individualizing is performed to improve the quality of the final paper.

Reducing the number of customer contacts: When a paper is accepted, one must provide notification of this status and the deadline for the final version, send the review comments that should be addressed in the final version, and provide information on the format of the final version, the rules of copyright, the copyright form to be used, and how to register for the conference (and that it is mandated that at least one of the authors of the paper will register and come to the conference to present the paper). Sending all of the information at once is better than sending 3–4 individual e-mails.

Increasing quality through redundancy: One could have only one or two reviewers of each paper and still claim that all of the papers were peer-reviewed, but good conferences typically provide three or four reviews because if there is only one, much depends on the fact that the one reviewer knows the field of the paper well (which is difficult to guarantee) and that all of the reviewers use the reviewing scale in the same manner (something that never occurs). Additionally, having 4 and not 3 reviewers in case one wants to end up with at least 3 reviews is more robust because not all of the reviewers will manage to return the reviews in time. Providing several reviews will also be useful for the author to improve the paper (also if it is not accepted).

Using fewer controls to simplify and improve efficiency: This action could be used as an argument to reduce the number of reviewers. Additionally, not checking the submitted CRCs (if they are updated according to the comments from the reviewers) could be a method of improving efficiency (possibly jeopardizing quality).

Using critical resources more efficiently: One should understand which resources are the most critical to process success and find methods to make the most of them. What makes a resource critical?

- The process cannot operate without it.
- It is a high-cost item (either fixed or variable).
- It differentiates the company from competitors and drives competitive advantage in the marketplace.

In assembling the scientific program, the program committee chair has an important task. To allow the program committee chair to focus on this task, one may have others examine other parts of the program, the production of the proceedings, etc.

Enabling greater effectiveness through more information: Both having authors provide keywords and having keywords be automatically extracted using text mining techniques makes it easier to distribute papers to knowledgeable reviewers. Automatic keyword extraction using a similar technique based on the reviewers' publication over the last 5 years might be a way to improve the accuracy of the classification of the reviewer expertise.

Retooling (How)

This set of heuristics concerns how work is accomplished: the technologies, human capital, and competencies that enable organizations to do work. Few truly innovative processes are created without the extensive introduction of new technology and skills into an organization. Some examples include the following:

Transforming the process with the use of technology: Access to new technology will provide opportunities to change and improve the process execution. It is important for the enterprise to evaluate the time to perform the change so that it matches with, e.g., new releases of a software product. One should remember that introducing new technology may necessitate other processes that use resources; thus, one must examine the total resource consumption. For example, distributing papers to reviewers has historically been a manual task for the program committee chair. Instead, by having the program committee members bid for papers, this distribution can be performed automatically by a tool, making it more likely that a reviewer will receive a paper that fits his knowledge and interest. The evaluation of different subareas (e.g., novelty) could be improved by analyzing the age of the references.

Automating activity: One would like to avoid plagiarism. Traditionally, plagiarism needed to be checked manually (thus, cases of plagiarism were rarely discovered). In recent years, a number of tools for plagiarism detection have been developed so that one can now check for plagiarism on a routine basis.

Creating competitive advantage through technology: There are many methods of publishing the papers of a proceeding; thus, traditional publishers need to provide further services in addition to the actual publication and the reputation of the publisher. Thus, e.g., Springer is getting papers indexed very quickly, making references, etc., available through tools based on Google Scholar contributing to the citation statistics. Springer also has specific services in relation to download statistics, which makes it easier for authors and conference organizers to track the interest in their work.

Improving the process through up-skilling, down-skilling, or multiskilling: An increase in employees' skill levels can enable each individual to handle a wider range of integrated tasks, thereby reducing the need for handoffs. Thus, having the general chair of a conference handle most of the practical follow-up as part of his role can be more efficient than having separate people working to follow up all the different service suppliers.

At times, lower skill levels may be more cost-effective, e.g., Springer does typesetting and other tasks in India to use the cheaper cost of labor there.

Custom building or buying technology: As a rule, one should use packaged software for tactical processes and custom applications for strategic processes. Custom software lends itself to strategic processes in which flexibility is more important than fast implementation. Packaged software lends itself to tactical processes that require less flexibility and to situations where getting the system quickly installed and operational is more important. Twenty years ago, no Web-based review systems existed; thus, conferences had to create such a system themselves (Krogstie 1995). Over the last 15 years, a number of such services exist on the Web, and it is better to use (and configure) one of these services than it is to build the service oneself.

2.3.2 *Guidelines of Modeling—GoM*

The earliest approach to discussing the quality of process models in particular was GoM—Guidelines of Modeling (Becker et al. 1995, 2002). A number of basic principles of modeling addressing syntactic, semantic, and pragmatic demands on the proper creation of process models are proposed in Becker et al. (1995). They are also applicable to enterprise process models. There principles are as follows:

- The principle of accuracy: Subsequently renamed correctness, the model complies with the corresponding excerpt of the real world. As illustrated in Fig. 2.5, correctness has two aspects inspired by Batini's work on data quality described earlier: syntactic correctness and semantic correctness. A model is syntactically correct if it is consistent and complete in relation to the language on which the model is based. Semantic correctness entails that the structure and the behavior of the model are consistent with the real world. Consistency between different models is viewed as a part of the correctness of the model.
- The principle of relevance: Modeling constructs should be included in the model with a purpose; not everything should be represented in the model. Which information is relevant for a model depends on the intended use, i.e., the goal of the model, touching upon deontic quality using SEQUAL terminology.
- The principle of economic efficiency: The costs of modeling should not exceed the intended benefit, e.g., modeling should not be used for addressing trivial problems that can be resolved by other methods.

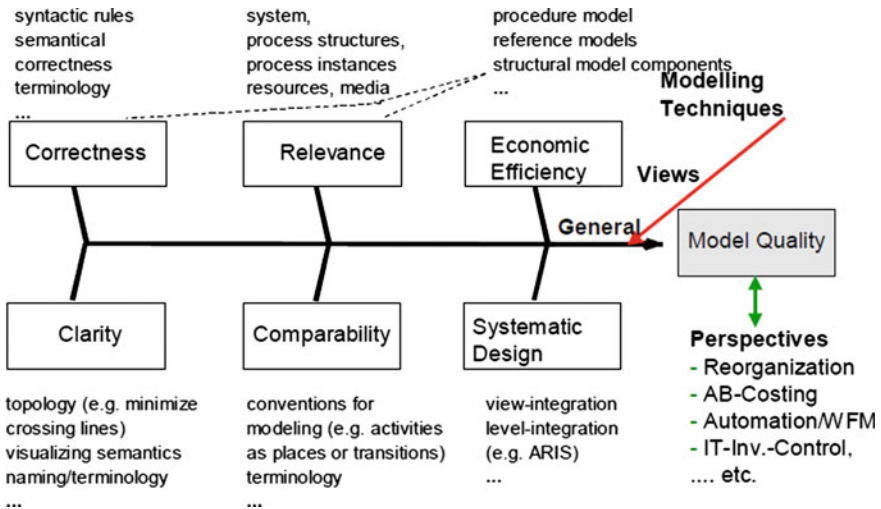


Fig. 2.5 Guidelines of Modeling (Becker et al. 2002)

- The principle of clarity: Models should be presented legibly and clearly, without more constructs than are necessary to be comprehensible for all stakeholders, supporting what in SEQUAL is termed empirical quality.
- The principle of comparability: Models created with different modeling techniques should be comparable at least to some extent.
- The principle of systematic design: If several models are created, then they should be connected in some structure to show how they contribute to the overall purpose of modeling.

In Becker et al. (2002), a specific version of these guidelines for (business) process models is presented. In addition to the six *general guidelines* (level 1), the GoM framework described there includes recommendations for different *views* (level 2, e.g., process models) and for different *modeling techniques* (level 3, e.g., event-driven process chains (EPCs) or UML activity diagrams), as indicated in Fig. 2.5.

These more detailed guidelines also take into account that there are different things that are important based on the goal of modeling (cf. Chap. 1), particularly aspects related to workflow models (usage area 5b, automatic activation) and model analysis/simulation (usage area 3).

2.3.3 Seven Process Modeling Guidelines (7PMG)

In Mendling et al. (2010c), the authors suggest seven process modeling guidelines (7PMG) in an attempt to provide a limited set of easily understandable guidelines.

- G1: Using as few elements in the model as possible. Larger models tend to be more difficult to understand (Mendling et al. 2007a) and have a higher probability of error than small models (Mendling et al. 2007a, 2010b).
- G2: Minimizing the routing paths per element. The higher the degree of an element in the process model is, i.e., the number of input and output arcs together, the more difficult it becomes to understand the model (Mendling et al. 2007a). As shown in Mendling et al. (2007b), there is a strong correlation between the number of modeling errors and the average or maximum degree of elements in a model.
- G3: Using one start event and one end event. The number of start and end events is positively connected to an increase in the probability of error (Mendling et al. 2007b). Additionally, most workflow engines require a single start and end node (van der Aalst et al. 2003). Moreover, models that satisfy this requirement are easier to understand and allow for all types of analysis (e.g., soundness checks). Note that these last aspects are primarily an issue when wanting to execute the process model.
- G4: Modeling as structured as possible. A process model is structured if every split connector matches a respective join connector of the same type. Structured models can be viewed as formulas with balanced brackets, i.e., every opening bracket has a corresponding closing bracket of the same type. Not only are unstructured models more likely to include errors (Mendling et al. 2007b), but people also tend to have larger problems with understanding them (Mendling et al. 2007a, b, c).
- G5: Avoiding OR routing elements. Models that have only AND and XOR connectors are less error-prone (Mendling et al. 2007b). Furthermore, there are some ambiguities in the semantics of the OR-join, which leads to paradoxes and potential implementation problems (Kindler 2006).
- G6: Using verb-object activity labels. A wide exploration of labeling styles that are used in actual process models reveals the existence of two popular styles (Recker and Mendling 2006). Based on these, people consider the verb-object style, such as “inform complainant,” to be significantly less ambiguous and more useful than action-noun labels (e.g., “complaint analysis”) or labels that follow neither of these styles (e.g., “incident agenda”) (Mendling et al. 2007b).
- G7: Decomposing the model if it has more than 50 elements. For models with more than 50 elements, the probability of error tends to be higher than 50 % (Mendling et al. 2007b). The implication is that large models should be divided into smaller models. Note that the early guidelines for DFD were more restrictive, e.g., having no more than seven processes at a given decomposition level (based on the 7 ± 2 guideline for human short-term memory) (Gane and Sarson 1979).

It should be noticed that there are potential interaction effects between the seven proposed guidelines. For a given process model, many guidelines can be applicable at various places in a process model and conflicting to different degrees. In Mendling et al. (2010c), a suggested prioritization is G4, G7, G1, G6, G2, G3,

and G5. The 7PMG guidelines primarily focus on aspects of empirical quality using the SEQUAL vocabulary. This suggestion should clearly also be held against other quality types (e.g., model completeness and validity). In Reijers et al. (2015), the 7PMG is placed as part of pragmatic quality means (using the original usage of this level from Lindland et al. (1994) before the split of pragmatic quality in SEQUAL into empirical and pragmatic qualities was done in 1995), and looking upon this in concert with syntactic and semantic goals and means to achieve these goals, although not discussing the interrelationship between quality of the different levels.

2.3.4 *Pragmatic Guidelines for Business Process Modeling*

Whereas 7PMG is meant to highlight the most important guidelines, the work by Moreno-Montes and Snoeck (2014) presents a comprehensive overview of such guidelines based on numerous sources (Arkilic et al. 2013; Becker et al. 2003; Cardoso et al. 2006; Claes et al. 2012; Davis 2001; Dijkman et al. 2008; Dumas et al. 2012; Effinger et al. 2010; Figl and Laue 2011; Gruhn and Laue 2007a, b; Gruhn and Laue 2011; Koehler and Vanatalo 2007; Lassen and van der Aalst 2009; Laue and Mendling 2008, 2010; Mendling 2007; Mendling et al. 2007a, b, c; Mendling and Reijers 2008a, b, c; Mendling et al. 2010a, b, c, 2012; Reggio et al. 2011a, b; Reijers and Mendling 2008, 2011; Reijers et al. 2010, 2011a, b; Rolón et al. 2007, 2009a, b; Sánchez-González et al. 2010; Sánchez-González et al. 2011a, b, 2012; Schrepfer et al. 2009; Sharp and McDerott 2001; Silver 2008, 2012; Vanderfeesten et al. 2008; Vanhatalo et al. 2007; Weber et al. 2011) that also include 7PMG. Their report presents an overview of the guidelines for undertaking business process modeling tasks. These guidelines can support practitioners and non-experts in modeling business process models. In particular, the guidelines focus on obtaining high-quality business process models in terms of their quality as a model, what we in SEQUAL place under empirical and syntactic qualities.

The guidelines which in particular are relevant for process models using languages like BPMN are structured into three groups:

1. Counting the number of different elements,
2. Composition of components,
3. Presentation.

We list all of the guidelines below, indicating the issue and the proposed guideline. In Moreno-Montes and Snoeck (2014), the authors discuss the problem, the rationale of the guideline, and how to use it in practice in more detail. Snoeck et al. (2015) provide an overview of how these guidelines are supported in different modeling tools.

2.3.4.1 Number of Elements

1. The model contains a high number of elements (i.e., gateways, activities, and events) -> Decompose models with more than 31 elements.
2. The model contains duplicate elements (e.g., identical start events, identical end events, and identical activities) or fragments, capturing the same control flow logic -> Avoid duplicate elements and fragments in the process models.
3. Models contain unnecessary elements (e.g., one empty arc between an AND split and an AND join) -> Avoid unnecessary elements.
4. A high number of events -> Avoid models with more than 7 events.
5. The model contains multiple start/end events -> Use no more than two start/end events in the top process level; use one start event in the subprocesses; and use two end events to distinguish success and fail states in the subprocesses.
6. Do not omit start and end events -> Have at least one start event and one end event in the process model.
7. A high number of intermediate events -> Avoid high numbers of intermediate events in the process model.
8. The model contains too many arcs -> Avoid models with more than 34 arcs.
9. The model contains too many gateways -> Avoid models with more than 12 gateways.
10. A high number of activities -> Minimize the number of activities.
11. A high number of routing paths per gateway -> Use no more than 3 routing paths per gateway. The associated metrics are as follows:
 - i. Average connector degree (ACD),
 - ii. Maximum connector degree (MCD),
 - iii. Number of sequence flows from gateways (NSFG),
 - iv. Control flow complexity for AND splits (CFCand split),
 - v. Control flow complexity for inclusive OR splits (CFCor split),
 - vi. Control flow complexity for XOR splits (CFCxor split).
12. Split/join gateways have more than one incoming and outgoing flows (i.e., two behaviors in the same gateway) -> Do not combine multiple inputs and multiple outputs in the same gateway.
13. There are too many outgoing sequence flows from an event -> Do not use more than 4 outgoing sequence flows from events.

2.3.4.2 Composition of Components

- 14 The model has deeply nested structured blocks -> Avoid deeply nesting structured blocks.
- 15 The model contains multiple cycles -> Avoid cycles in the process models, especially unstructured cycles (i.e., cycles with multiple exit points).

- 16 Badly formed cycles: The backward connection of a loop construct does not begin in an XOR split or does not lead back to an XOR join -> When modeling cycles, the backward connection should begin in an XOR split and lead back to an XOR join.
- 17 Multiple exit points per cycle -> Avoid multiple exit points per cycle.
- 18 A high level of parallelism (the sum of the output degrees of the AND and XOR gateways should be 8 at most) -> Avoid a high level of parallelism in the process models.
- 19 Bad parallelism: Parallel paths do not reach end events or do not synchronize -> Each parallel path must reach an end event or must be synchronized.
- 20 A high level of unstructuredness -> Every split gateway should match a respective join gateway of the same type.
- 21 The model contains a long path from the start node to the end node -> Keep the path from a start node to the end node as short as possible.
- 22 High gateway diversity -> Minimize gateway diversity.
- 23 Existence of inclusive OR gateways in the process models -> Avoid the use of inclusive OR gateways.
- 24 High complexity in the model -> Select the less complex alternative when modeling.
- 25 The model lacks modularity -> There should be no more than 31 nodes in a diagram (cf. guideline 1) and no less than 5 activities in a subprocess.

2.3.4.3 Presentation

- 26 The model is not readable because of a suboptimal layout -> In general: Keep the diagram as neat and consistently organized as possible by following the following list of advice:
 - Minimize the number of unnecessarily crossing lines.
 - Minimize the number of overlapping (connection) elements (edges should not overlap edges or other nodes.).
 - Minimize the number of bends in connecting elements.
 - Maximize the number of orthogonally drawn connecting objects.
 - Make the models long and thin (instead of square): Maximize the number of connecting objects that respect the workflow direction.
 - Place elements as symmetrically as possible.
 - Minimize the drawing area.
 - Place related elements close to each other.
 - Adapt the size of objects such that elements have sufficient space.
 - Consider the use of partitions, e.g., pools and swimlanes.
 - Specify task types, especially user (human task) and service (automated task) tasks.
 - Use a uniform style for the flow layout.

27 Labels are not correct/optimal.

- Labels do not follow the verb–object style.
- Labels are too long.
- Pools label is different from the process.
- Timer events are not labeled with the duration or date/time parameter.
- Gateways are not labeled.
- Black box pools are not labeled with the participant’s name.
- There are constructions other than the send/receive task types that are labeled as send or receive.

2.3.5 *Quality Through the Use of Reference Models*

An important generic means often used primarily for improving semantic quality is the reuse of existing (good) models. The success of reuse is dependent on many factors at different quality levels:

- The model needs to be of good physical quality, i.e., it must be physically represented in a persistent form that is available to those who will potentially want to reuse it.
- For the reuse of semiformal and formal models, it is not always the model itself that is reused; rather, their presence will cause the next modeler to reuse the use of such modeling languages and do so correctly. For this usage to be successful, the original models should be syntactically correct.
- In cases where one actually wants to reuse the model as is (i.e., where the domains are very similar), the model should have a high semantic quality. For white box reuse, the model needs to be modifiable and should also be comprehensible and comprehended; thus, one must support techniques for achieving empirical and pragmatic qualities. The model should also be annotated with additional statements, making it easier to find the sought-for model, thus influencing what is an appropriate completeness.
- Where existing models need to be compared with models developed in a separate project, social means and techniques, such as model integration and conflict resolution, can be useful to investigate the extent to which the solutions based on the model to be reused should actually be reused.
- Successful reuse will influence the cost of modeling in a positive manner, addressing aspects of deontic quality. However, the reuse of, e.g., a reference model comes at a cost that itself should not be higher than the benefit gained.

Model reuse can be both within and between organizations. In regard to process models, a number of areas have developed “reference models” with what is established as good practices/best practices within a field. The right reuse of such

models can be viewed as a particularly efficient method of improving the quality of business processes and business process models, especially when the processes are supported by a tool such as those found in SAP ERP.

In Frank (2007), a detailed overview of the relevant aspects for the evaluation of reference models is provided. First, he differentiates three usage settings:

1. Predevelopment, where the model is a basis for model activation or system implementation,
2. Post-development, where the reference model serves mostly as documentation,
3. Business redesign on an organizational/strategic level.

Four evaluation perspectives are described:

1. The economic perspective,
2. The deployment perspective,
3. The engineering perspective,
4. The epistemological perspective.

They all have their own detailed evaluation criteria, some of which are relevant for models in general, whereas others are specifically relevant for reference models, as detailed below.

2.3.5.1 Economic Criteria

These criteria address different aspects of the costs and benefits of using the reference model (cf. how reuse ties into the deontic quality level of SEQUAL). Although reference models are aimed at reducing costs, their use will also cause costs. Costs are in relation to the introduction (Table 2.3), transformation and analysis (Table 2.4), and maintenance of the reference models (Table 2.5).

Using a reference model promises a number of benefits. Two categories are proposed for this purpose: efficiency (Table 2.6) and flexibility (Table 2.7). The relevance of each point depends a lot on the goal of modeling.

As discussed in Chap. 1, one of the goals of all models should act to foster communication. An overview of aspects in this regard is found in Table 2.8.

Taking into account that using a reference model can cause substantial investments, the question of how these investments are protected is a core issue, as outlined in Table 2.9.

2.3.5.2 Deployment Criteria

The success of a reference model depends heavily on the ability and willingness of the users to address the model. Important aspects in this regard are outlined in Table 2.10.

Table 2.3 Cost of the introduction of the reference model

Aspect	Relevant for type of use	Criteria
Acquisition	1, 2, 3	Cost of purchasing, licensing model Cost of in-house development
Training	1, 2, 3	Familiarity of own staff with modeling language, terminology In-house modeling expertise Availability of training offers Overall complexity of the model
Adaptation	1, 2, 3	Concepts that support adaptation in a safe and convenient manner Availability of tools Cost of tools Cost of integrating with existing tools/systems
Strategic redesign	1, 2, 3	The model recommends/requires strategic adaptation Degree of change required
Organizational redesign	1, 2, 3	The model recommends/requires organizational adaptation Degree of change required
Integration	1, 2	Integration with existing models Integration with business partners Amount of integration required Compatibility of modeling concepts

Table 2.4 Cost of transformation and analysis

Aspect	Relevant for type of use	Criteria
Suitability	1, 2	Modeling concepts allow for automatic transformation into implementation-level documents Modeling concepts support required types of analysis If necessary: cost for adapting model for transformation/analysis
Tools	1	Availability of tools that feature transformation/analysis functions Cost of tools Cost of integrating tool with the existing software development environment
Training/support	1, 2	Skills required for performing transformation/analysis tasks available Cost of training Cost of external support

Table 2.5 Cost of maintenance of reference models

Aspect	Relevant for type of use	Criteria
Conceptual support	1, 2, 3	Concepts that support adaptation in a safe and convenient manner
Tools	1, 2, 3	Availability of tools that support model management (versions, users) Cost of tools
Skills	1, 2, 3	Cost of internal skills Cost of external skills

Table 2.6 Efficiency/effectiveness

Aspect	Relevant for type of use	Criteria
Software development and maintenance	1	Improvement in productivity Improvement in software quality Functionality and maturity of available tools Compatibility with existing abstractions Skills of software developers Willingness to use the reference model
Business/management	1, 2, 3	Increased efficiency of affected business processes Cost reduction in business processes Support for specific decision scenarios Familiarity with model-based decision making Willingness to use the model in decision scenarios Improved customer orientation

Table 2.7 Flexibility/integration

Aspect	Relevant for type of use	Criteria
Dependence on IT vendors	1, 2	Number of relevant IT vendors that support the model Number of users Degree of customization Standardization Level of industry commitment
Openness	1, 2	Compatibility with relevant standards Integration with further reference models Coverage of possible future business models
Expressive power	1, 2, 3	Degree of (ontological) completeness of the modeling language
Relationship with other IT artifacts	1, 2	Concepts that foster integration/transformation into other relevant representations

Table 2.8 Coordination/knowledge management

Aspect	Relevant for type of use	Criteria
Coordination	1, 2, 3	Helps overcome communication barriers within the company Fosters communication with external partners Improves coordination of business processes Fosters the establishment of interorganizational coordination

Table 2.9 Protection of investments

Aspect	Relevant for type of use	Criteria
Spreading/commitment	1, 2, 3	Number of organizations that use the model Number of vendors and service providers that support the model Standardization of the modeling language Standardization of the model
Technological change	1, 2	Independent of a particular technology Supports technologies that can be expected in the near future

Table 2.10 Deployment aspects of reference models

Aspect	Relevant for type of use	Criteria
Understandability	1, 2, 3	Elaborate structure for documentation (e.g., with design patterns) Comprehensive documentation Scenarios and examples Familiarity with the modeling language Familiarity with terminology Intuitive access to graphical representation Views for different groups of stakeholders
Appropriateness	1, 2	Amount of support for purposes relevant for users Supports technologies that can be expected in the near future
Attitude	1, 2, 3	“Not invented here” syndrome Reputation of model developers Resistance to organizational change Cultural barriers

Table 2.11 Engineering perspective on reference models

Aspect	Relevant for type of use	Criteria
Definition	1, 2, 3	Comprehensive description of intended application domains Comprehensive description of intended purposes
Explanation	1, 2, 3	Assigning model elements to requirements Justification/substantiation of design decisions Discussing design compromises and the resulting drawbacks Discussion of alternative approaches
Language features	1, 2, 3	Level of formalization, extensibility, supported conceptual views, integration of views, tool support, concepts to support the adaptation of models, and concept to foster model integrity
Technical model features	1, 2, 3	Formal correctness/consistency Model architecture Use of classes Use of generalization/specialization Use of modularization/encapsulation

2.3.5.3 Engineering Criteria

From an engineering perspective, two questions are important: Does the model fulfill the requirements to be taken into account? Is the specification appropriate for supporting the intended purposes of the model? These questions are detailed in Table 2.11.

2.3.5.4 Epistemological Criteria

This perspective serves to enrich the evaluation of reference models with epistemological considerations. Detailed aspects are described in Table 2.12.

2.3.6 Successful Business Process Modeling Projects

Sedera et al. (2003) have presented a process modeling success model where the identified success measures in their model are as follows:

1. Model use: How extensively the models are applied and utilized.
2. User satisfaction: The extent to which users believe that process modeling meets the fulfillment of the objectives that underlie the modeling project.

Table 2.12 Epistemological perspective on reference models

Aspect	Relevant for type of use	Criteria
Evaluation of theories	1, 2, 3	Precise description of core concepts with respect to the corresponding real-world concepts; precise description of underlying assumptions
Generic principles	1, 2, 3	Abstraction Originality Judgement
Critical distance	1, 2, 3	Subjective nature of underlying decisions Bias through familiarity with the modeling language High degree of spreading may be mistaken for high quality
Scientific progress	1, 2, 3	Discussion of long-term goals of the research Elaborate documentation of the model with respect to generic principles and long-term research goals Comparison with alternatives

3. Process impact: Measures the effects of modeling on process performance.
4. Process model quality: The extent to which all of the desirable properties of a model are fulfilled to satisfy the needs of the model users.

We will return to an application of these categories used in a case in Sect. 4.1.

2.4 Summary

We have in this paper provided description of thinking and framework on quality of IT artifact, including the quality of systems, data, and traditional conceptual models (including data, requirements, enterprise, and process models). Also aspects relative to business process quality and the area of reference models are touched upon. A main learning from these works and the work on more generic frameworks on quality of models (Nelson et al. and SEQUAL) is that although there are many similarities in the thinking on quality, comprehensive frameworks looking upon these holistically are useful. In the next chapter, we will extend the generic SEQUAL framework with aspects relative to quality of business processes and business process models and describing a framework for quality of business process models.

References

- Andersen Consulting Process Excellence Handbook (1997). <http://www.scribd.com/doc/31730974/Process-Excellence-Handbook#scribd>
- Arkilic, I.G., Reijers, H.A., Goverde, R.R.H.M.J.: How good is an as-is model really? In: Rosa, M., Soffer, P. (eds.) Business Process Management Workshops. Springer, Berlin, pp. 89–100 (2013)

Quality in Business Process Modeling

Krogstie, J.

2016, XVI, 250 p. 76 illus., 48 illus. in color., Hardcover

ISBN: 978-3-319-42510-8