How to Teach Regulatory Compliant Data Warehouse Engineering?

Completed Research Paper

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ABSTRACT

The steady increase of regulatory reporting requirements for banks increases the demand for compliant data warehouse and reporting systems. Data warehouse designers are forced to work in interdisciplinary teams consisting of accountants and legal experts in order to meet the regulatory requirements. In this paper, we present a teaching concept that simulates a realistic data warehouse development scenario in financial service industries. By applying this teaching concept, students learn how to design compliant data warehouse systems. Implicitly students experience the challenges of interdisciplinary data warehouse engineering teams and conceptual (reference) modeling. The didactical concept, which is based on learning levels, sensitizes students for the usefulness and applicability of conceptual (reference) modeling and was positively evaluated in two elective courses.

Keywords
IS Education, Teaching, Data Warehouse, Reporting, Regulation, Conceptual Modeling.

INTRODUCTION

The development and maintenance of data warehouse (DWH) and reporting systems (Devlin 1996; Inmon 1996; Kimball et al. 2008) are essential parts of the Information Systems discipline and its corresponding education. DWH education comprises the conceptual development as well as the technical implementation of requirements. Teaching courses generally focus on teaching basic constructs of DWHs and online analytical processing (OLAP) reports (i.e. cases from the Teradata university network). Developing case studies for the conceptualization and implementation of DWHs aims to simulate a realistic impression of the tasks associated with data warehousing (e. g. Boyno 2003; Dadashzadeh 2007; Nenad and Gray 2008). The teaching concept at hand differs from existing teaching concepts because it confronts students with selected data warehousing challenges the complexity of which has been mostly ignored in other didactic approaches.

Students need to learn that it might be necessary to adapt conceptual modeling methods to a certain application scenario. Domain- and purpose-oriented modeling methods are an essential part of method engineering (Brinkkemper et al. 1999). The financial crisis provides evidence that it is essential to comply with legal and internal reporting requirements. Relevant reporting regulations of the financial sector are part of, for example, national solvency and banking acts, report regulation acts, million credit acts, the European regulation for market transparency (MiFID) or in equity requirements, such as Basel II/III. Existing modeling methods (e.g., ME/RM (Sapia et al. 1998), ADAPT (Bulos 1998), DFM (Golfarelli et al. 1998) or even data exchange formats like XBRL (Bergeron 2004)) fail to document the relationship between DWH elements and the associated regulations. The integration of linkages to regulatory requirements in conceptual DWH models motivates us to teach students the necessity and meaning of method engineering. The teaching concept at hand gives students a realistic impression of the conceptual challenges of DWH design. Since it focuses on the conceptual design phase, it is very independent of the reporting tool (e.g., SAP BW), which is in use to fulfill the regulatory requirements. In addition, the financial context of our teaching concept enables students to understand the importance of conceptual reference models (Fettke and Loos 2003; Misic and Zhao 2000) for the design of DWHs.
Based on the idea to simulate a realistic supervisory reporting scenario in financial industries, this paper has three goals. First, students should learn how to design DWH systems. Therefore, we want to face students with the challenges that arise in interdisciplinary DWH engineering teams. Second, we aim to sensitize students for the usefulness and applicability of conceptual (reference) modeling for DWH engineering based on regulatory reporting requirements. Third, students should learn how to evaluate modeling techniques. They should be encouraged to discuss the strength and weaknesses of conceptual (reference) modeling.

The structure of the teaching concept is as follows. First, we describe the target group for our teaching concept and briefly explain our learning goals. Our teaching concept comprises three phases that enable the teaching of conceptual DWH modeling based on legal reporting regulations. Aside from the teaching concept, we provide and discuss the evaluation results from two courses that were conducted using the presented concept. Finally, the discussion of the teaching concept and its adaption to different types of education are outlined.

**LEARNING GOALS AND TARGET GROUP**

In most cases, compliance and legal experts are not experienced with DWH structures. At the same time, DWH engineers are currently not educated to handle supervisory regulations. This necessarily leads to communication problems between DWH engineers and reporting compliance experts caused by a missing common ground (Clark and Brennan 1996). To solve the obviously arising communication problem, conceptual information models help to build a common ground between compliance experts and system engineers (Kung and Solvberg 1986; Mylopoulos 1992). High quality conceptual work is a fundamental requirement for the early detection and correction of system planning mistakes (Wand and Weber 2002). Thus, this teaching concept is designed for IS students who aim to design DWHs with a special focus on regulations. Additionally, it addresses accounting students who study supervisory law and want to become familiar with conceptual report design.

<table>
<thead>
<tr>
<th>Level</th>
<th>Phase Goal</th>
<th>Phase A Preparation</th>
<th>Phase B Study</th>
<th>Phase C Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level I Knowledge</td>
<td>Preparation</td>
<td>Knowing common techniques for conceptual data warehouse reference modeling (A.I)</td>
<td>Knowing additional modeling constructs for conceptual reference modeling of legal reporting requirements (B.I)</td>
<td>Knowing fundamental project management methods (C.Ia) and certain legal reporting requirements in detail (C.Ib)</td>
</tr>
<tr>
<td>Level II Application</td>
<td>Study</td>
<td>Being able to develop conceptual reference models (A.II)</td>
<td>Being able to apply modeling techniques for reference data warehouse modeling to support reporting compliance (B.II)</td>
<td>Being able to work on an extensive project that develops reference models for reporting compliance (C.II)</td>
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<tr>
<td>Level III Reflection</td>
<td>Practice</td>
<td>Evaluating advantages and disadvantages of modeling techniques (A.III)</td>
<td>Evaluating the usefulness and the limitations of reference models for ensuring reporting compliance (B.III)</td>
<td>Evaluating the usefulness and limits of reference modeling for reporting compliance within a real project scenario (C.III)</td>
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</tbody>
</table>

**Figure 1. Learning goal framework**

Our learning goals for the teaching concept are divided into two orthogonal dimensions (cp. Figure 1). All teaching concept phases of the next section refer to the goals that are described within the rectangles (A.I - C.III). According to the didactic concept of learning levels (Bloom and Engelhart 1971), the first dimension differentiates the following three levels:

- **Level 1 (Knowledge):** The first level contains the teaching of facts and relevant concepts or methods for conceptual DWH design.
- **Level 2 (Application):** The second level enables the students to use the learned knowledge to solve tasks that are adjusted to the methods taught.
- **Level 3 (Reflection):** The third level enables students to reflect the facts and to discuss advantages and disadvantages of the learned concepts or methods.
The second dimension classifies the learning goals in three phases:

- **Phase A (Preparation):** Phase A comprises foundations of conceptual reference DWH modeling. Its scope depends on the background knowledge of the participants.

- **Phase B (Study):** The study phase aims to provide an insight into conceptual DWH modeling focused on legal reporting requirements. The transfer of knowledge regarding special challenges that arise when legal requirements need to be modeled are the focus of this phase.

- **Phase C (Practice):** The goal of the third and last learning phase is to apply the taught modeling technique while acting more independently in a project setting.

**TEACHING CONCEPT**

The teaching concept is divided into the three learning phases that are conducted in the order they appear: preparation, study, and practice. Within the learning phases, we separate between the three learning levels (knowledge, application, and reflection). We provide all exercise details online1 and refer to them by using “teaching note 1 to 5”. We applied the teaching concept twice in the elective course on Business Process Management (BPM) in Financial Industries, which gives students the opportunity to work on a complex subject that has practical relevance. Participating students of both courses studied Information Systems and were in the fifth or sixth bachelor semester.

**Learning Phase A: Preparation**

The first learning phase aims to bring all participants to a unique level of theoretical and practical knowledge. Thus, this phase focuses on three fundamentals: the understanding of DWHs and reporting systems; the knowledge of conceptual modeling of DWHs and reporting systems as well as its application. The exercises of this learning phase do not focus on legal reporting requirements since we want to begin with simple and familiar cases, such as retail or video industry scenarios.

**Teaching Block A1 (Lecture): Introduction to conceptual DWH modeling**

Teaching block A1 is conducted as a lecture, providing a motivation to the problem and an introduction to DWH concepts, their applications as well as the fundamentals of conceptual DWH modeling techniques (to address learning goal A.I). Current conceptual DWH modeling techniques, such as ME/RM (Sapia et al. 1998), ADAPT (Bulos 1998), and DFM (Golfarelli et al. 1998), enable representation of common DWH constructs like ratios, dimensions, hierarchies, and cubes. In our case setting, we used the modeling technique \(H2\) for Reporting \((H2fR)\) (Becker et al. 2012) and a software-based modeling tool, the \(H2\)-Toolset (Janiesch 2007), in order to introduce commonly used DWH modeling constructs (see Appendix A). Even if the presented teaching concept uses \(H2fR\) and \(H2\)-Toolset, it is not limited to it. It can also be applied with any other modeling technique that is suitable for the development of conceptual DWH (and reporting system) models. In the following, we sketch the basic DWH constructs, report extensions and reference extensions in \(H2\)forReporting (for the technique see Appendix A).

**Teaching Block A2 (Exercise): Training the basic modeling concepts**

Teaching block A2 aims to enable students to identify relevant dimensions and ratios from a given text that describes a retail scenario of a web shop (see teaching note 1). The task is to create a conceptual model describing a retail scenario of a web shop (see teaching note 1). The task is to create a conceptual model describing a retail scenario of a web shop (see teaching note 1). The task is to create a conceptual model describing a retail scenario of a web shop (see teaching note 1). The task is to create a conceptual model describing a retail scenario of a web shop (see teaching note 1). The task is to create a conceptual model describing a retail scenario of a web shop (see teaching note 1). The task is to create a conceptual model describing a retail scenario of a web shop (see teaching note 1). The task is to create a conceptual model describing a retail scenario of a web shop (see teaching note 1). The task is to create a conceptual model describing a retail scenario of a web shop (see teaching note 1). The task is to create a conceptual model describing a retail scenario of a web shop (see teaching note 1). The task is to create a conceptual model describing a retail scenario of a web shop (see teaching note 1). The task is to create a conceptual model describing a retail scenario of a web shop (see teaching note 1). The task is to create a conceptual model describing a retail scenario of a web shop (see teaching note 1). The task is to create a conceptual model describing a retail scenario of a web shop (see teaching note 1). The task is to create a conceptual model describing a retail scenario of a web shop (see teaching note 1). The task is to create a conceptual model describing a retail scenario of a web shop (see teaching note 1). The task is to create a conceptual model describing a retail scenario of a web shop (see teaching note 1).

**Teaching Block A3 (Exercise): Gaining a deeper modeling experience**

Teaching block A3 conveys a deeper insight into the modeling technique and addresses conditions that are on a higher difficulty level. The goal is to identify those conditions and to consider different approaches for abstraction and level of detail as well as a trade-off between both. Again, the workshop participants receive a textual case study that is to be transformed

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1 See www.wi.uni-muenster.de/sites/default/files/public/stuff/AMCIS-2013-1065-TeachingNotes.pdf.
into a conceptual model. The case is about a multinational video games company producing hardware and software. Games, applications and widgets are distinguished with respect to the software products. Hardware products are divided into consoles and accessories (for details see teaching note 2).

The report should contain Tie Ratios of consoles as well as Attach Rates of software titles and accessories regarding the console systems. The Tie Ratio indicates how many games have been sold for each console purchased. In other words, the Tie Ratio shows how many games a system owner buys on average. A system’s Tie Ratio is the total game unit sales divided by the total console unit sales. The Attach Rate expresses approximately how many owners of a console also own another item for that specific system, such as a software title or an accessory. The Attach Rate for a software title, for example, is calculated by dividing the total number of units sold of that software title by the total console unit sales of the system on which the software runs.

Aside from a deeper understanding of the modeling technique and the application of some complex modeling aspects, another goal of this exercise is to present and discuss different solutions and their advantages and disadvantages. As the flexibility of some modeling techniques (among others $H_{2fR}$) allows for specifying the same facts in many different ways, in particular regarding the trade-off between abstraction and detail, the discussion of different solutions is an important issue. The discussions during exercises address both, learning goal A.II, but also goal A.III.

Learning Phase B: Study

Learning phase B addresses in particular the teaching of (modeling) constructs that are necessary (1) to develop regulatory compliant DWHs (learning goal B.I), (2) to apply the learned knowledge of compliant DWH modeling (learning goal B.II) and (3) to reflect it (learning goal B.III). Consequently, the focus is on teaching and application of the legal extension of the modeling technique ($H_{2fR}$ in our case). The participating students learn the meaning and use of the regulation elements when modeling legally required reports. We conducted learning phase B in a one-day workshop.

Teaching Block B1 (Lecture): Introduction to legal modeling

This lecture block aims to teach the legal extensions of the modeling technique $H_{2fR}$ (learning goal B.I). Modeling elements taught in this block are described below and can also be found in Appendix 1. To express the regulatory foundation of report and DWH elements, External and Internal Regulations are used. While external regulations represent legal report requirements, internal regulations represent either the concretization of a law or a single internal reporting requirement. Regulations can be classified into deontic regulations (for deontic logic see Risto 2001; von Wright 1951) that characterize obligations, exemptions, prohibitions and permissions. Non-deontic Regulation elements are used to express executive power and qualifications of regulations. Regulation Element Relations are used to represent relations between regulation elements. For example, when a certain paragraph might refer to another paragraph and both paragraphs are important to calculate a certain ratio, they are related to each other. A Validity relation is used to express that a certain regulation is valid for a set of DWH model elements. In this context Validity Attributes describe the validity in cases of temporal constraints.

Teaching Block B2 (Exercise): Modeling legal text snippets

Teaching block B2 is about modeling excerpts of regulatory reporting requirements and applying the learned modeling technique with its legal extensions for reference DWH modeling (learning goal B.II). Participants receive one small text snippet that contains one or two original sentences from the law. Selected legal text snippets and their example model solutions are depicted in teaching note 3. The task is to transform these sentences into a conceptual DWH model. We have chosen parts of the German Liquidity Act to create eight tasks altogether. Each task contains the legal requirements for the representation of one or two DWH elements (dimensions, ratios, dimension scopes, etc.). The time limit to complete each task is five minutes. After each task, the optimal solution is presented and the participants are asked to write down their major problems. For this task they receive paper cards, on which they are instructed to make a note of each problem they have encountered. After all course participants are finished, they each present and describe their problems in front of the board. Finally, all problems are classified in seven categories (cf. Table 1), which have already been prepared. The goal of discussing the modeling problems is to let the students experience the usefulness of conceptual reference models (learning goal B.III).
Term definitions
- Understanding legal terms in law
- Achieving background knowledge

Data warehouse constructs
- Recognizing ratios and ratio systems
- Modeling of dynamic reporting frequencies
- Decision making between dimension and ratio

Extended constructs
- Variables and functions are missing
- Recognition of dynamic elements
- Representation and differentiation of regulation elements

Configuration
- Recognition of different application scenarios (private vs. business customers)
- Modeling of exceptions
- Representation of configuration scenarios

Interrelations problems
- Representation of time
- Modeling of law excerpts that are too short
- Legal requirements are interdependent
- Difficult to recognize interdependencies

Granularity
- Assignment of legal paragraphs to model elements
- Granularity of argumentation

Table 1. Categorized modeling problems

Teaching Block B3 (Exercise): Comparing text and model understanding

Teaching block B3 simulates a practical environment in which the participants learn how to evaluate whether a certain modeling technique is an appropriate means to model legal reporting requirements. In this way, the participants are motivated to evaluate the use of suitable modeling techniques (learning goal B.III).

We reach this goal by conducting a memorization exercise, in which the participants are divided into two groups. The task is to memorize either a legal reporting requirement text or the corresponding conceptual model. Three tasks altogether have been conducted in this exercise. Firstly, Group A received the legal text excerpt and Group B received the corresponding model. Both groups were given 7 minutes to memorize the information contained in the text and shown in the model. Then the sheets were collected and 7 to 10 multiple-choice questions about the content of the legal text and model were answered. With a different task this procedure is repeated by switching the groups (former group A is now B and vice versa). Tasks one and two have a comparable difficulty level; task three has a larger scope and was conducted in a new randomized group setting. A detailed description of the exercise containing the legal text, model and sample questions can be found in teaching note 4. A final discussion should confront the students with questions regarding the applicability of the evaluation method used (learning level 3).

Two out of three groups achieved better results for the textual content and one group achieved better results for the model case. After the exercise was finished, we asked the students for their opinion about the method results as well as the method itself. The goal of this discussion is to recognize that memorization is only one of several factors that influence the applicability of a modeling technique (Siau and Rossi 2007).

Teaching Block B4 (Exercise): Reaching the limits of reference models for disclosure regulations

The teaching block B4 aims to discuss the usefulness of conceptual reference models. It comprises a kind of competition between two groups who both face the same task. Students receive an excerpt of a (longer) legal reporting requirement text and are asked to prepare a conceptual DWH model to practice the development of conceptual reference models (learning goal B.II). The detailed task description is available under teaching note 5. By modeling a longer section of the law, the students are confronted with the limitations of multidimensional DWH modeling. For example, process requirements, such as separation of duties, cannot be represented in DWH models. In this way the students learn both, the modeling of legal requirements (learning goal B.II) and the limitations of conceptual modeling (learning goal B.III).

While the participants prepare the report model they are also asked to think about questions that the opposite group should answer. The questions should address modeling challenges, which the group is confronted with while creating the report model. Questions could be, for example, “How do you represent fact calculation in order to consider dynamic maturity
bands?” This method has two advantages: Firstly, the groups have to think about a solution of how to create a suitable DWH representation of the legal text excerpt. Secondly, by creating questions for the other group, it is clear that these questions should be as challenging as possible to win the competition. But challenging questions imply that the asking group already found a solution. Thus, an increased motivation to solve even difficult modeling problems can be assumed. After modeling the requirements, we used moderator techniques to discuss the strengths and weaknesses of conceptual reference models in a legal context. Our initial question was: “What strengths and weaknesses do conceptual reference models for legal reporting requirements have?” Each participant receives paper cards to write each strength and weakness on one card. When finished writing, each participant is asked to present the cards and classify them at the board among five categories which we prepared (Cost, Time, Quality, Risk, Competitor Position). The discussion particularly addresses the evaluation and usefulness of reference models for reporting compliance (learning goal B.III).

Learning Phase C: Practice

While learning phases A and B already cover the knowledge and application of legal modeling as well as aspects of reflection regarding the benefits of (reference) modeling, the third (and last) learning phase intensifies the application of the modeling technique and focuses even more on reflection. It addresses learning level 1 through lectures in project management and reporting basics and levels 2 and 3 through intensive application of legal modeling in a project setting. The goal is to apply the taught modeling technique in a realistic and more sophisticated environment. In this way, we foster discussions of the modeling technique and its application as well as reflections regarding advantages and disadvantages of certain modeling alternatives and the fundamental contribution of reference models.

The main part of learning phase C is a practical project, which includes the development of a reference model for a complete legislative text. To prepare for the project, the participants are trained in project management concepts and methods.

Teaching Block C1 (Lecture): Introduction to project management and legal reporting requirements

To prepare for the project block of this learning phase, the participants are trained in project management and legal reporting requirements. In our case reporting regulations from the German Large Exposures Act and Basel III have been applied. Therefore, general project management concepts and methods are conferred (cf. learning goal C.Ia in Figure 1). The participants have to manage the project independently and are responsible for the project success. For this, they have to choose an appropriate project management configuration. To create a deeper understanding of reporting compliance and to create an overview of legal reporting requirements, certain legal reporting regulations are introduced and discussed in detail (cf. learning goal C.Ib). As a result, the participants are expected to improve their understanding and ability to classify regulations among their deontic function.

Teaching Block C2 (Project): Conceptual modeling of Large Exposures Act and Basel III

The course participants receive a complete legislative text (Large Exposure Act and Basel III) that they are asked to transfer to a conceptual DWH reference model. The reference model is developed in an iterative modeling process over a period of seven to eight weeks. Therefore, the participants have to organize themselves and apply project management methods to achieve a clean organization and a productive workflow. This reinforces the concepts learned in the preceding lecture block addressing learning goal C.Ia. The intensive examination of the legislative text leads to a greater knowledge and deeper understanding of legal reporting requirements (learning goal C.Ib). Modeling conceptual models in a more realistic and sophisticated environment (learning goal C.II) is not the only objective. Rather, the consensus-finding process and discussions on how to come to a suitable solution are essential aspects of this learning phase as well. The challenge of creating such a complex but consistent and suitable model is expected to sensitize the participants regarding the importance, usefulness and limitations of reference modeling. Through this, the project implementation addresses learning goal C.III (see Figure 1).

EVALUATION

The teaching concept is part of the bachelor program Information Systems. During the study program, courses and lectures are continuously evaluated with a standardized questionnaire. The evaluation criteria were adjusted faculty-wide before it was first applied in an extensive test phase. After this test phase the questionnaire is now a constant evaluation component of each lecture and course. All participants of the presented teaching course received such a questionnaire in order to evaluate it. Figure 2 depicts the evaluation results of the elective course BPM in Financial Industries (aggregated for both courses).
The overall evaluation of the course was quite positive which signals an outstanding satisfaction of the participating students compared to other courses in the bachelor program. The average evaluation of the implementation of the teaching concept regarding all evaluation criteria is at minimum in the range of good. The participants evaluated the course content as relevant from both a theoretical and practical perspective and confirmed that the learning goals were sectioned in realistically achievable blocks. Less positive was the evaluation of the transparency of learning goals and the visibility of the leitmotif. This less positive evaluation might be ascribed to the fact that in the beginning of each learning block the learning goals were not named explicitly. The participants did not receive the learning goal framework represented here (cf. Figure 1) when the course began. We decided to skip the learning goal presentation because we did not want to bias the participants when expressing their opinions (i.e. about the limitations of reference modeling and reporting compliance). In future applications of this teaching concept it is necessary to find a better compromise between an early explication of the learning goals and the establishment of an unbiased workshop atmosphere.

LIMITATIONS AND CONCLUSION

In this paper we presented a teaching concept that is based on the idea to simulate a realistic reporting scenario in financial industries. By applying this teaching concept, students learn how to design DWH systems and what challenges arise in interdisciplinary DWH engineering teams. The didactical concept sensitizes students for the usefulness and applicability of conceptual (reference) modeling for DWH engineering. We used the financial sector in order to provide an environment which is highly regulated and thus forces students to work with terms and conditions that do not necessarily belong to the educational field of IS. We further enable students to evaluate modeling techniques and discuss the strength and weaknesses of conceptual modeling in general and reference modeling in particular.

The learning goals are completely covered by the presented learning blocks (cf. area a in Figure 3). So far, the proposed teaching concept has been successfully conducted two times within the elective course on BPM in Financial Industries. We expect the teaching concept to be applicable and adaptable to other teaching contexts. But there are limitations regarding the reuse of the teaching concept. Depending on the extent and the homogeneity of the participants’ prior knowledge, the learning blocks of phase A (Preparation) might need to be adjusted – at best they can be skipped completely. In particular in cases where participants have a stronger legal but less technical educational background, the first learning phase should include additional elements to ensure an equal level of knowledge regarding conceptual DWH modeling. Furthermore, according to the participants’ practical project experience, the extent of the lecture part C1 (project management and reporting knowledge) has to be adjusted. In our case, the teaching concept and its application are in form of a seminar allowing the implementation of a medium-term practical project. If these conditions are not met, the teaching concept can be adapted to only address the learning goals of the workshop covering learning phases A and B (cf. area b in Figure 3). Further applications of the concept should also shed light on the effectiveness and efficiency of the concept.
The teaching concept proposed in this paper has been applied to the framework of a bachelor program. The three addressed learning levels seem to be appropriate for this environment. In the case of a master program or a set of more qualified or more practically experienced participants, the teaching concept should be extended to also include learning level IV (Improvement). By applying creative techniques, the participants are able to develop and implement their own improvements for the applied concepts and methods (cf. area c in Figure 3).

**REFERENCES**


APPENDIX A

The example includes a report template provided by the German Solvency Act (above), an H2IR-model (with brief notes) conceptually implementing the report template, and a description of the model (below). The excerpt of the German Solvency Act comprises reporting relevant requirements and has been chosen because of its simplicity.

<table>
<thead>
<tr>
<th>Report Template Market Risk</th>
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</thead>
<tbody>
<tr>
<td><strong>2010</strong></td>
</tr>
<tr>
<td><strong>Germany</strong></td>
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<td><strong>France</strong></td>
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<td><strong>Japan</strong></td>
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<td><strong>USA</strong></td>
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<td><strong>Other</strong></td>
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