Available online at www.sciencedirect.com

ScienceDirect

Procedia Technology 16 (2014) 440 – 446

Procedia Technology

CENTERIS 2014 - Conference on ENTERprise Information Systems / ProjMAN 2014 - International Conference on Project MANagement / HCIST 2014 - International Conference on Health and Social Care Information Systems and Technologies

Designing a Decision Support System for Tasting Panels

Leonor Teixeira[a,b,*], Ana Luísa Ramos[a,c], Ana Raquel Xambre[a], Helena Alvelos[a,d]

[a]*Department of Economics, Management and Industrial Engineering, University of Aveiro, 3810-193 Aveiro, Portugal*
[b]*IEETA - Institute of Telematics and Electronic Engineering of Aveiro, University of Aveiro, 3810-193 Aveiro, Portugal*
[c]*GOVCOPP - Governance, Competitiveness and Public Policies, University of Aveiro, 3810-193 Aveiro, Portugal*
[d]*CIDMA - Center for Research and Development in Mathematics and Applications, University of Aveiro, 3810-193 Aveiro, Portugal*

Abstract

Tasting Panels are used in Sensory Analysis in order to evaluate products according to the way they are perceived by human senses. In this context, the main job of a professional taster is to assess the sensorial characteristics of products, for example in the food industry. Evaluating the individual performance of the tasters is thus essential, so the results produced are as reliable as possible. The tasting process usually generates a large amount of data that is used in decisions about the products and can also be used to evaluate the tasters. The main objective of this work is to specify and conceptualize a Decision Support System (DSS) to help managing and handling the referred data. This is considered a valuable contribution, since there are no known technological decision tools to support the tasting process.

Peer-review under responsibility of the Organizing Committee of CENTERIS 2014.

Keywords: Decision Support Systems; Sensory Analysis; Tasting Panels; UML.

1. Introduction

A classical definition of Sensory Analysis is referred by Stone and Sidel [1] and Dijksterhuis [2] as "a scientific discipline used to evoke measure, analyse, and interpret reactions to those characteristics of products or materials as

*Corresponding author. Tel.: +351-234-370361; fax: +351-234-370215.
E-mail address: lteixeira@ua.pt

Peer-review under responsibility of the Organizing Committee of CENTERIS 2014.
doi:10.1016/j.protcy.2014.10.110

they are perceived by the senses of sight, smell, taste, touch and hearing". According to Zeng *et al.* [3] Sensory Evaluation is usually carried out by one or several sensory (or tasting) panels, being a Tasting Panel (TP) defined as a group of individuals that evaluate sensory characteristics of products' samples.

The various characteristics (or parameters) are frequently assessed using numeric scales (e.g., 1 to 5) that reflect the quality of the sample on the parameter, or using binary scales (0 or 1) that indicate the presence or absence of a certain aspect (e.g., defect) of the sample. The samples are thus evaluated according to those parameters by each member of the TP using a scorecard that aggregates all the necessary information.

Additionally, often the purpose of the Tasting Process is to make a binary decision regarding the product under analysis, namely "approve" or "reject". The final decision is then made by the TP responsible (decision-maker), taking into account the scorecards filled by the tasters and considering the overall performance of each one.

Tasting Panels have thus a determinant role in Sensory Analysis as they can be seen as "measurement instruments" for sensorial characteristics. This type of panels are widely used in the food industry, namely, wine, olive oil, chocolate, among others, as well as in other types of industry, for example cosmetics and perfumes.

Conventional measurement instruments are, usually, calibrated and controlled in order to guarantee reliable results. The specificity of tasters as measurement instruments does not allow, however, for the direct use of the same methods for calibration and control used with conventional instruments. On the other hand, tasters, as humans, can be influenced by external factors which can lead to situations where the same product is evaluated differently, by the same taster, in different moments.

The assessment of the individual panelists is used in various activities in the sensory analysis process, like in the selection, training and qualification [4]. Then again, the evaluation of the performance of the panel as a whole is also considered [5], [6], [7]. The panel consonance and the establishment of standards for the products under analysis [8], [9] are questions that are frequently raised when addressing these issues [10].

This work is part of a broader project which aim is the specification, conceptualization, development and test of a Decision Support System (DSS) prototype to be used in Sensory Analysis, in order to improve the consistency and quality of the decision process of the TP, and that encompasses the following two main components:

- the identification and development of methods to be used in Sensory Analysis, so that products can be adequately evaluated, tasters control can be carried out properly, and Tasting Panels' decisions can be delineated considering the utmost available information possible, and;
- the use of Information and Communication Technologies (ICT) as a way to aggregate the available data, integrate the different methods and generate results that can contribute to guarantee the quality of the decision making process associated with tasting procedures.

The first part is strongly related to statistics on one hand, because the data which result from the scorecards filled out by the tasters must be analysed using statistical methods (like descriptive statistics, hypothesis testing and analysis of variance) in order to allow an adequate product evaluation. On the other hand, tasters, as measurement instruments "… are highly variable and very prone to bias, but they are the only instruments that will measure what we want to measure, so we must minimize the variability and control the bias by making full use of the best existing techniques …" [11]. Nevertheless, the specificity of tasters as measurement instruments does not allow for the application of the traditional methods used with conventional instruments [10]. In this context, the use of statistical techniques is essential in order to extract the relevant information from the data generated by the tasting procedure and also from other sensory tests used specifically to assess tasters' performance (e.g. difference tests, attribute difference tests and threshold definition tests ([11], [12] and [13])). The statistical techniques used in this scope can include analysis of variance ([14], [15] and [16]), regression analysis ([17] and [18]), multivariate statistics approaches ([3], [14], [15], [19], [20]), and Receiver Operating Characteristics Curve ([21] and [22]). Although this field of study seems to be reasonably covered by the literature, integration of the methods that allows individual information on panellists' performance to be incorporated into the final decisions of the panel is still not found.

While this first component of the project is undoubtedly important, it is, however, out of the scope of this paper.

The second part of the work arose from the realization of the inexistence of technological decision tools to support tasting processes. Additionally, advances in ICT have made possible to collect, store and process massive, often highly complex datasets [23]. All this data can hold valuable information such as trends and patterns, which can be used to improve decision making. Decision Support Systems (DSS) are a specific class of computer-based information systems that support decision-making activities and that use analytical models (including knowledge-based systems) and specialized databases [24].

Additionally, Zeng *et al*. [3] state that "sensory evaluation is a multidisciplinary topic which needs the common efforts of researchers, engineers, managers, and consultants having different professional backgrounds and different knowledge profiles". The same authors [3] classify this research topic into three categories, being the objective of one of them the development of new computing methods or adapting existing techniques in order to model and analyse sensory evaluation from sensory data.

The purpose of this paper is to present the specification and modelling phase of the database component of the Decision Support System, through the use of structural and behavioural models.

2. System design: specification and modelling

The system will be designed to support the evaluation of Tasting Panels in sectors where Sensory Analysis is used to assess product quality.

The following subsections describe key aspects of the system through UML (Unified Modeling Language) models [25]. As widely known, UML constitutes the *de facto* modelling language for object-oriented analysis and design and this independent-methodology graphical language helps to view and organize the world as a collection of interacting objects, which are cohesive clusters of data and function [25 and 26]. By applying object-oriented modelling concepts to software development we can achieve characteristics like reusability (ability to reuse a module/component in new models) and extendibility (ability to extend a model when system functions are expanded) and consequently, we can get adaptable and extensible software. Behind these capabilities we find concepts like abstraction, encapsulation, inheritance and polymorphism.

The UML models capture information about the static structure (what types of objects are important to describe the system and how they are related) and the dynamic behaviour (the life cycles of those objects and how they interact with each other to accomplish the system functionality) of a system. The UML diagrams are windows or views into UML models. They are the way to visualize what the system will do or how it will do, and the primary mechanism for entering information into the model.

The UML diagrams can be divided in two main categories: structural and behavioural. The structural group describes the components of the system and their relationships (e.g. package diagrams, class diagrams, component diagrams) and the behavioural category describes the behaviour of a system over time (e.g. activity diagrams, use case diagrams). In the following subsections are described the UML diagrams selected to illustrate the structural and behavioural modelling of the system-in-analysis.

2.1. Structural modelling

The main objective of the structural modelling phase was to identify, for this system, the key components and their relationships. The diagrams selected for that purpose were the Package Diagram and the Class Diagram. The Package Diagram enables the organization of model elements into coherent groups acting like a high-level architecture and the Class Diagram provides a more detailed static view highlighting the sets of objects that share the same attributes and the relationships between those sets or classes.

The Package Diagram depicted in Figure 1 considers the high-level system (SysSensory) and the two primary subsystems: the Tasting Process and the Taster Performance. The Tasting Process subsystem refers to the tasting procedure and to all the elements involved in a tasting session. The Taster Performance subsystem groups the methods for assessing tasters' and Tasting Panels' performance such as sensory methods and statistical based techniques. The description of this subsystem requires the identification, the development and the grouping of the referred sensory tests, in order to select the appropriate statistical techniques. The algorithms for the information processing are obviously incorporated in this subsystem, being however their description out of the scope of this paper. The combined information from these two subsystems will help the TP responsible to make the final decision about the products based on a consistent evaluation process.

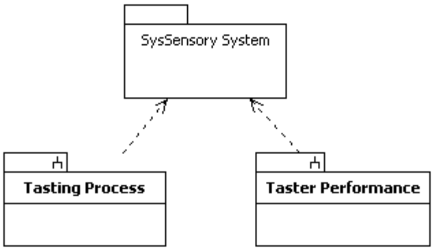

Fig. 1. Package Diagram for the main system and its subsystems

From this point on, the focus of this paper will be on the Tasting Process subsystem, being presented a set of models that explain with greater detail the operation of the referred subsystem.

The Class Diagram shown in Figure 2 details the structure of the Tasting Process subsystem that, as mentioned before, refers to the tasting procedure. Following, a brief explanation of the diagram's content is given. A collaborator can be: (i) a technician, who is responsible for the organization of tasting sessions; (ii) a taster, who evaluates the products under analysis or (iii) a decision-maker, who makes the final decision regarding the assessment of the products. A tasting session is created, by the technician, whenever there is a set of products to evaluate. Typically, each product can generate several samples, one for each time the product is assessed. During the tasting session, the tasters appraise each sample by filling in a scorecard that comprises, according to the product being analysed, several parameters (e.g., colour, aroma) and the related scales. Using the scores provided by the tasters, and also the information provided by the Taster Performance subsystem, the decision-maker will make the final decision.

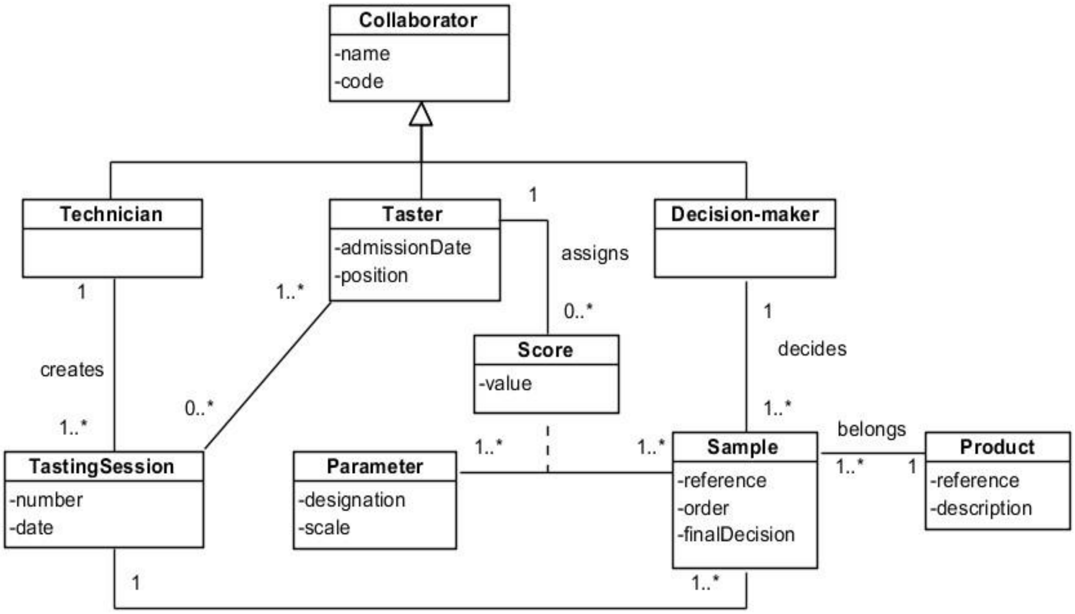

Fig. 2. Class Diagram for the tasting process subsystem

The following subsection will present some UML behaviour models in order to highlight the life cycles of the main elements of the system and how they interact with each other in order to accomplish the system functionality.

2.2. Behavioural modelling

The domain model in Section 2.1 shows the essential data reflecting the static modelling of the system. In this section, some behaviour diagrams are presented, in order to emphasize what must happen in the system in terms of access permissions and functionalities. The diagrams selected for that purpose were the Activity Diagram and the Use-Case Diagram. The Activity Diagram enables the description of the business process and the flow of work between the users and the system. The Use-Case Diagram allows for the representation of a set of actions (use cases) that a system should or can perform in collaboration with one or more external users (actors).

The Activity Diagram illustrated in figure 3 represents the tasting process, which includes a set of activities performed by different actors namely, the technician, the taster and the decision-maker.

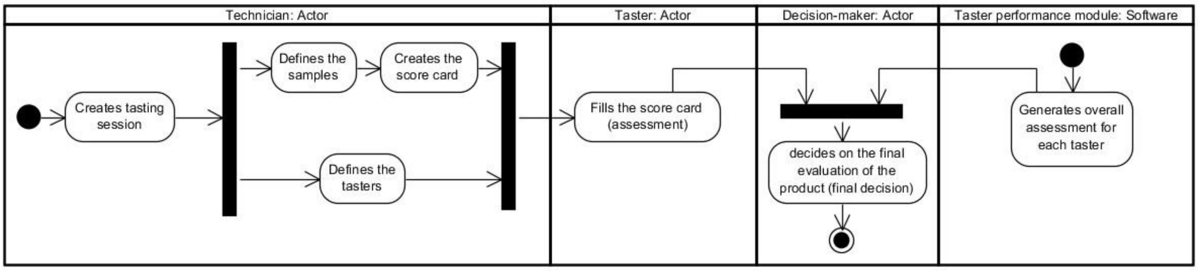

Fig. 3. Activity Diagram for the main activities for the tasting process subsystem.

The tasting process begins with the creation of a tasting session, by the technician, who has to determine: (i) the set of samples, (ii) the tasters who will participate in the session (the Tasting Panel), as well as, (iii) the decision-maker. In this particular case, the samples refer to the products (e.g., wines, chocolates) to be evaluated, and each product can generate more than one sample.

Each product, and therefore each sample, is evaluated according to a set of sensory characteristics or parameters, like colour, aroma, flavour, clarity, which have an associated scale.

The technician creates a scorecard by sample defining the set of parameters and the respective scales to be used in the evaluation process. After creating the tasting session, the tasters in the panel are notified.

The taster has access to the scorecard, after authentication and validation on the system. During the tasting session, each taster must complete the scorecard for each sample, using the presented scales and assigning a score to each parameter. The main role of this actor is to evaluate the product by completing the scorecard with the respective test results.

Finally, and after the tasting session is ended, the decision-maker will validate the final decision of approving or rejecting the product using, for that purpose, the results of the tasters' panel evaluation, as well as additional information generated by the taster performance module of the system. This module will use the accumulated data resulting from the answers given by the tasters, in a given time-period, to calculate the overall performance of the taster [6]. This time-based performance should be incorporated in the final decision in order to ensure that the product evaluation was accomplished through calibrated and controlled "measuring instruments".

The Use-Case diagram shown in figure 4 presents the high-level functionalities provided by the system to the three actors involved in the tasting process, the goals represented as use cases, and the dependencies among those use cases.

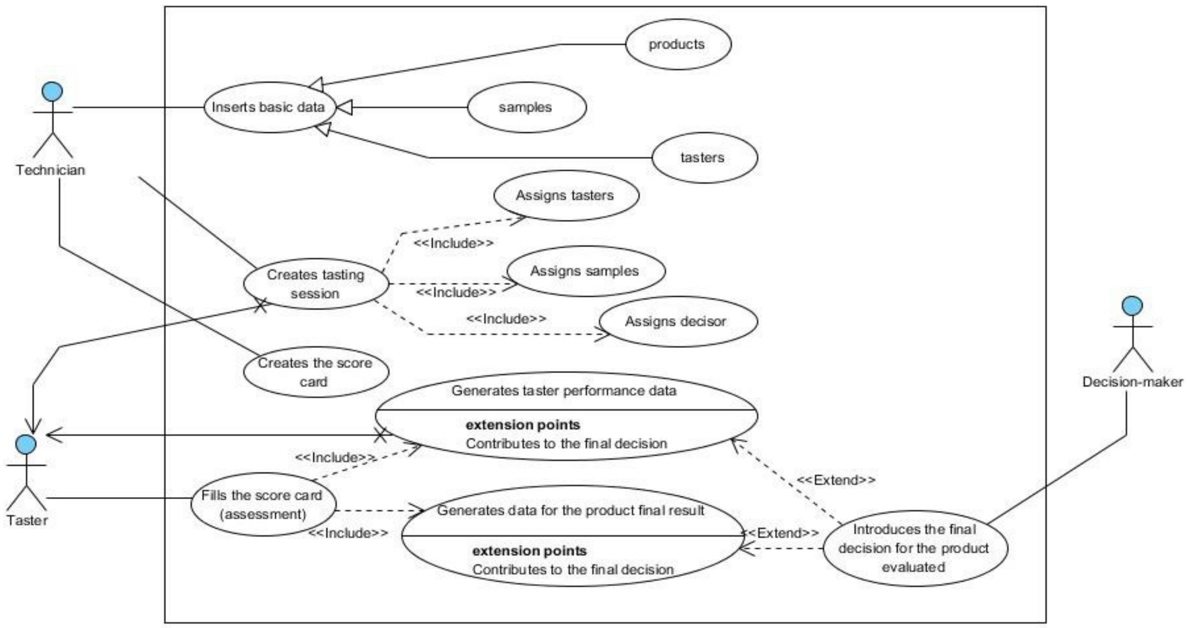

Fig. 4. Use Case Diagram for the main functionalities Class Diagram for the tasting process subsystem .

3. Conclusions and future research

This paper presented the specification and design process of a component of a Decision Support System in Sensory Analysis, more specifically a Tasting process. The main result of this analysis, designated as *Model*, was documented by a set of UML diagrams, grouped on a structural modelling set (Package Diagram and Class Diagram) and on a behavioural modelling set (Activity Diagram and Use-Case Diagram).

It is noteworthy that the presented *Model* of the Decision Support System just described is believed to adequately represent the majority of the Tasting Processes in Sensory Analysis since it can be adapted to different types of scorecards, for evaluating various sets of parameters according to different scales. Additionally, the actors considered in this system (Technician, Taster and Decision-maker) are the same as those found in the more common professional Tasting Panels. Although the system is being designed having in mind the food industry context, it is also being thought to be sufficiently versatile in order to be used in other industries such as cosmetics and perfumes. Nonetheless, in order to validate the model developed so far, there will be further discussions with TP's responsible from organizations that use professional tasters as "measurement instruments".

The work reported in this article is part of a broader project that is under development. As such, the next steps involve the specification and modelling of the other components of the DSS namely, the model base and the user interfaces, and the development of the DSS prototype. The prototype will then be tested in a real scenario.

It is important to emphasize that studies addressing this type of systems associated with Sensory Analysis were not found in the literature so, the development of such a system would thus be a valuable contribution to the integration of the two areas – Sensory Analysis and Information Technologies – with benefits for researchers of both of them and also for the tasting process' stakeholders.

Acknowledgements

This work is funded by FEDER funds through COMPETE (Operational Programme Factors of Competitiveness) and by National Funds through FCT (Foundation for Science and Technology) in the context of the project FCOMP-01-0124-FEDER-041776.

References

[1] Stone H, Sidel L. Sensory Evaluation Practices. San Diego: Academic Press;1993.
[2] Dijksterhuis G. Multivariate Data Analysis in Sensory and Consumer Science. Food & Nutrition Press Inc., Trumbull, Connecticut, USA; 1997.
[3] Zeng X, Ruan D, Koehl L.Intelligent sensory evaluation: Concepts, implementations, and applications. Mathematics and Computers in Simulation; 2008. 77 (5–6): 443-452.
[4] Etaio I, Albisu M. Ojeda M, Gil P F, Salmerón J, Pérez Elortondo F J. Sensory quality control for food certification: A case study on wine. Panel training and qualification, method validation and monitoring. Food Control; 2010. 21(4): 542-548.
[5] Latreille J, Mauger E, Ambroisine L, Tenenhaus M, Vincent M, Navarro S, et al.. Measurement of the reliability of sensory panel performances. Food Quality and Preference, 2006. 17(5): 369-375.
[6] Alvelos H, Cabral JA, Amaral B, Barros P. Statistical Methods for Controlling Wine Tasting Panels. Ciência e Técnica Vitivinícola, 2000. 15: 15-26.
[7] Alvelos H, Amaral B, Cabral JA, "Assessing the Global Performance of the Members of a Wine Tasting Panel", Proceedings of the XXV World Congress on the Vine and Wine, Section II, 2000. pp. 373-378, Paris.
[8] Lerma-García M J, Cerretani L, Cevoli C, Simó-Alfonso E F, Bendini A, Toschi T G. Use of electronic nose to determine defect percentage in oils. Comparison with sensory panel results. Sensors and Actuators B: Chemical, 2010. 147(1): 283-289.
[9] Rocha S, Delgadillo I, Barros P, Alvelos H, Cabral J A. Characterising Different Types of Port Wine Using An Electronic Aroma Sensing Equipment and Chemical and Colour Analyses. Proceedings of the 24th OIV Mundial Congress, Section II – "Oenology Faced With Market Requirements", Vol. 2, p. 217-224. Mainz, Deutschland, 5-9 Julho 1999.
[10] Alvelos H. "Análise, Desenvolvimento e Teste de Métodos e Técnicas para Controlo Estatístico em Análise Sensorial", PhD. Thesis, Faculdade de Engenharia da Universidade do Porto, Porto, 2002.
[11] Meilgaard M, Civille G, Carr B. Sensory Evaluation Techniques, Vol. 1. Boca Raton, Florida: CRC Press, 1987.
[12] Cubero E, Almeida T, O'Mahony M. Cognitive Aspects of Difference Testing: Memory and Interstimulus Delay. Journal of Sensory Studies, 1995. 10: 307-324.
[13] Bi J, Ennis D M. The Power of Sensory Discrimination Methods Used in Replicated Difference and Preference Tests. Journal of Sensory Studies, 1999. 14: 289-302.
[14] Antoniou KD, Petridis D, Raphaelides S, Bem-Omar Z, Kesteloot R. Texture Assessment of French Cheeses. Journal of Food Science, 2000. 65: 168-172.
[15] Castura JC, Findlay CJ, Lesschaeve I. Monitoring calibration of descriptive sensory panels using distance from target measurements. Food Quality and Preference, 2006. 17(3–4): 282-289.
[16] Naima HA, Mehdi S, Morched CH. Training and control of performance of a tactile sensory panel. Journal of Applied Sciences, 2013. 13(3): 366-376.
[17] Korth B. Use of regression in sensory evaluation. Food Technol, 1982. 36(11): 91-95.
[18] Alvelos H, Cabral JA. Modelling and monitoring the decision process of wine tasting panellists. Food Quality and Preference, 2007. 18(1): 51-57.
[19] Anzanello MJ, Fogliatto FS, Rossini K. Data mining-based method for identifying discriminant attributes in sensory profiling. Food Quality and Preference, 2011. 22(1): 139-148.
[20] Tepper B, Kuang T. Perception of Fat in a Milk Model System Using Multidimensional Scaling. Journal of Sensory Studies, 1996. 11: 175-190.
[21] Bi J, Ennis D, O'Mahony M. How to Estimate and use the Variance of d' from Difference Tests. Journal of Sensory Studies, 1997. 12: 87-104.
[22] Hautus M, Irwin R. Two Models for Estimating the Discriminability of Foods and Beverages. Journal of Sensory Studies, 1995. 10: 203-215.
[23] Cortez P, Cerdeira A, Almeida F, Matos T, Reis J. Modeling wine preferences by data mining from physicochemical properties. Decision Support Systems, 2009. 47 (4): 547-553.
[24] Arnott D, Pervan G. A critical analysis of Decision Support Systems research. Journal of Information Technology, 2005. 20 (2): 67-87.
[25] Booch G, Rumbaugh J, Jacobson I. The Unified Modeling Language User Guide. 2nd ed. Reading (MA), Addison-Wisley, 2005.
[26] Arlow J, Neustdt I. UML 2 and The Unified Process: practical object-oriented analysis and design. 2nd ed. Massachussets, Pearson Education, Inc, 2005.