Mourgues, C., and Norero, H. 2015. Improvement opportunity in the design process of a social housing developer. In: *Proc. 23rd Ann. Conf. of the Int'l. Group for Lean Construction*. Perth, Australia, July 29-31, pp. 558-567, available at www.iglc.net

IMPROVEMENT OPPORTUNITY IN THE DESIGN PROCESS OF A SOCIAL HOUSING DEVELOPER

Claudio Mourgues[1], and Hugo Norero[2]

ABSTRACT

The design process in social housing projects includes several inefficiencies that impact not only the design itself but the whole project results. Part of the problem is that the design includes several non-value adding activities such as waits, design modifications, and rework.

Preliminary data from a case study in this research shows that deliverable control; work team coordination, communication and integration; personnel workload; and work planning and allocation are the main drivers of a good design in these projects. On the other hand, existing literature suggests the use of lean philosophy to improve the design but there is no evidence of how lean could be used in the context of social housing design. Therefore, this research assesses the most relevant drivers from the identified list for a case study and proposes and tests the use of Last Planner System and Collaborative Design to address these drivers to support social housing design.

The article describes the case study context and discusses the results from the interviews and surveys used to identify the main drivers for a good design. The article also proposes a lean design process and the validation methodology which is still to be implemented.

KEYWORDS

Social housing, lean design, last planner system, collaborative design

INTRODUCTION

Social housing projects in Chile are developed by social real estate management entities (EGIS, by its Spanish acronym), which establish contact with the future recipients of the state subsidies for the houses (future house owners) and support them during the whole process. This process usually goes from the organization of the group of individual owners to 9 months after the houses are delivered to the owners (MINVU, 2014). It is common to find EGIS that include the service of design and construction of the houses.

In this context, the design of the houses is basic, as the budget is very small and so, a same design – with small changes – is repeated in several projects. The limited effort spent in the design process affects not only the quality of the design but also the

[1] Assistant Professor, Construction Engineering and Management Dept., Pontificia Universidad Católica de Chile, Chile, +56-2-2354-4245, cmourgue@ing.puc.cl

[2] OVAL, Construction and Development Company, Chile, hugonorero@gmail.com

efficiency and effectiveness of the construction as the early project phases dramatically impact project performance (Kolltveit and Grønhaug, 2004).

Despite the impact that the design process has in the rest of the project, research on the management and engineering of this process has been limited (Freire and Alarcón, 2002). Several authors (Cornick, 1991; Austin, Baldwin and Newton, 1994; Koskela, Ballard and Tanhuanpaa, 1997; Ballard and Koskela, 1998; Formoso et al., 1998), referenced by Freire and Alarcón (2002), indicate that "planning and control are substituted by chaos and improvising in design, causing poor communication, lack of adequate documentation, deficient or missing input information, unbalanced resource allocation, lack of coordination between disciplines, and erratic decision making."

To reduce these problems, some authors have proposed the use of Last Planner™ for the design process (Freire and Alarcón, 2002; Choo et al., 2004; Hamzeh, Balard and Tommelein, 2009). Other authors have proposed integrated concurrent engineering – an adaptation of extreme collaboration (XC), which is a design collaboration methodology developed at NASA (National Aeronautics and Space Administration) – to accelerate the design process (Chachere, Levitt and John Kunz, 2003; Chachere, 2009). Jara, Alarcón and Mourgues (2009), proposed an interesting combination of both approaches, using last planner to manage the design commitments and thus increasing the productivity and efficacy of the integrated concurrent engineering sessions.

This research aims at identifying main drivers of efficient design for social housing in Chile and assessing Last Planner™ system and collaborative design to reduce an EGIS design problems. This paper presents the drivers and the proposal for the application and validation of these methods, as the application is still undergoing.

METHODOLOGY

The research is based on a case study where interviews – together with the literature review – provided key information to identify relevant factors for an efficient design process. The interviews included the four managers of the case study's company. Then, based on a survey applied to the case study, we chose the most important design factors for the company. Finally, to improve the design efficiency addressing the identified factors, we propose the use of two Lean Methodologies.

The validation of these methodologies is still to be implemented, and the methodology for this validation is described in the "Proposed Intervention" section of this paper.

SOCIAL HOUSING DESIGN – CHILEAN CASE STUDY

The case used in this research is an EGIS company that coexists with a construction company, which is a common case in Chile. This company develops and builds about 8 projects per year, ranging from 15 to 160 units, with an approximate annual revenue of 20 million USD. This company's design process usually is longer than the initially estimated duration, forcing an overlap between design and construction. The case study aims at understanding the causes of this problem and proposing/testing a solution.

First, we collected preliminary data that allowed us to identify factors that are relevant for an efficient design and the company's performance and improvement need regarding those factors.

RELEVANT FACTORS FOR DESIGN EFFICIENCY

Open interviews to the company's four managers – guided by the literature review – helped us to identify the following factors.

- Human resource quantity and quality: number of persons working in the design process with experience, skills and attitude proper for the work.
- Quality of design input information: clear definition of a client's requirements and scope.
- Personnel workload: amount of work that design workers are performing at the same time.
- Leader skills: soft skills such as proper decision making, empathy, being able to motivate, work coordination, conflict solving, etc.
- Coordination, communication and integration of the work team: how well the design team members relate to each other to perform their job.
- Work planning and allocation: analysis of dependencies and constraints in the design process in order to plan and allocate resources accordingly.
- Quality and quantity of infrastructure, equipment and tools: Proper relation between the needs of the design tasks and the amount and quality of resources such as physical spaces, computers, software, etc.
- Document management: being able to efficiently and securely create, find, distribute, review and store design documents.
- Deliverable control: systematic review of the deliverables to reduce design mistakes and omissions.

These factors do not intend to be a comprehensive list but they represent the view of the company´s managers about the drivers of design efficiency for their projects.

In order to assess the importance of these factors for the company's design efficiency, we applied a survey to the company's design professionals.

SURVEY

The survey asked about the need for improvement and the general performance of the company for each of these factors. These two questions try to gather the relevance of the factors from different perspectives. The first question (improvement need) emphasizes the implicit relevance of the factor in order to reach higher efficiency in the design process. The second question (general performance) assesses how well the company is doing related to that factor.

The respondents include 8 professionals that represent almost 73% of the company´s personnel involved in the design process (11 persons).

Table 1 shows the assessment of the company's improvement need for each of the identified factors. The survey asked the respondents to identify the three factors (without order) that the company needed to improve the most to have a successful design process.

Table 1. Survey Results for the Company's Improvement Need

Design Efficiency Factor	**Respondents**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Work planning and allocation	1	1	1			1	1	1
Work team coordination, communication and integration	1	1	1	1	1		1	
Deliverable control	1	1	1					
Leader skills				1		1		1
Personnel workload					1	1		1
Quality of design input information				1	1			
Document management							1	
Human resource quantity and quality								
Quality and quantity of infrastructure, equipment and tools								

The assessment of the company's performance is based on a 5 point Likert scale where 5 is the worst behaviour and 1 is the best one. Table 2 shows these results.

Table 2. Survey Results for the Company's Performance

Design Efficiency Factor	**Respondents**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Work planning and allocation	4	3	3	3	4	4	3	4
Work team coordination, communication and integration	4	3	3	4	3	3	3	2
Deliverable control	4	3	3	3	4	5	4	4
Leader skills	3	2	3	3	4	3	3	2
Personnel workload	5	1	5	5	5	5	1	1
Quality of design input information	2	2	4	4	3	3	3	3
Document management	3	2	4	3	3	3	3	4
Human resource quantity and quality	2	2	2	2	2	2	2	3
Quality and quantity of infrastructure, equipment and tools	2	2	1	2	1	2	2	2

Figure 1 compares the company's performance and improvement need regarding the design efficiency factors. The performance is calculated as the average of the responses shown in Table 2, while the improvement need is calculated as the percentage of respondents that identified each factor as shown in Table 1. Figure 1 also highlights the most relevant factors considering they either were selected by a majority of respondents in Table 1 or averaged a bad performance based on Table 2.

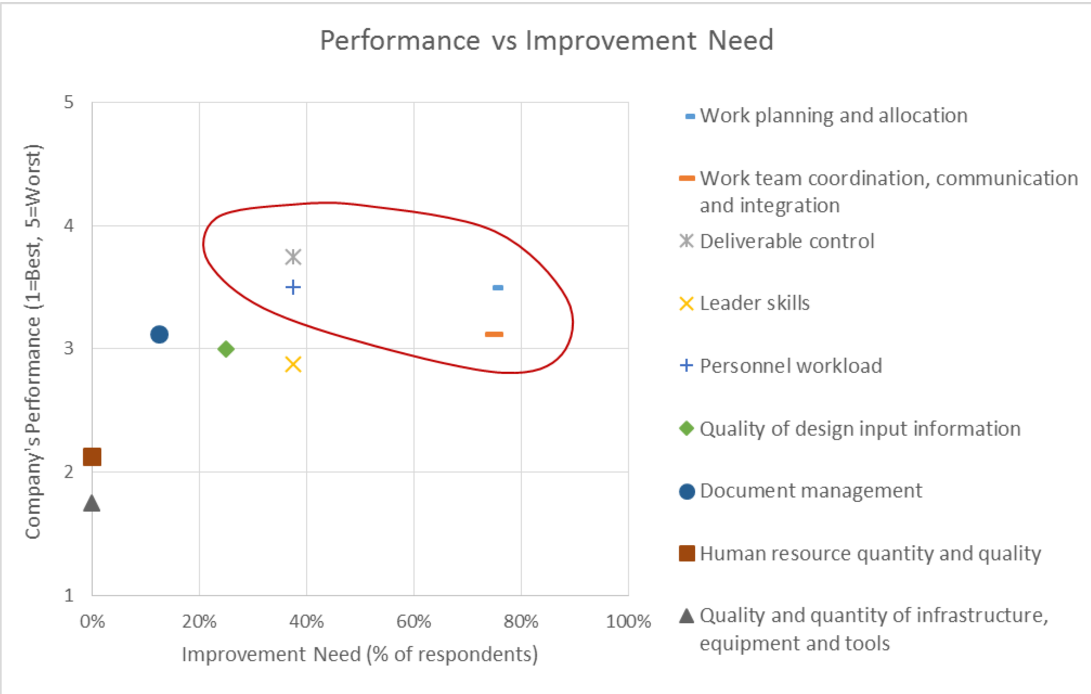

Figure 1. Company's performance and improvement need regarding the identified factors for an efficient design. Annotation highlights the most relevant factors.

Figure 1 shows that none of the design professionals consider that quantity and quality of both human resources and infrastructure, equipment and tools are part of the three most important factors that need improvement to accomplish an efficient design. At the same time, the professionals declare that the company is doing relatively well on those factors.

On the contrary, 80% of the design professionals that answered the survey considered the coordination, communication and integration of the work team, and the work planning and allocation to be within the three most important factors for an efficient design.

Regarding the company's performance, the respondents considered that the company's worst performance is on deliverable control, personnel workload, and work team coordination, communication and integration.

DESIGN EFFICIENCY METRICS

This study assesses the design efficiency as the duration of this process, considering a constant amount of design resources. The social design process includes two main phases: Design until delivery to SERVIU, and design from this delivery until final approval. SERVIU (Regional Service of Housing and Urbanism) is the state organism that approves the social housing projects. Figure 2 shows the data for 6 projects of the case study company. These projects are ordered chronologically with the newest projects to the right of the figure, covering a period of 5 years. The amount of design resources is considered the same for all the projects.

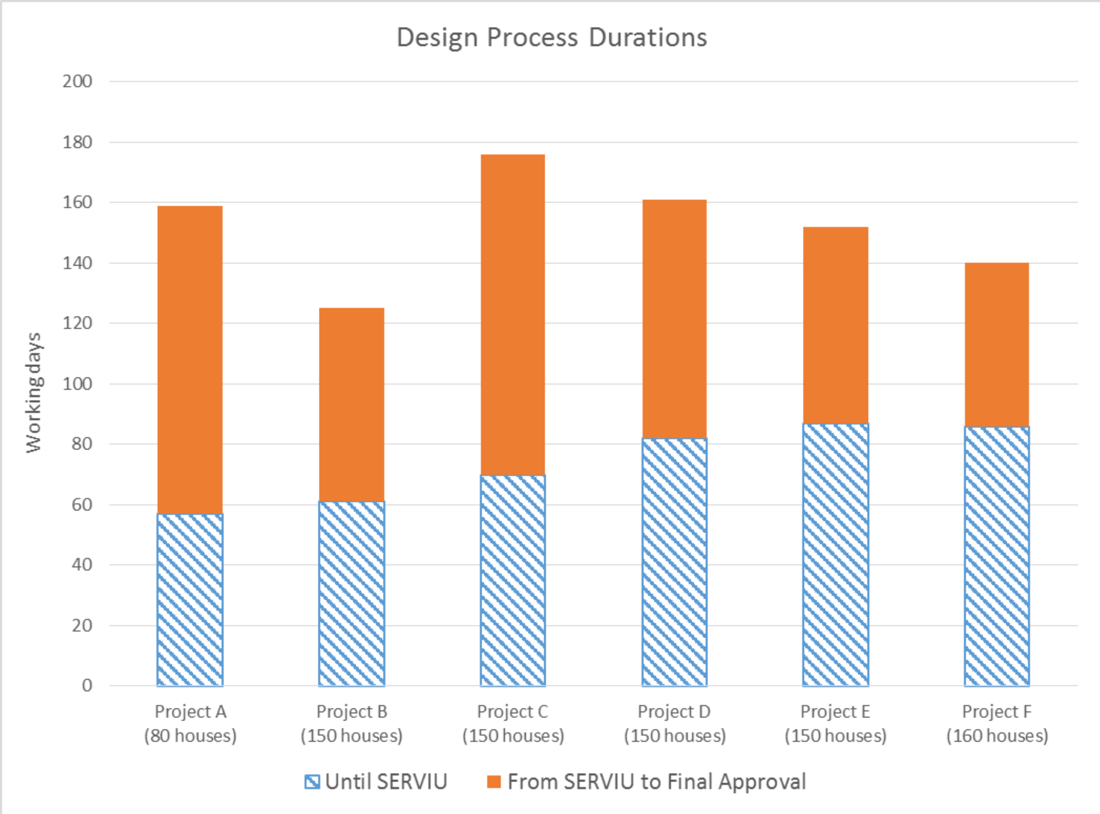

Figure 2. Duration of the social housing design process.

The projects include the number of house units to show that there is not apparent relation between number of houses and design duration. This is expected as even though there is certain design work related with the extension of the project (e.g., urbanization design), most of the work is focused on the houses but the same design applies to all the project houses.

Figure 2 shows an increment in the duration of the first phase of the design, i.e., all the work needed to present the design to the approving agency. At the same time, general duration decreases from project C. A possible interpretation of this incipient trend is that the longer process of preparing the design for the approving agency leads to a shorter review process and even total duration.

Despite this positive general trend, the company's managers consider that the total duration is still too long, which affects their competitiveness.

PROPOSED INTERVENTION

The next step in this ongoing research is to implement lean methodologies in the design process and compare the design efficiency metrics with the historic data.

Based on the results shown in Figure 1 and literature recommendations, we decided to implement Last Planner^{TM} System and Collaborative Design to address the most relevant factors for the design efficiency. The scope of this intervention is the first part of the design process shown in Figure 2: the internal design to prepare the information submitted to the approving agency (SERVIU). The next section describes this process with the proposed changes.

PROPOSED DESIGN PROCESS

The proposed process, depicted in Figure 3, aims at incorporating design collaboration sessions that are planned and prepared within the Last Planner^{TM} framework. The underlying idea is to use commitment management to facilitate the collaborative design (CD) sessions.

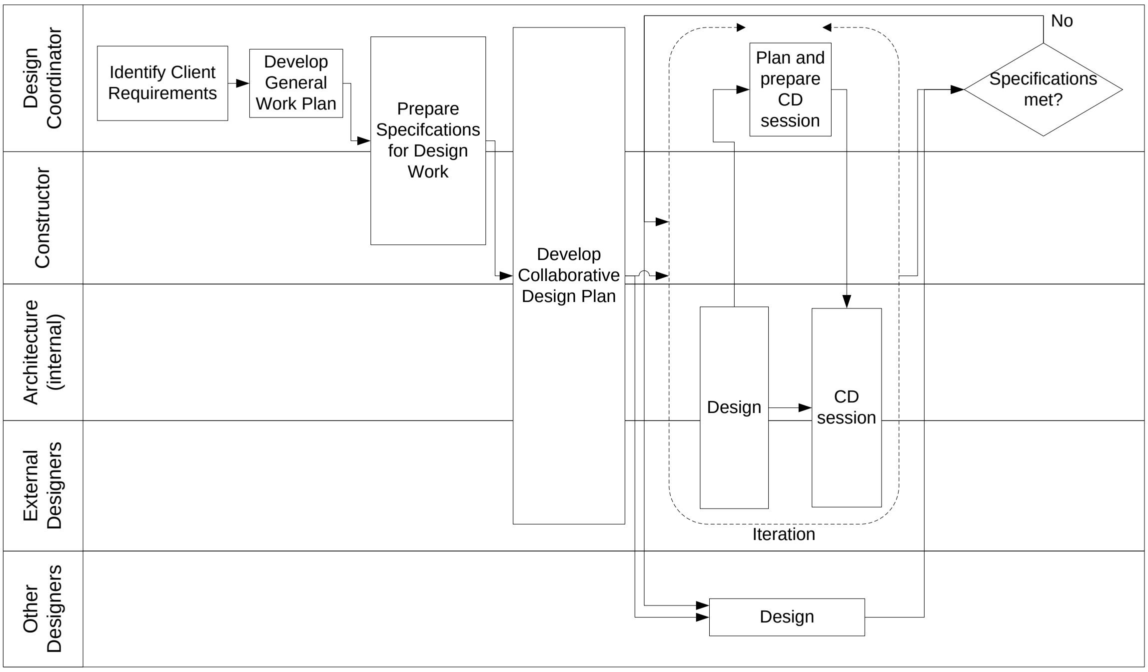

Figure 3. Proposed design process.

The process starts designating a design coordinator whose responsibility is to facilitate and ensure that the design plan is met. This coordinator must identify the client requirements and develop a general work plan. Then, using input from the constructor, the coordinator prepares the specifications for the design work.

The next activity is the development of the collaborative design plan. This activity is led by the design coordinator but all the design team must participate with the exception of designers whose work scope is very limited and does not considerably affect the project ("Other designers", in Figure 3). The collaborative design plan identifies parts of the design that would benefit the most from a collaborative approach. These parts of the design will be executed in the Collaborative Design (CD) sessions.

The CD sessions are work sessions (not coordination/revision meetings) of at least half day, where the designers meet to perform parts of their design work that are very interdependent with other parts of the design. These sessions are spread during the design period and alternated with regular design sessions where the designers perform work that does not considerably affect the others. Also, during the regular design sessions, the designers must prepare all the information they need to make the CD sessions productive. Here is where the last planner^{TM} methodology is used, led by the design coordinator, in order to ensure that design commitments are met by removing the identified constraints. The idea is that at the end of a CD session, the designers do a lookahead, identify constraints and make commitments to free certain constraints in order to be ready for the next CD session. The designers must free those constraints during the regular design period and the design coordination must facilitate that process. This design/CD-sessions cycle repeats until the design work is completed. In parallel to this cycle, the designers whose work is more independent ("Other designers", in Figure 3) will perform their work in the traditional approach.

At the end of this design cycle, there is checking point where the design coordinator assesses the achievement of the design specifications. If there are observations, the process goes back to the design cycle.

PROPOSED VALIDATION

The validation has two parts: field-based and theoretical. For the field-based validation, we will apply the design process proposed above in one project of the company and compare the design efficiency metrics described previously. Ideally, more projects should be used for a more robust field-based validation but time and project availability cannot be guaranteed.

For the theoretical validation, we will carry out a charrette exercise with two groups performing the design for the same project but using different methods: traditional and lean. The scope of the design exercise will be limited so it can be performed in a reasonable amount of time (not longer than 4 hours). Therefore, the exercise will focus in the actual design, starting with a set of given specifications. The experiment subjects should be professional designers. This validation will allow to capture, besides the design efficiency metrics, other metrics such as interactions among designers, design quality, and variability of the results.

CONCLUSIONS

The preliminary data shows that the factors related with planning, coordination, communication and integration were considered the most relevant to achieve an efficient design. These factors are strongly related with the proposed methodologies: last planner™ and collaborative design. On the other hand, the company's worst performance related to the control of the deliverables, personnel workload and work planning. Again, the proposed methodologies address these identified factors.

Some of the initially identified factors seem to be conceptually related, for example the amount and quality of human resources, work planning and allocation, and personnel workload. This conceptual relation does not affect the validity of the findings nor the proposed design process.

The context of social housing plays an important role in the identified factors as the tight budgets lead to a reduced investment in the design planning and coordination. This hinders the control of the deliverables and work assignments leading to personnel's work overload. At the same time, the interaction with the groups of future house owners challenges the management of the design process.

Also related with the context of social housing, one of the main foreseen challenges is the alignment of the external designers. In this regard, designers for social housing projects usually are independent professionals or very small companies which presents a challenge to the implementation of the methodologies. The case study's EGIS – in its owner capacity – plans to generate incentives such as long-term relations and methodology training. On the other hand, the discrimination between external and other designers (Figure 3) reduces this challenge.

Although the research is still ongoing and validation is yet to be performed, the company's managers positively assessed the proposal.

The expected outcomes of this research are efficiency and quality increments in the design process. These outcomes should reflect in a shorter duration for the overall design process – including the design until the delivery to the SERVIU and the SERVIU's review and its respective iterations – as it is assumed that a better design quality should facilitate the review process. This assumption may be affected by the project location (and then this variable is important for the field validation) as different SERVIUs differ in bureaucracy and requirement levels, which impacts the review process duration.

ACKNOWLEDGMENTS

We thank OVAL, Construction and Development Company, for providing access to their data and personnel.

REFERENCES

Austin, S., Baldwin, A. and Newton, A. 1994. Manipulating the flow of design information to improve the programming of building design. *Construction Management and Economics,* [online] 12(5), pp.445–455. Available at: <http://www.tandfonline.com/doi/abs/10.1080/01446199400000054#.VQbSfI7F_iU> [Accessed 7 Mar. 2015].

Ballard, G. and Koskela, L. 1998. On the Agenda of Design Management Research. In: *Proc. 6th Ann. Conf. of the Int'l. Group for Lean Construction*. Guarujá, Brazil, Aug. 13-15.

Chachere, J. 2009. *Observation, Theory, and Simulation of Integrated Concurrent Engineering.* Working Paper 118. Stanford University.

Chachere, J., Levitt, R.E. and John Kunz. 2003. *Can You Accelerate Your Project Using Extreme Collaboration? A Model Based Analysis.* Technical Report 154, Stanford University.

Choo, H.J., Hammond, J., Tommelein, I.D., Austin, S. a. and Ballard, G. 2004. DePlan: A tool for integrated design management. *Automation in Construction.* 13(3), pp.313–326.

Cornick, T. 1991. *Quality Management for Building Design.* London: Butterworth Architecture.

Formoso, C.C.T., Tzotzopoulos, P., Jobim, M.S.S. and Liedtke, R. 1998. Developing a protocol for managing the design process in the building industry. In: *Proc. 6th Ann. Conf. of the Int'l. Group for Lean Construction*. Guarujá, Brazil, Aug. 13-15.

Freire, J. and Alarcón, L.F. 2002. Achieving Lean Design Process: Improvement Methodology. *Journal of Construction Engineering and Management.* 128(3), pp.248–256.

Hamzeh, F., Balard, G. and Tommelein, I.D. 2009. Is the Last Planner System applicable to design?—A case study. In: *Proc. 17th Ann. Conf. of the Int'l. Group for Lean Construction*. Taipei, Taiwan, July 15-17.

Jara, C., Alarcón, L.F. and Mourgues, C. 2009. Accelerating Interactions in Project Design Through Extreme Collaboration and Commitment Management – a Case

Study. In: *Proc. 17th Ann. Conf. of the Int'l. Group for Lean Construction*. Taipei, Taiwan, July 15-17.

Kolltveit, B.J. and Grønhaug, K. 2004. The importance of the early phase: The case of construction and building projects. *International Journal of Project Management.* 22(7), pp.545–551.

Koskela, L., Ballard, G. and Tanhuanpaa, V.P. 1997. Towards Lean Design Management. In: *Proc. 5th Ann. Conf. of the Int'l. Group for Lean Construction*. Gold Coast, Australia, July 16-17.

MINVU. 2014. *Nuevas Entidades Patrocinantes.* Ministerio de Vivienda y Urbanismo de Chile. [online] Available at: <http://www.minvu.cl/opensite_20070311161529.aspx> [Accessed 1 Jan. 2014].