Chapter 2
Prior Research Design

Initial Questions and Goals

The main objective of the research carried out here is determining and showing how it is possible for software to assist to the knowledge generation process as practiced by specialists in archaeology. Thus, we shall attempt at the beginning to identify possible improvements that can be made in the knowledge generation process by way of software assistance and to propose software models that can provide systems with such a capacity of assistance. This assistance could materialize in the form of guidelines for the application of knowledge extraction techniques or in the proposal of the application of techniques for the visualization of archaeological information, which are adapted to the characteristics of the knowledge-generation process. Due to the broad scope treated, this book focusses in the second type of software-assistance, that is, providing visualization techniques appropriated to the special characteristics of archaeological data sets and archaeologists' needs.

As any other research process, a fundamental research question must be asked in accordance with our objective:

> To What Extent Is It Possible to Improve Knowledge Generation Processes in Archaeology by Way of Software Assistance to the User with Information Visualization Techniques?

Having defined each of the relevant concepts in the principal research question (see Terminology Adoption section in previous chapter), we can understand its scope more exactly. Taking as its starting point the principal research question, this study has the objective of validating the initial hypothesis on the premise that the answer to the question is affirmative. That is to say, we take the hypothesis that it is possible to significantly improve knowledge-generation processes in archaeology by way of providing software assistance to the user with information visualization techniques.

The fundamental research question posed here are too abstract to stablish a practical approach. Thus, we decomposed it in more specific secondary questions that allow us to deal with the complexity of them.

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Firstly, and in order to prove that the software assistance is possible, it is necessary to know in depth how knowledge is generated in Archaeology. We wonder: **What problems exist in knowledge-generation processes in archaeology as they are normally carried out?**

Secondly, the study of the knowledge-generation process in the discipline allowed us to detect the need to formally characterize the cognitive processes carried out in the aforementioned process in order to improve it. Then, we need to answer to: **What are the most common cognitive processes carried out by archaeologists in the generation of knowledge?**

Finally, the application of information visualization techniques was included within the main research question in order to produce the software assistance, which we wish to provide. In this point, the need arose to study which of these techniques would offer us the software assistance we proposed. We need to know: **Which are some appropriate information visualization techniques to assist each one of the cognitive processes identified within archaeology?**

Along the book, we verify this affirmation by means of hypothetico-deductive reasoning, gathering evidence of all types, both formal and empirical, in favor of and against it. Although next section may deviate slightly from the central theme of the book for more practical readers, we believe it is necessary to document the research methodology employed, for two main reasons: its inherent relationship with the strategies and solutions developed here and explained in successive chapters, as well as to consider this methodology a reference for researchers interested in knowledge generation areas and what kind of underlying methodology is possible to follow for future developments.

"Design Science Methodology" in Practice

In order to answering the research questions raised, confirming and testing the possible improvements via software to the knowledge generation process in archaeology, it is necessary to be very careful with the research methodology employed, choosing a hypothetico-deductive approach that allow us to subsequently evaluate our progresses.

Several authors have highlighted the application of "Design Science Methodology" [276, 281] as an appropriate methodological framework for research into software engineering, but maintaining a great degree of flexibility and innovation required due to the multidisciplinary research in the topic addressed here. Other reason is the fact that research in this area is "oriented towards solutions". In contrast to more observational research "oriented towards problems", in which the objectives focus on explaining and/or understanding a part of the reality, in software engineering a solution is sought for a given problem. This fact may imply a part of observational research (which explains a part of the reality) but it adds a component of definition, design and/or creation of a solution to that problem.

Many of the models of "Design Science Methodology" are based on the fact that a research project begins from one perspective, generally oriented towards a solution. Nevertheless, the research presented here being an example of this, a research project can originate from a great variety of perspectives, each one of them beginning in a different phase of research methodology. This fact is particularly relevant and commonplace in multidisciplinary contexts. For example, we can take a more observational perspective oriented towards a problem during the exploratory phase. However, it is common to change to a more solution-oriented perspective once the problem has been identified and defined and we have moved on to the phase of designing a possible solution. Taking this into account, Peffers' model [213], as opposed to other existing models for the application of "Design Science Methodology", makes it possible to apply various perspectives or to vary the perspective over the course of the research, thus adding flexibility to the application of "Design Science Methodology" [267]. Figure 2.1 illustrates the research methodology of "Design Science Methodology" followed throughout this book, based on Peffers' model [213].

Firstly, the phase "Identification of the Problem and Motivation" defines the research problem to be tackled and justify the value and scientific contribution of the solution. In our case, this phase includes the detailing of the research questions, as well as the whole exploratory review to characterize the problem. Thus, the existing techniques and the designing of tools to explore and characterize the problem described in Part II is also part of this phase. Later, the phase "Definition of Objectives of the Solution" establishes the objective of the solution that we want to design, bearing in mind what is feasible as a solution and what is not. The previous decomposition of the main question in secondary questions and their corresponding solutions created and tested in Chaps. 4 and 5 constituted this phase.

The Design and Development phase includes the creation of the artefact-solution. In our case, this phase includes the design and creation of all the software models which make up the framework proposed. This phase corresponds structurally to Part III of the book. To initially trial the design, the Demonstration phase deals with the question of whether the use of the artefact allows one or more instances of the identified problem to be resolved. In our case, we must demonstrate the framework proposed and their strategies helps archaeologists as far as knowledge-generation processes are concerned. The demonstration is detailed in the Chap. 11.

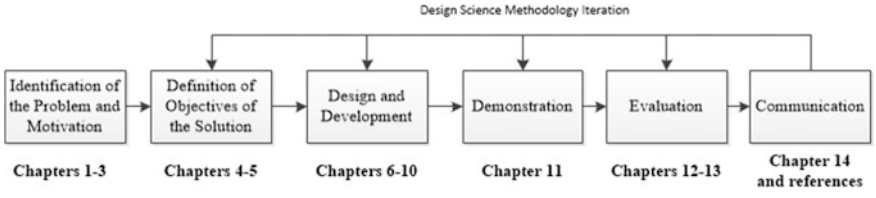

Fig. 2.1 Design science methodology phases and corresponding chapters in this book

Once we have a solution, the Evaluation phase observe and measure the degree to which the artefact (our framework) resolves the problem. This consists of comparing the objective of the solution with the observed results of the use of the artefact in an empirical way. This phase requires, therefore, knowledge of the relevant metrics and techniques of empirical analysis. In our case, an empirical validation has been carried out with the chosen case study, building a software prototype and evaluating it with archaeologists. All of this is dealt with in the Chap. 12 and is discussed in Part V.

Finally, Communication phase includes a dissemination of the results, to communicate the problem and its importance, the artefact-solution, its usefulness and novelty, the precision of its design and its effectiveness for the target users/specialists. Most intermediate results explained in the book are also referenced in the bibliography. In addition, Chap. 14 explains the lines open for future research and their possible implications.

It should be noted that Peffers [213] establishes these phases in an iterative cycle. Thus, it is possible to complete a full cycle for all the phases, for example for each secondary research question which we have posed or for each sub-problem identified in a research project. These iterative cycles have occurred throughout this research, as shall be seen over the course of the book. However, here, a lineal narrative of the methodology has been maintained since this chapter should give a generic overview of the research methodology carried out. Next part reviews existing works on software knowledge generation and what kind of archaeological particularities we should deal with when we want to apply it to large archaeological data sets.

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