What Do I Get from Modeling?

An Empirical Study on Using Structural Conceptual Models

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Abstract. In the context of enterprises, a wide range of models is developed and used for diverse purposes. Due to the investments involved in modeling, these models should ideally be used in projects in which their benefits outweigh their costs. The analysis of modeling benefits and costs requires an in-depth understanding of the goals of modeling and the properties of models that influence their achievement. This is an issue that has not been sufficiently investigated in the literature. Therefore, we conducted an empirical study to identify and understand the goals modelers aim to achieve through their models, the properties of the models that can aid in the achievement of these goals, and how they assess this achievement. In this study, we focus on a subset of these models, namely structural conceptual models. We found empirical evidence to state that modelers usually achieve more than one goal that can vary among six types of functional goals of modeling and four types of quality goals of modeling. Moreover, according to them, there are six properties of structural conceptual models that can aid in satisfying these goals. Finally, the analysis presented insights into why modelers only subjectively assess the satisfaction of their modeling goals.

Keywords: Conceptual modeling · Modeling goals · Value in modeling

1 Introduction

Models are abstractions of certain aspects of the world that are created and used to meet diverse purposes. Within enterprises, they support complex human activities such as decision-making, training, communication, and systems development. Among the different types of models used within organizations, conceptual models are those focused on defining business entities and their relationships [20]. As such, they can explicitly capture descriptive, prescriptive, and creative aspects of the modeled domain, providing an explicit representation of reality given a level of abstraction and a perspective from which to observe [10,16]. In this study, we focus on a subset of these models, namely structural conceptual

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models (also called domain models) [8]. Those are conceptual models that focus on structural (as opposed to dynamic) aspects of the domain aiming at identifying, analyzing, and describing key structural regularities (i.e., types, attributes, relations and constraints) of a specific universe of discourse [9]. Examples of languages that can be used to create such models are Entity Relationship (ER), UML Class Diagram, OntoUML [8], and Object-Role modeling (ORM).

Despite its benefits, modeling activities, such as the development, management, and use of models, require investments in terms of time, money, cognitive effort, etc [10]. Thus, a deeper understanding of the benefits and costs associated with modeling can help modelers to (i) motivate the adoption of a modeling technique in a project or an organization, (ii) convince sponsors to invest in modeling initiatives and teams, and (iii) persuade modeling skeptics to partake in modeling activities. It can also help researchers in developing and improving modeling languages, methods, and tools.

In this paper, we delve deeper into the benefits of modeling—a topic that has not been sufficiently investigated empirically in the literature yet. Assuming that benefits emerge from goal satisfaction [18], we start from Guizzardi and Proper's taxonomy of the functional goals of modeling[1] [10] and further investigate this phenomenon via an empirical study driven by the following research questions:

RQ1: *Is the taxonomy of modeling goals proposed by Guizzardi and Proper* [10] *sufficient to describe the goals achieved through structural conceptual modeling?*
RQ2: *What properties of structural conceptual models contribute to the satisfaction of these goals?*
RQ3: *How do modelers assess the satisfaction of these goals?*

To answer these questions, we conducted nine semi-structured interviews [1] with researchers and practitioners who worked on projects in Brazil, Italy, and the Netherlands. We then performed an inductive and deductive thematic analysis [3,4] on the interview transcriptions.

Our study found evidence that, when creating and using structural conceptual models in practice, modelers are driven by five of the six functional goals proposed by Guizzardi and Proper's taxonomy [10]. We did, however, discover a functional goal not foreseen by them and four recurrent quality goals that are orthogonal to their taxonomy. Additionally, we identified six properties of structural conceptual models that contribute to the accomplishment of these goals, as well as that modelers only subjectively assess the satisfaction of their goals.

The remainder of the paper unfolds as follows. Section 2 explains Guizzardi and Proper's taxonomy. Section 3 discusses the process we followed and the tools we used to collect and analyze the data. Section 4 presents and discusses the results of our analysis of modeling goals. Section 5 positions our work in relation to the state of the art. Finally, Sect. 6 makes some final considerations and discusses the direction of future work.

[1] In [10], Guizzardi and Proper refer to them simply as modeling goals. The distinction between functional and quality goals is well-known in the requirements engineering literature [11].

2 Research Baseline: A Taxonomy of Modeling Goals

Guizzardi and Proper [10] proposed a taxonomy of modeling goals (Fig. 1) based on the notion of *direction of fit* [19] to reason about the goals one may achieve by modeling, the resulting model, or both. For them, "*this notion is meant to connect the propositional content of intentional aspects (i.e., mental states or speech acts) to the external state of affairs of which they are about*" [10]. Guizzardi and Proper argue that models are complex speech acts, so they propose three categories to classify them that are analogous to the ones stated in the notion of direction of fit—World-to-Model (Prescriptive Models), Model-to-World (Descriptive Models), and World-to-Model-to-World (Creative Models).

Prescriptive models are used to intervene in the world. That is, they are used as instruments through which someone brings about changes in the world. Examples include a design that will be implemented, such as a blueprint for a house, and a plan to be followed, such as a BPM model of a process To-Be.

Creative models are those whose existence or recognition in a given community brings about a change in the world. For example, a diagram in a patent file establishes intellectual property rights; a model in a contract outlining the division of a property specifies the ownership rights of each landowner.

Descriptive models are representations of the relationship between conceptualizations (the meaning assigned to a symbol) in the mind of an agent and some existing external reality. In this sense, a model is an instrument through which modelers can represent an individual or collective abstraction of an existing or desired world, such as the blueprint of an actual house or the BPM model of a process As-Is. The creation, manipulation, and communication of this type of model aids in achieving goals related to domain understanding, problem-solving, and domain communication, respectively.

The goal of understanding can be achieved mainly via conceptualization; that is, via the creation of an abstraction in the mind(s) of the modeler(s). This creation process allows both an individual understanding of the domain and its concepts, as well as a collective negotiation of meanings and the formation of a

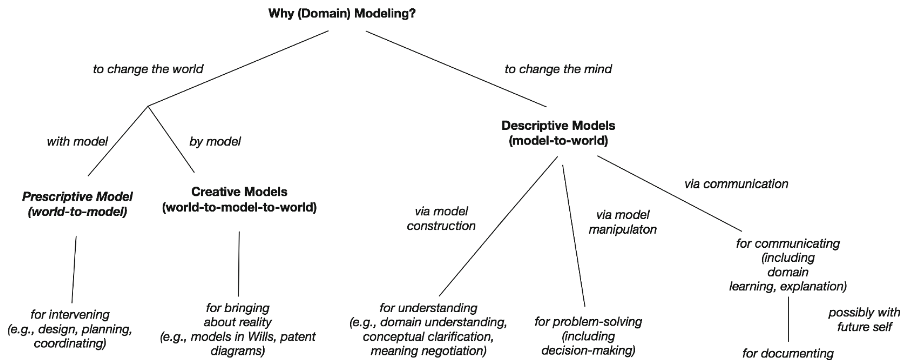

Fig. 1. Guizzardi and Proper's Taxonomy of Modeling Goals [10].

shared conceptualization. To better understand this idea, you just need to think about a time in which you have created a model and how the process of defining concepts and establishing relations helped to shape and develop your and your team's knowledge about a given domain.

When the modeler's goal is not only domain understanding but also the sharing of this understanding, the model can be used for communicating. By employing a model to communicate, the modeler can aim for asynchronous and/or synchronous communication. In the former, the goal is to develop a resource that can be used afterward, by both the modeler herself and others, to communicate an interpretation of the original externalized mental model. The latter, on the other hand, is when this communication happens in real-time interaction. For instance, a model is created as part of the documentation of a software (asynchronous communication); then the model is used to explain the software to new employees (synchronous communication).

An externalized mental model can also be used by those aiming to solve problems and make decisions. In this case, descriptive models are manipulated to support the formation of new beliefs about the world. It happens, for example, when one uses a subway map to decide on which station to exit or when a negotiator uses a game-theoretical matrix to decide which action to take.

According to Guizzardi and Proper [10], the categories proposed in their taxonomy are not mutually disjoint. Therefore, models can be created and used for more than one purpose. An ER model, for example, can be created to guide the implementation of a database schema (for intervening) and afterward be used as documentation for it (for documenting). When the schema needs to be modified, this ER model can help in understanding the schema (for communicating) and in deciding how to modify it (for decision-making). Similar patterns can be observed with the blueprint of a house and with a process model.

3 Research Method

To address our research questions, we conducted a deductive and inductive thematic analysis [3,4] of semi-structured interviews [1] with modelers.

Interviews. Between November and January 2022, the first author conducted 9 interviews with structural conceptual modelers. The interviews were conducted online through Microsoft Teams and each lasted about 60 min. They were conducted in English, Portuguese, and Italian, and analyzed in the original language. When necessary, the quotes used in the article were translated. The interviews were divided into four sections. The first section focused on the background of the interviewees and their knowledge and experiences with models and modeling languages in general. The second section focused on the description (e.g., goals, context, stakeholders, and constraints) of a specific project in which the interviewee has used structural conceptual models. If more than one project came up, both were explored. The third section focused on model creation and use (e.g., goals, facilitators, obstacles, usability, and reusability) and its influence on the project (e.g., modeling costs and benefits). The final section focused on the interviewees' personal opinions about models and modeling (e.g., associated costs and benefits, model reusability, and return of modeling effort).

Participants. Participants in the study were randomly selected from a list developed with authors of relevant literature in structural conceptual modeling, professional networks, and personal contacts of the authors. While developing this list, we focused on modelers who had experience with structural conceptual modeling and had worked on projects in which this type of model was used to solve organizational problems. The selection was interactive until saturation was reached and no new relevant knowledge was obtained from new participants [21]. The professionals were contacted by e-mail and invited to participate in the research. Of the 22 participants invited, 16 agreed to participate. From the 16 interviews conducted, we proceeded to the analysis of only the 9 in which, in the project given as an example, the modeler used a class diagram conceptual model designed with UML or OntoUML. We narrow our focus to guarantee the quality of the analysis since the inclusion of other modeling designs and languages would generate a very heterogeneous sample making it difficult to generalize the results.

In our sample, modelers were located in or worked on projects based in, Brazil (4), the Netherlands (4), and Italy (1). There was 1 female and 8 males. On average, a modeler in our study has a higher education degree in computer science-related fields, has been developing models for longer than 5 years, knows more than one type of model or modeling language, and has worked on more than 20 projects in which models were developed and/or used in diverse domains. All of them actively participated in the development of the model in the project they chose to talk about.

We interviewed modelers working in universities (4), large companies (3), and small companies (2). They were researchers, technical leaders, consultants, and founders. The interviewees who worked in academia chose to talk about projects carried out in partnership with private and governmental organizations. Thus, in all the examples analyzed, the models were used in real-world situations in the fields of energy (2), security (2), environment (1), government (1), healthcare (1), software development (1), and tourism (1).

Research Ethics and Anonymization. During recruitment, participants were informed about the purpose of the study, the content of the questions, and the affiliation of the interviewer. Participants signed an informed consent form and a privacy information sheet acknowledging their knowledge of the purpose of the study and the data management procedures (collection, analysis, and storage). At the beginning of each interview, the interviewer ensured the purpose of the study and the anonymization of the content, explained the dynamics of the interview, and additionally obtained verbal informed consent. As the interviews were conducted through Teams, they were recorded with the participant's permission. The video recordings were transcribed using the NVivo transcription service and manually anonymized by the interviewer.

To protect the identities of the participants, the entire process from conducting the interview to anonymizing the transcripts was done by the same researcher within 24 h of each interview. All personally identifiable information was deleted and the remaining data was stored in a private repository on UNIBZ's GitLab server, with access limited to the research team. We also edited information when quoting participants to avoid personal identification.

Data Analysis. To analyze the transcriptions we developed deductive and inductive coding. We used deductive coding to identify the functional goals of modeling since this is a more theoretical-driven approach in which the researcher codes based on a preliminary list of codes [3]. In our case, this list was composed of the concepts of Guizzardi and Proper's taxonomy [10]. Inductive coding, on the other hand, was used to further investigate participants' goals of modeling and the properties of models that influence their achievement. In this approach, themes emerge from the data, and codes are signed when concepts become apparent in the data. This means that the researcher codes the data without trying to fit it into a pre-existing coding frame or their own analytic preconceptions [3]. To develop the analyses we used the Nvivo 12 software and followed the thematic synthesis process proposed by Braun and Clarke [3]. A researcher began reading the transcripts and familiarizing herself with the data. Next, she identified and labeled specific segments of text generating initial codes that were then randomly selected for analysis and validation by the research group. This procedure helped align the definition of the codes among the group members. In sequence, she translated the codes into themes, sub-themes, and higher-order themes. Then, she revised the themes, the coded extracts, and the entire data to ensure an alignment between them and generate a thematic map of the analysis. At this stage, we introduce a second researcher to analyze and validate the text segments coded and themes created. When there was no consensus between the two researchers, a third party was introduced into the analysis process to mediate the decision about the exclusion, inclusion, or adaptation of a theme or coded extract. The final themes and subthemes generated from the analysis are listed below and discussed in the following section.

- **Functional goals of modeling**: For intervening, For understanding, For problem-solving, For communicating, For documenting, For learning.
- **Quality goals of modeling**: For minimizing effort, For maximizing functional correctness, For maximizing interoperability, For maximizing analyzability and modifiability
- **Model properties**: Reusability, Correctness, Comprehensibility, Completeness, Confinement, Maintainability.

4 Results and Discussion

4.1 Functional Goals of Modeling

The functional goals of modeling are those that modelers try to accomplish through modeling, the resulting model, or both. In Table 1 we present and define the functional goals used as themes in our analysis. The first five were based on Guizzardi and Proper's work [10] and the last one was proposed by us.

Table 1. Functional Goals of Modeling

Goal	Definition	Reference
For Intervening	A goal of using a model as an instrument through which one changes something in the world	[10]
For Understanding	A goal of creating a model to support domain understanding and meaning negotiation	[10]
For Problem-solving	A goal of using a model to guide problem-solving and decision-making	[10]
For Communicating	A goal of using a model to support communication between people about a domain of interest	[10]
For Documenting	A goal of using a model to support *asynchronous* communication between people about a domain of interest	[10]
For Learning	A goal of creating or using a model to learn modeling, modeling methods, and modeling tools	Proposed

The results of our deductive coding showed evidence that five of the six functional goals of modeling proposed by Guizzardi and Proper—"For Intervening", "For Understanding", "For Problem-solving", "For Communicating", and "For Documenting"—are suitable to describe the goals modelers aim to achieve through structural conceptual modeling (RQ1-F1).[2] However, there was no empirical evidence of modelers' desire to accomplish the goal "For Bringing About Reality". We speculate that the reason for that is that the use of models for creating reality due to their sheer existence is indeed much more limited in practice (e.g., patent diagrams, treaties, wills).

The goal of intervening was the most mentioned among modelers, being achieved in ten of the eleven projects given as an example by the interviewees (F1-A).[3] It can be evidenced in the following quote: "*We created a layer that we called the ontological layer. [...] It was a layer to support all the systems. [...] We did the conceptual modeling part, using OntoUML, generated artifacts in OWL and, from then on, we implemented those systems [a semantic search engine, a chatbot, and a legal opinion automator]. We used this conceptual base to develop solutions based on inferences as well.*"

Our analysis showed that the use of structural conceptual models for intervening in the world can be shaped by three factors, the intervention's purpose, type, and result (F1-B). Therefore, the model can be used to change the world by creating or modifying, manually or automatically,

[2] Research Question 1 - Finding 1: It refers to the first find of the study that answers its first research question.

[3] Finding 1-A: It refers to a relevant finding related to Finding 1, but which does not directly answer a research question.

diverse artifacts. For instance, one of the interviewees used an OntoUML model to support the development of an API and any change in the model (e.g. adding a new class) would reflect a change in the API. In this case, the OntoUML model was an instrument through which he could manually create and modify a given artifact. Although no interviewee mentioned doing an automatic intervention, an example would be forward engineering a relational schema from a conceptual model using a method such as that proposed by Guidoni et al. [7].

`For Understanding` was one of the modelers' goals in four projects involving structural conceptual models. One of them said: *"The ontology is an integral part of the standard because it defines what the data is and describes what the interpretation of the information being exchanged is. It provides a starting point for us to understand the nature of the data being exchanged."*

`For Problem-solving` was one of the goals achieved in three projects given as an example by the interviewed modelers. It can be evidenced by the following quote: *"We had discussions with domain experts on the other things in the model, and just by having the model, we could have a better discussion on what should be changed in the data. If you just have a file and you say 'Well, this item in the file needs to be changed', and we do not really understand how this data item relates to other data items. So by having a model, there is more comprehension of the relationships between things."*

Since the term problem-solving is very broad, while defining and codifying this goal, we had to delineate aspects that were not clear in Guizzardi and Proper's work [10]. First, we considered that by "via manipulation" they were also referring to the use and analysis of a model. Second, we noticed that there is a very thin line separating situations in which a model is used for problem-solving and for intervening. In our analysis, we coded the goal `''For Problem-solving''` only in situations in which the model was used to support stakeholders in understanding a given situation and making decisions, but it was not directly used in the intervention process. For example, let us consider again the example of using an ER model to evolve an existing database schema. If one first changes the model and then reflects this change in the schema, we considered it to be an intervention. Conversely, if one used a model simply to identify shortcomings in a schema, we would consider it as problem-solving.

`For Communicating` was one of the goals that drove the interviewed modelers in eight projects. One example can be seen in the following quote: *"So, I think it was fundamental to have an artifact [the model] to guide this communication between two different worlds. They [domain experts] had no knowledge of what ICT [Information and Communication Technology] did, right? That is, they did not have the technical knowledge to know how we actually implemented things, and we also didn't have enough knowledge of the business to be able to develop without support."*

`For Documenting` was the goal achieved in six projects given as an example by the interviewees. One of them said: *"We would want to have, let's say, documentation or knowledge available to have the consistency and the coherence to understand where things live in our organization. Then, it could still be a* *goal to make general models, but not very specific probably, to have this kind of documentation or knowledge management."*

Through the inductive coding conducted in this study, we identified a modeling goal that was not foreseen by Guizzardi and Proper [10]—***"For Learning" (RQ1-F2)***. For Learning was a goal in four projects involving structural conceptual models. The following example was taken from one of the interviews: *"The main goal of the first project was to develop some example models to know if the process of conceptual modeling would be beneficial. So it would be really a test case. We also would do some learning by doing. Then, as a secondary goal, we had also the goal that we, as a team that participated, would also learn OntoUML a bit more."*.

The use of models for learning is an important goal that should be explored more among modelers. Most of our interviewees reported that their models were not used or updated after the project in which they were created ended or after they left the project. They believe this happened because there were no others in the organization/project with the expertise to maintain and use them. For instance, two of them said: *"I think it [the model] should be maintained, but the issue is that I'm leaving the project. So I need someone else to take over my knowledge and there's no one available."* and *"I think they would not be able to follow it on their own because it is a client that does not have the skills to understand this type of model."* They also mentioned difficulties emerging from the lack of knowledge about modeling and modeling language among their project's stakeholders.

Despite these problems, most of the interviewees did not use their models to help others learn. It might be a missed opportunity. By teaching non-modelers to read and understand models, we are allowing them the opportunity to benefit from our models. This can also help to spread the culture of conceptual modeling among those not used to it, bridge the communication gap between modelers and industry, and encourage the continued use, update, and reuse of existing models. One of the interviewees who used the structural models developed in a project for learning purposes was emphatic in highlighting its benefits. He said: *"This involvement, this approach of the client to the conceptual modeling area, I think was so positive that they not only learn, but they develop."*

4.2 Quality Goals of Modeling

The quality goals of modeling are those that determine how the modeling process and/or the resulting model might support the achievement of specific conditions and capabilities in the pursuit or result of a functional goal of modeling. In Table 2 we present and define the quality goals identified in our analysis. After identifying them, we use the ISO/IEC 25010:2011 [13] to support their understanding and definition.

The inductive coding conducted in this study showed empirical evidence of the existence of four quality goals of modeling—"For Minimizing Effort", "For Maximizing Functional Correctness", "For

Maximizing Interoperability", and "For Maximizing Analyzability & Modifiability" (RQ1-F3).

For Minimizing Effort is an objective that goes beyond the desire to communicate or intervene, for example, it is about how these things should be done (e.g. easier, faster, or cheaper). It was one of the goals achieved in five projects given as an example by the interviewees. In the following quote one of them explains how he used the model to simplify and accelerate the development of the artifact in one of his projects: *"Generating a computational artifact without any conceptual modeling reference, going straight to the final product, I think it would be a huge challenge. [...] If you take the model out as an element, we would have to produce the same artifact that we produced in 3 months. I believe we would produce it in a much longer time."* This is an example of using models to minimize both physical and cognitive efforts.

The following three quality goals of modeling are directly related to how the use of a model to intervene in the world can contribute to achieving specific conditions or characteristics in the system arising from that intervention.

For Maximizing Functional Correctness was one of the goals accomplished by three interviewees and can be evidenced in the following quote: *"We use semantics in order to consolidate how data is being processed because a lot of problems and errors in software originate from data being processed in the wrong way."*

For Maximizing Interoperability was one of the goals accomplished by three interviewees and one of them gave the following example: *"I had to create a model that would be able to, at one hand, serve as a kind of a range between the terms that were used in the video environment and the terms that were used in a textual environment."*

For Maximizing Analyzability & Modifiability was one of the goals achieved by three of the interviewees and can be evinced in the following quote: *"It would help future developers to pick it up, read that [the model-based documentation], and understand that the system was made that way. So, if I need to*

Table 2. Quality Goals of Modeling

Goal	Definition
For Minimizing Effort	A goal of minimizing a user's effort in using a model to change the world or people's minds
For Maximizing Functional Correctness	A goal of maximizing the degree to which a system functions correctly by using a model
For Maximizing Interoperability	A goal of maximizing the degree to which systems, products, or components can exchange information and use the information that has been exchanged by using a model
For Maximizing Analyzability & Modifiability	A goal of maximizing the degree to which it is possible to analyze and modify a system by using a model

maintain such a part, from this diagram I can see that it was a given component that is in a given place. So you can go directly to where the component is."

4.3 Model Properties and Their Relation to Modeling Goals

Through inductive coding, we identified six properties of structural conceptual models that, according to modelers, helped in the achievement of their modeling goals— `Reusability`***,*** `Correctness`***,*** `Completeness`***,*** `Comprehensibility`***,*** `Confinement`***, and*** `Maintainability` ***(RQ2-F4)***. To better understand these properties and propose the definitions shown in Table 3, we used Mohagheghi et al.'s work on the quality of UML models used in model-based software development [15] as the basis. We chose this model quality framework because the modelers who participated in our study used structural conceptual models for intervening in the world.

`Reusability` ***was the model's property that most helped modelers in achieving their goals (F4-A)***. Eight of them mentioned this during the interview. Regarding reusability, our analysis points out that it can be planned or unplanned and its benefit is directly related to the reduction of effort and costs in the process of changing the world and people's minds. This is because it is easier, faster, and cheaper to reuse a model than to create a new one from scratch. Note that we also considered reuse when the model is extended; that is when it is used as a basis for the creation of another model.

Despite the advantages associated with the reuse of models, we found that the knowledge about the model and its reuse potential is usually restricted to the modelers (F4-B). This can be explained by the fact that in most of the examples given by the modelers interviewed, they created the model to help develop a solution, kept the model to themselves, and did not show or explain it to others involved in the project.

Table 3. Model properties relevant for achieving modeling goals.

Property	Definition
Reusability	The degree to which a model can be reused in a different context and/or for a different purpose than it originally intended
Correctness	The degree to which a model can properly represent the domain, its elements, and their relations
Comprehensibility	The degree to which a model can be understood by its intended users
Completeness	The degree to which a model has the necessary information to fulfill its purpose
Confinement	The degree to which a model only has the necessary information to fulfill its purpose
Maintainability	The degree to which a model can be changed

Interestingly, the only example in which the model was reused by users who were not the initial modelers was given by the only interviewee who reported concern about teaching his project's stakeholders about modeling and involving them in the creation of the model. According to this participant, the initial project consisted of creating an OntoUML model to support the development of three technical solutions. Therefore, reusability in the project context was planned and helped accelerate the software development. What they did not expect, however, was that a different group from another department in the company would use the same model to train new employees. In both cases, the model reuse in the same context for different goals contributed to reduce effort in interventions and communications.

`Correctness` was mentioned by two interviewees. This is a broad term that needs further explanation. First, we do not include the idea of syntax correctness in our definition because there is not any evidence that it actually helped study participants achieve their modeling goals. Second, our definition is centered on the notion of coverage and precision used by Sales in [17]. Therefore, the correctness of the model is related to how well it allows instantiations intended by the modeler and avoids unintended ones. For example, consider the "married to" relation, which holds between two persons. In a common sense ontology about marriage, if a person can marry herself or only marry someone from another gender, the ontology is not precise and has coverage issues respectively. Thus, it has a low level of correctness.

Although in this sense model's correctness can aid in achieving all modeling goals, there are situations in which it is essential to achieve it. These were the case in the two situations considered in our coding process. In both, the model was essential to achieve and maximize the software's functional correctness. For example, one of the participants talked about a project in which the system should be accurate in deciding when and how much tax the company must pay. He said: *"We were working in a domain of sensitive knowledge, where we can have no error margin. So, to have categorical knowledge, you need to use artifacts derived from a categorical approach."*

`Comprehensibility` was mentioned by six interviewed modelers. This property is the key to reaching all goals related to the use of models since to properly use them you should be able to understand them. However, comprehensibility is not an absolute property; it depends on factors that can affect how well it supports users in achieving a given modeling goal. For instance, the type of domain represented, the modeling language used, the level of abstraction chosen, and the dimension and structure of the diagrams may all have a different effect on the user's comprehension, depending on their modeling expertise as well as the given domain and language. One of the interviewees highlighted the importance of the diagram's layout to model comprehension and acceptance. He said: *"I also learned something else in this project where I was the guy that aligned the diagrams. [...] So, for people not used to reading models, I'm sure that the position, the presentation and the colors and everything, that's really important. And even that important, they will say that they like it very much or don't like it at all."*

`Completeness` and `Confinement` were cited by six and three interviewees respectively. The former increases the quality of users' changes in the world and minds by allowing them to fully represent and understand a given reality. The latter reduce their effort in the processes of making these changes by preventing them from wasting time on unnecessary things. Regarding completeness, one of the interviewees said that he knows that the model is complete when it can answer all of the project's team questions. He said: *"This was an easy project to do because the competency questions were kind of look-up questions. We had these questions that we wanted to answer. So the depth of the model was very much based on that."*. Regarding confinement, another interviewee mentioned that while creating the ontology the modelers only focused on the information they previously defined as necessary. He said: *"We listed what types of information we wanted to exchange, what the agents thought was relevant to exchange, and we only went as far as the ontology could describe them. We didn't introduce anything into the ontology that went beyond describing that information."*

`Maintainability` was pointed out by two participants. According to them, this property can positively affect the functional goal of documenting and the quality goal of maximizing software modifiability. In these cases, the model should be constantly changed to properly represent reality increasing the effectiveness of users when documenting and modifying artifacts. Furthermore, on the one hand, maintainability can affect the model's correctness by facilitating its updating. On the other hand, it can be affected by the model's comprehensibility since the more complex the model is, the more difficult it is to maintain. One of the interviewees talked about that in the following quote: *"Maintenance is a quality that should be an architectural concern when you develop your data. So it will have an impact on our own software and also on your models, since other people must be able to read your model in order to maintain it."*

4.4 Assessing the Satisfaction of Modeling Goals

If models are created and used to satisfy certain goals, assessing their satisfaction seems to be necessary to know whether or not modeling was worthwhile. When analyzing our interviewees' answers on this subject, ***we found out that modelers only subjectively assess the satisfaction of their modeling goals due to the difficulties in identifying and measuring the benefits of the modeling process and/or the resulting model (RQ3-F5)***.

Some of them argue that not all benefits of modeling can be defined at the beginning of the project since it is difficult to foresee all possible uses of the model. Sometimes the model is created for a specific goal and used for other unplanned purposes, such as in the example above in which the model was created to guide the development of systems and later used to train new employees.

There are also reverse situations in which the expected benefits are not achieved due to reasons such as a lack of modeling culture in the company or the modeler's resignation from the project. For example, one of the interviewees reported that he was hired as a consultant to develop a model to mediate the external communication between the company and its clients. However, he knows that the model could also be used for internal communication among the company's modelers. Unfortunately, he doesn't know if this will happen since his job was only to develop the model and the company has no modeling culture.

The interviewed modelers also mentioned the difficulty of measuring the modeling benefits to justify their subjective analysis. According to them, even when they identify these benefits, they don't know how much they contributed to achieving the modeling goal. Indeed, it is harder to measure how much a model facilitated the development of a system, accelerated a decision-making process, or increased the modifiability of software. The following quote from one of the interviewees illustrates this difficulty: *"I don't know if there are techniques capable of measuring, for example, that I reduced something. I have no way of measuring, for example, that I reduced meeting time to make a decision by 50% because I used an ontology [in OntoUML] to agree on what data people wanted to exchange."*

Two respondents argued that an objective analysis of the satisfaction of modeling goals would be worthwhile if one could analyze diverse scenarios to evaluate which option would offer the best cost benefit. Although we agree with this claim, in most modeling initiatives it is not possible to concretely compare alternatives. This does not mean that an objective cost-benefit analysis is not beneficial. It might not help you prove that model-driven software development is better than non-model-driven software development. Still, it might help you demonstrate that the former is good enough to justify the investments in it. This may help convince those skeptical of modeling to adopt it, which is, according to most of the interviewed modelers, a difficult task.

Finally, ***our results showed that due to the difficulties in identifying and measuring the benefits of a modeling initiative, modelers do not analyze them to decide when to create or use structural conceptual models in their projects but to justify them (F5-A).*** Modelers do not seem to want to know when it is worth modeling. They always choose to solve problems through models, even if they do not rationally know whether modeling is the best option for a given situation. They will model because their experience shows that modeling was a good option in similar cases and they use it to base their modeling decisions such as when to model, when to stop modeling, or what modeling language to use. For instance, one of the interviewees said: *"I have a quick discussion, I identify the problem, and I already know the approach we are going to work with, I already know the language. Experience is everything!"*

4.5 Threats to Validity

We believe that our study could be affected by the rosy view phenomenon. This phenomenon is associated with the fact that within days after the event, people have much more positive evaluations of the event [14]. Therefore, by asking the practitioner to choose a project and talk about it, we take the risk of getting a more positive version of their modeling experience. Although this positive view of the facts can not affect the functional goal of modeling, it can affect the quality goal of modeling. To overcome the self-reported data challenges, sufficient rigor and care were applied in covering the subjects through multiple questions and solicitation of examples.

We understand that online interviews may have some disadvantages compared to face-to-face interviews, but the latter was not an option in this study because the participants were geographically dispersed. Although some authors argue that interviewees' performance is usually typically inferior in the online setting [2], this was not a problem for our study since we did not ask the interviewee to perform any task and did not seek to evaluate their performance or behavior throughout the interview. We concentrated on the content of their responses. Moreover, the use of video and the interviewer's expertise effectively mitigated any potential consequences of the online interview on social presence, eye contact, and impression management as perceived by the participants.

The modest size of the sample used in the study can also be seen as a threat to the validity and generalization of the results. Despite its size, we believe that the sample selected faithfully represents the scenarios and population that we intend. The diversity of contexts of the projects given as examples and the high experience in structural conceptual modeling of the modelers interviewed helped us to create a meaningful data set. In addition, the sample size complies with the saturation criterion associated with the chosen research method [21].

In thematic analyses such as the one developed, the way the coding is conducted might increase the risk of bias in the data analysis. To minimize this risk, we coded the complete data twice, one for each coding method (deductive and inductive) separately, and used more than one researcher to analyze and validate the text segments coded and themes created.

Finally, other possible research biases can be discussed. First, we interviewed only professionals who were already modelers and did not interview those who chose not to model. Second, we interviewed only one woman. However, we believe that for this research, they are not relevant.

5 Related Works

Davies et al. [5] conducted a survey in Australia to, among other aims, investigate practitioners' motivation for doing conceptual modeling. They asked respondents to choose among 17 pre-defined goals. The most frequent one ended up being to design and maintain databases. This result is in alignment with our findings about the goal of intervening. The authors investigated factors that might encourage or discourage the use of modeling techniques (e.g. ER, UML). However, their results are more related to the properties of modeling tools than the properties of the models themselves. They did not investigate how modelers assess the achievement of their modeling purposes.

Dobin and Parsons [6] empirically investigated how much and for what purposes UML components (e.g. class and use case diagrams) were used. They found that class diagrams were the most used ones and they were mainly used to support the understanding of the application among technical members of the project team. The authors also investigated the effectiveness of UML components in facilitating communication within software development teams. For this purpose, class diagrams were rated as "moderately useful" by most of the respondents. They did not investigate why or how they facilitate communication and did not extend their analysis to other modeling purposes.

Ho-Quang et al. [12] empirically analyzed the motivation and benefits of the use of UML models within software development teams. Their results showed that collaboration is the most important motivation for using UML. They also claim that the use of UML positively affects the project's planning phase and development process, as well as the communication among team members. This last one helps to attract new contributors and facilitate their integration.

Both Dobin and Parsons [6] and Ho-Quang et al. [12] had similar aims to ours in terms of investigating the goals related to structural conceptual modeling. However, they had a more restricted scope regarding the type of models and goals analyzed and did not mention the use of a theory to support the modeling goal selection employed. Despite these differences, our results align with theirs as they also identified the benefits of using UML class diagrams for intervening, documenting, and communicating in software development projects.

Finally, regarding the assessment of modeling goals, there is one main theoretical work that addresses the notion of Return on Modeling Effort (RoME). In their paper, Proper and Guizzardi [16] deepened the discussion of RoME and introduced the idea of a model's Value in Action (ViA) and the need to manage the Retention of Modeling Effort (RiME). The authors also stressed the demand for a more rigorous underpinning of the costs and benefits involved in domain modeling. This is not only in line with the aim of our study but also highlights its importance. Although they enriched the discussions on modeling value-based assessment, no empirical evidence of their work was presented.

6 Conclusion

The study we reported in this paper focused on identifying and understanding the goals modelers aim to achieve through structural conceptual modeling (RQ1), the properties of models that can aid in the achievement of these goals (RQ2), and how they assess this achievement (RQ3).

Our empirical study found evidence that, when creating and using structural conceptual models in practice, modelers are driven by five of the six functional goals proposed by Guizzardi and Proper's taxonomy ***(RQ1-F1)***. Throughout the study, we clarified and refined the authors' definitions. We also discovered a functional goal not foreseen by them ***(RQ1-F2)*** and four quality goals that are orthogonal to their taxonomy ***(RQ1-F3)***. We also identified six properties of structural conceptual models that can aid in the accomplishment of these goals ***(RQ2-F4)***. Additionally, our analysis uncovered that modelers only subjectively assess the satisfaction of their modeling goals due to the difficulties in doing so***(RQ3-F5)***. The new functional goal (`for learning`) can be seen as a subcategory of the use of models *to change the modeler's mind*, but now about the modeling approach itself as opposed to about the domain.

Our study also found that the goal `‘‘For Intervening’’` was the most frequent among projects involving structural conceptual models ***(F1-A)*** and that it can be shaped by three factors, the intervention's purpose, type, and result ***(F1-B)***. Moreover, we found that reusability was the property that most helped modelers in achieving their goals ***(F4-A)***, although we uncovered that the knowledge within the model and its reuse potential is usually restricted to the modelers ***(F4-B)***. Finally, our results showed that modelers do not analyze their modeling goals to decide when to create or use structural conceptual models in their projects but to justify them ***(F5-A)***.

Our findings can serve as a guide to model evaluation. A clear understanding of why and how modeling should be done can help modelers to motivate the adoption of a modeling technique, convince sponsors to invest in modeling initiatives, and persuade modeling skeptics to partake in modeling activities. It can also help researchers in developing and improving modeling ecosystems.

In subsequent work, we plan to investigate the costs of structural conceptual modeling, the barriers and incentives for the adoption of its modeling techniques, and the perspective of those against it.

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