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Key Indicators for Linguistic Action Perspective in the Last Planner® System

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Abstract: Since 2001, a link has been established between the Last Planner® System (LPS) and Linguistic Action Perspective (LAP). However, to date, it has not been studied in sufficient depth. This research developed a system of indicators to measure and control the management of commitments, through the Design Science Research (DSR) methodology, and thus contribute to the development of the social dimension of sustainability that is often neglected in construction management research. The main contributions of this paper are a proposal of five main activities to apply the DSR method, a checklist to analyze the engagement of meeting participants, a notebook for last planners, delve into the variations that can occur to the basic movements of LAP, and the creation of a system of indicators hence updating the Percent Plan Complete (PPC) with a reliability indicator. The main limitation of this research is that the system was only validated in two South American countries that implemented LPS. In future studies, we propose to apply case studies in weekly planning meetings in other industries worldwide and to determine the recommended values to improve communication and achieve the proper implementation of LAP with LPS and without LPS.

Keywords: linguistic action indicators; last planner system; linguistic action perspective

1. Introduction

1.1. Context

Traditional construction systems, mostly spread worldwide, are based on the concept of transforming raw materials (input) into a product result (output), through an established production process, not distinguishing between activities that add value and those that do not add value to the final product [1], which has generated a worldwide issue in construction productivity, since it adds costs to construction projects without really adding value [2]. As a result, in the last 50 years, productivity in the Architecture, Engineering and Construction (AEC) industry has dropped by almost 20%, while the productivity in non-farm business enterprises has grown by over 150% [3]. Therefore, according to González et al. [4], to improve project performance, it is necessary to increase the reliability of the planning of commitments at the operational level, through a production control and planning system.

1.2. Need and Relevance of Research

In response to the low productivity, starting in the 1950s, a production system called "Lean Production" was developed and led by engineers Taiichi Ohno and Eiji Toyoda, in the implementation of concepts, methods, and tools applied in the Toyota car manufacturing company in Japan [5], this production system later became part of the construction industry with the name of

"Lean Construction" [6]. This system's main objective is to increase production efficiency by reducing losses or waste and satisfying customer requirements through the delivery of a product or service with higher value [5].

Regarding sustainability ("meet present needs without compromising the ability of future generations to meet their needs" [7]) the United Nations (UN) has defined 12 areas to be developed around sustainability. Of these, number 12 specifies "Ensure sustainable consumption and production patterns" [8], thus determining the need to ensure sustainability in industries such as construction. The high impact that building construction has on the environment has been demonstrated [9]. Therefore, improving the productivity of the construction industry is a fundamental need for a more sustainable society. Various authors have indicated a useful link between Lean Construction and Sustainability [10–12], as it is necessary to ensure survival in a constantly evolving business environment, through a sustainable environment driven by Lean, with significant untapped potential [11]. Furthermore, organizations have recognized the need for an approach that contributes not only to the production of buildings but primarily to the delivery process and improvement in product quality as a whole [11]. Thus, Lean Thinking and sustainability serve as complements given that Lean helps to increase efficient production of construction projects [11].

However, considering the interconnection of the three sustainability components: environmental, economic and social [9], the latter component should not be neglected. According to the Salem and al. [13] discoveries, it is necessary to generate changes in behavior through the use of Lean tools and concepts, mainly because construction structure is different from manufacturing' due to its greater complexity and uncertainty [14]. Under those circumstances, the Last Planner® System (LPS), developed by Glenn Ballard and Greg Howell in the 1990s [15], has led the introduction of Lean Construction concepts and principles [16]. The LPS is a system of planning and control of commitments, which is based on the principles of the Lean production philosophy and which directs its efforts to increase the reliability of planning and levels of performance [17,18]. Moreover, with the appropriate use of this system a reduction of the uncertainty and variability of the projects is achieved and hereby the coordination of the work participants is improved. This coordination is regarded as an internal social aspect of the project.

It is important to note that, according to studies carried out by Goldratt and Cox [19], the reliability of production is affected by the effectiveness of the control of dependencies and fluctuations between the different activities of the project; for example, a measure of reliability is variability [20], which is understood as the possible changes that can be generated in the execution time or the duration of the processes [21]. On the other hand, the uncertainty is due to the existence of variables that are not considered, such as availability of labor, administrative problems and availability of suppliers, among others. [22]. Consequently, it is necessary to achieve an adequate management of commitments to reduce the uncertainty and variability of the projects by strengthening the commitment management system in the weekly planning meetings, through coordinated action by a complex network of requests and promises, as this could be the only viable method of coordination under dynamic conditions [18].

Howell et al. [23] propose Linguistic Action Perspective (LAP) as a suitable framework for understanding the operation and effectiveness of LPS [24]. This perspective developed by Flores [25] is basically an application of the Speech Act Theory of Austin [26] and Searle [27] to organizational management. Flores [25] says that conversations do not simply precede action but constitute actions in themselves through the commitments that arise. In this way, language can be seen as the main means to create a common future for the coordination of human action, cooperation [25]. As we mentioned earlier, this idea builds on Austin's work [26] and the notion of illocutionary acts (the actions we carry out when we say certain words). For example, by saying, "I promise to do it," I am changing my environment, due to the actions that I take and those that other people take waiting for me to do what I promised to do [24]. It is important to note that this idea was later developed by Searle [27], who proposed a taxonomy of speech acts.

Flores [25] proposes a fundamental and universal structure for the coordination of actions in his book "Conversations for action," based on the completion of four essential speech acts: (1) request or offer, (2) promise or acceptance, (3) declaration of compliance and (4) declaration of satisfaction. These speech acts, according to Searle's taxonomy [28], correspond respectively to directives (request), commissives (offer, promise, and acceptance) and declaratives (statement of compliance and declaration of satisfaction), these acts modify the possibilities of action in the future, or in other words, they change the state of affairs through words [28].

According to Flores [25], four stages can be defined that generate a network or chain of commitments: (1) preparation of a request, (2) negotiation and agreements, (3) execution and declaration of compliance and (4) acceptance and declaration of satisfaction (for more details see Figure 1, based on Flores [24,25]).
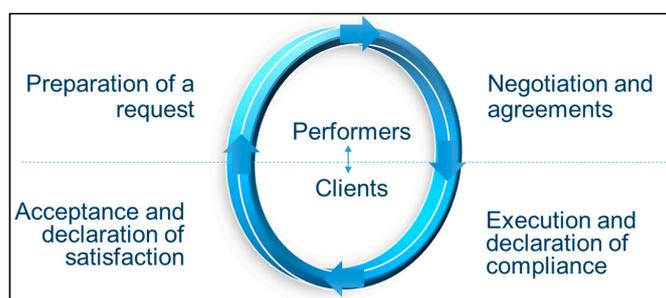
Figure 1. Network or Chain of Commitments.

In 2001 Ballard and Howell [15] established the first link between Last Planner® System and Linguistic Action Perspective. However, despite this, a system of quantitative instruments or methodologies has not been developed to carry out a specific management of the quality of commitments. Furthermore, recent studies show how the application of Lean Construction has focused on social responsibility (external) and engagement of the work environment (internal), filling gaps that sustainable practices alone cannot fill [11], also demonstrating that the application of Lean tools has a direct positive impact on the sustainability of projects [12].

1.3. State of the Art and Practice

Regarding state of the art, the authors carried out a thematic search in Web of Science, with the keywords "Language Action" or "Linguistic Action," obtaining, as a result, 217 documents. We consider it essential to clarify that in the literature, "Language Action" and "Linguistic Action" are used interchangeably. However, we respect both terms; we consider "Linguistic Action" more appropriate because "Linguistic," among many definitions, is the scientific study of language [29].

The authors carried out a preliminary analysis of co-occurrences, or joint appearances, to identify the conceptual and thematic structure of the scientific domain, through an analysis of the term co-occurrence based on text data, regarding the title and abstract fields of the 217 documents, creating Figure 2 through VOSviewer software. By means of this simple analysis, the co-occurrence of the key terms reported by the existing literature can be visually understood in order to obtain highly cited documents, to identify the most active lines of research in this domain of knowledge.

In Figure 2, each rounded rectangle represents a term, while the size of each figure indicates the number of publications in which that term appears in the title or abstract of the document. VOSviewer locates the terms that have greater coexistence close to each other in the visualization and defines the color according to the year of publication (see Figure 2 symbology, in the lower right corner). Determining with this, that the most published terms (language, study and system) are related to the area of linguistics, there is a gap in terms of construction, project, or indicators (our area of interest).

After this initial approach, the authors filtered the search, to find literature regarding construction projects and found only three publications [30–32]. The first paper, "The Role of Commitments in

the Management of Construction Make-to-Order Supply Chains" [30], regards the commitment loop, network of commitments, and the number of citations for the class of problem (rebar supply chain and elevator supply chain). The second paper is based on "Understanding the theory behind the Last Planner System using the Language-Action Perspective: two case studies" [31] where they develop two case studies demonstrating the explicit representations in the commitment flows, through a proposal of symbols used for mapping the network of commitments (mapping of materials and equipment) and also an evaluation of the percentage of each type of activity performed during planning meetings. Finally, the third paper called "Variability propagation in the production planning and control mechanism of construction projects" [32] analyzes the variability propagation and planning and control function, structure and behavior of a complex adaptive system and the baseline mechanism and conversations over the LPS structure.
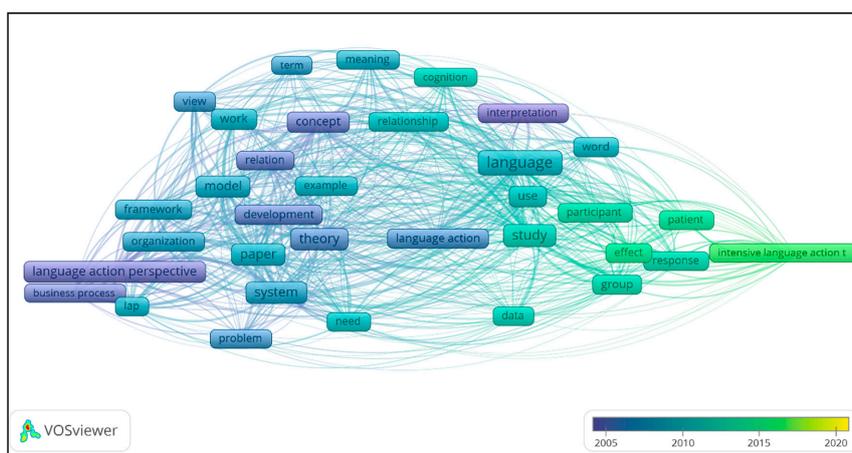
Figure 2. Term co-occurrence map created with VOSviewer.

Moreover, the authors review papers from the International Group for Lean Construction (IGLC) conference, where LAP has been proposed as a suitable framework to understand the effectiveness of LPS [23,33], but to date, the implications have not been fully understood. A first effort to understand the usefulness of LAP in LPS is the work of Viana, Formoso and Isatto [34], where based on a case study, they propose a descriptive model of the engagement networks in LPS, as well as a detailed analysis of the planning meetings. Otherwise, Vrijhoef, Koskela and Howell [35] studied construction supply chains from a LAP theoretical point of view, analyzing organizations as networks of commitments, determining that this perspective provides a plausible explanation for many of the root causes of problems in construction supply chains. Likewise, Ballard and Howell [15] argue that LAP represents an essential contribution to project management theory [33]. Macomber and Howell [33] pose five key aspects LAP: coordination, evaluation, speech (narration), trust, and moods, stating that these aspects influence how people work together and how this affects the results of the projects.

Nevertheless, the analysis offered by the publications mentioned above and all those that have been carried out to date in the IGLC does not explain the relationship between the way in which commitments are established, and the fulfillment of those commitments, except for the preliminary proposal of indicators carried out by these authors in the years 2018 and 2019 [24,36].

At last, the authors reviewed the database of this journal, mainly finding aspects of Social Networks, where the importance of understanding the relation between project dynamic interactions of the different project stakeholders and its performance has been mentioned [37]. Still, it has not been addressed through LAP.

1.4. Research Purpose and Why It Is New Knowledge

Based on the principles that view management as a process of opening, listening, obtaining, articulation and activation of the network of commitments produced mainly through promises and

requests (allowing the autonomy of the productive unit), [38] and given that there are currently only three publications on the Web of Science about LAP in construction, and finally because these demonstrate the importance of this perspective in managing commitments [30–32], a vital element of the Last Planner® System is that the authors have worked on the development of a system of indicators to measure and control commitments, requirements, promises, and reliability, generating an extension and updated and corrected version of their preliminary work published in the IGLC conferences [24,36], through the Design Science Research (DSR) methodology.

Thus, the purpose of this document is to respond to the need of measuring the main elements of LAP, to control and improve the management of commitments in the weekly LPS meetings, and thus contribute to the development of an LPS 2.0 that centers its focus on the social (internal) dimension in the context of Lean Construction [39], since this dimension of sustainability [40] has been neglected in construction management approaches [41].

2. Research Method

2.1. Design Science Research

The authors used the Design Science Research (DSR) because this method manages to solve practical problems and produce artifacts as results [42]. These artifacts can be models, methods, indicators or any designed object in which a research contribution is incorporated into the design [43], thus solving problems found in the real world, and in this way also, contribute theoretically to the discipline in which it is applied [44].

According to Alan Hevner's proposal [45], DSR bridges the gaps among the contextual environment of the research project (people, organizational systems, technical systems, problems and opportunities), design science research (artifacts and processes), and the knowledge base of scientific foundations (scientific theories, methods, experience and expertise), iterating between the activities of construction and evaluation of research design artifacts and processes [45].

Figure 3 shows the research approach based on the updated DSR model proposed by Robert Briggs and Gerhard Schwabe [46] because the purpose of this work is to perform an Applied Science/Engineering (AS/E) to produce an artifact, faced with a phenomenon that varies according to time, contexts and application conditions [46]. This figure shows the main elements of the investigation, highlighting a relevancy cycle between discovery and design activities, and a design cycle between design and validation activities so that any DSR activity can be extracted or added to the knowledge base [46].
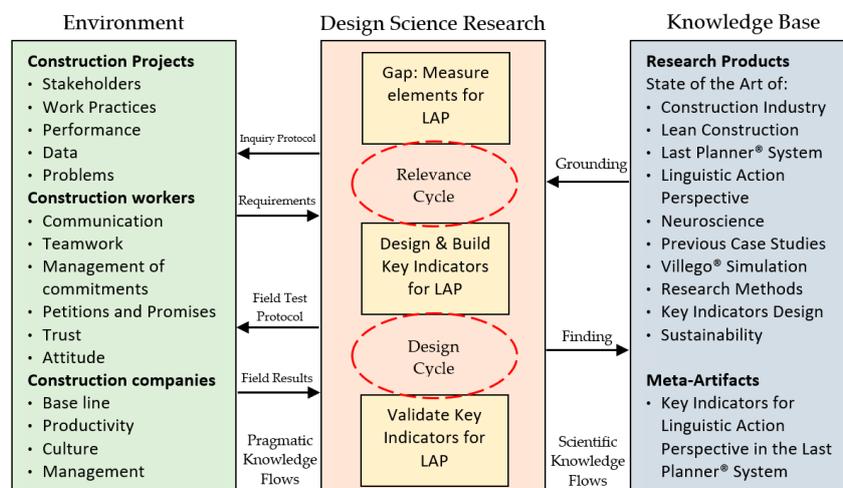

Figure 3. Design Science Research, Cycles Model.

This research consists of 5 main activities that have been adapted from the proposals of Lukka [44] and Peffers et al. [43], regarding the DSR method:

1. Discovery of problems and opportunities, through exhaustive analysis of the context.
2. Deep understanding of the subject, state of the art and practice.
3. Design and construction of artifact (indicators system), through constant iteration.
4. Evaluation of the solution to find a satisfactory solution (which fulfills its function).
5. Validation of artifact, through practical application and analysis of results.

Figure 4 shows how the artifact was developed through 3 cycles of continuous improvement based on Design Science Research (DSR). The first version of the artifact was developed from the identification of LAP elements, later it was evaluated by a panel of international experts, and it was applied in the Villego® Simulation (a game that allows teaching LPS by the construction of a house with Lego). Then, the second version of the artifact was developed from the elements of LAP applied in LPS, later it was evaluated through measurement in four construction projects in Chile and validated by means of comparison and analysis of results concerning artifact 1.0. The final version of the artifact was developed from the analysis of the LPS implementation in different countries. Later it was evaluated through measurement in two construction projects in Chile and two construction projects in Colombia, to be finally validated from the comparison and analysis of results (functionality) with respect to artifact 2.0.
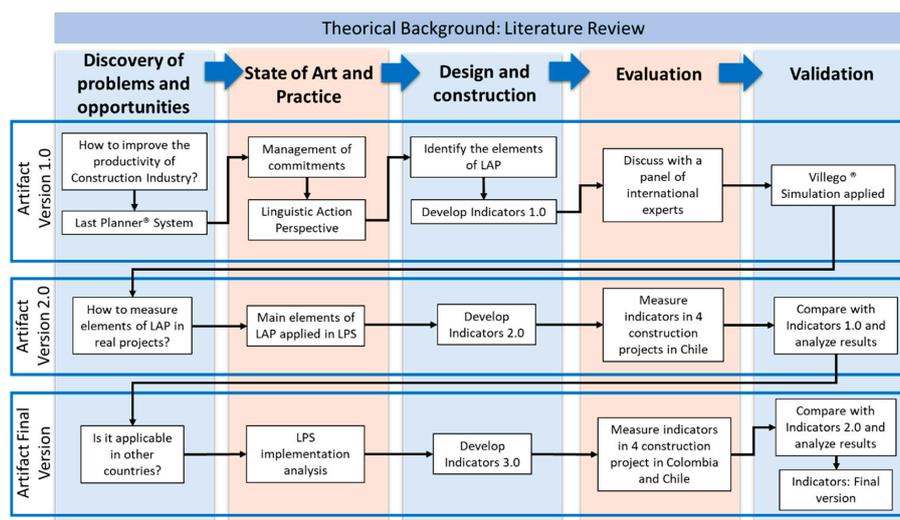

Figure 4. Research Method based on Design Science Research (DSR).

2.2. Identification of the Problem

Although the implementation of the Last Planner® System indeed increases the reliability of planning and performance levels through the management of commitments, the conversations during which commitments are made at weekly planning meetings have not been discussed and analyzed in sufficient depth [24]. Being a fundamental problem the lack of indicators to control this aspect, there is only the Percent Plan Complete (PPC) indicator, which is the number of planned activities completed, divided by the total number of planned activities and expressed as a percentage [47]; Hence, the authors set the goal of developing a measurement system that allows quantifying the fundamental elements of LAP present in LPS, since by measuring the management of commitments, we can enrich LPS and advance in an improved and updated version of it.

2.3. Creation of Indicators: Version 1.0

For the creation of the first version of indicators, the researchers carried out five key steps, after having discovered the problem and research opportunity, as detailed by Salazar et al. [24]:

1. To study the Linguistic Action Perspective, to generate a knowledge base, based mainly on Flores [25].
2. To identify the elements of this perspective that were potentially quantifiable, creating a list of concepts and data to be measured. Mainly aspects of the commitments, requests, promises and foundations of trust.
3. To develop indicators that could measure and control the previously identified elements, to generate the Design Science Research. For more details, see Table 1, which borrows the Indicators System found in Salazar et al. 2018 [24].
4. To discuss with a panel of international experts (Linguistic Action in Last Planner System Group) the feasibility of measuring and controlling these indicators, which allows improving the initial design. This panel consisted of academics from University of California-Berkeley, PhD students, a Master with a degree in linguistics, and Senior Lean consultants.
5. To validate proposed indicators, verifying the feasibility of observing these indicators utilizing a Villego® Simulation applied to a group of students as a pilot test to validate them through the Environment in a controlled situation.

These indicators are divided into three groups according to the study objective: (1) measurement and control of commitments: the primary data to be evaluated are network or chain of commitments, roles and responsibilities of the performers, declaration of the importance of the commitment, and the availability of the performers; (2) measurement and control of petitions and promises: the relevant data to be evaluated are specification of the deadline, unnecessary requests, and incomplete promises; and (3) measurement and control of fundamentals of trust: among the data to be evaluated are competence of the performer, reliability and engaged participants [24].

It is important to emphasize that these indicators are designed to analyze the management of commitments in weekly planning meetings, so the frequency of measurement should be every seven days [24]. Notwithstanding the preceding, it necessary to measure at least two weekly meetings to complete the network or chain of commitments, since the first two movements will be seen in the first meeting: (1) preparation of a request and (2) negotiation and agreements; and in the second meeting, the last two: (3) execution and declaration of compliance, and (4) acceptance and declaration of satisfaction [24]. If the client does not accept and declare satisfaction, it is understood that the committee did not comply with the agreed terms and therefore, the network or chain of commitments must be started again with the preparation of the request until the commitment is closed (when the client accepts and declares satisfaction).

2.4. Pilot Application-Villego® Simulation

To analyze and validate the proposed indicators system, we decided to verify the feasibility of observing and measuring these indicators employing the Villego® Simulation, which is a hands-on LPS experience where participants build a house with Lego bricks. For this purpose, 11 volunteer students of the sixth semester of Civil Engineering, at Pontificia Universidad Católica de Chile, were asked to perform the simulation. The authors video-recorded the two rounds of the simulation (first round simulates a traditional planning process and the second round simulates a process with LPS) to be able to analyze the proposed indicators system [24].

2.4.1. First Round Villego® Simulation

Next explaining the general rules of the simulation, we asked the students to define the roles and responsibilities that each one would assume in this round, establishing roles in the following areas: administration, quality, technical inspection, security, warehouse and several subcontractors who were identified with different colors; gray, blue, white, yellow, green and red [24].

Table 1. Indicators for observing elements of Linguistic Action Perspective in Last Planner® System.

Aim	Measure Name	Description	Formula	Means of Verification
Measurement and Control of Commitments	% of compliance network or chain of commitments	KPI measures the percentage of compliance with the chain of commitments; that is to say, that the 4 movements for the coordination are fulfilled	(Number of commitments in which the 4 movements for coordination are fulfilled)/(Total number of commitments) × 100	That the 4 movements for coordination (LAP movements presented in Figure 1) are fulfilled
	% of definition of roles and responsibilities of the performers	KPI measures the percentage of commitments that define roles and responsibilities of performers	(Number of commitments with defined roles and responsibilities)/(Total number of commitments) × 100	Roles (Who): Client and Performer Responsibilities (What): Definition of the promise of which the performer takes charge
	% of fulfillment of roles and responsibilities of performers	KPI measures the percentage of commitments in which the roles and responsibilities of previously defined performers are met	(Number of commitments that fulfilled previously defined roles and responsibilities)/(Total number of commitments) × 100	That the performer (not another) fulfills the promise and declares compliance to the client
	% of declaration of the importance of commitment	KPI measures the percentage of commitments that declare the importance (priority) of this, explicitly	(Number of commitments declaring importance)/(Total number of commitments) × 100	Declare the importance (priority) of commitment in the first 2 movements for coordination (LAP movements presented in Figure 1)
	% of compliance with priority commitments	KPI measures the percentage of commitments that were declared important (priority) and that are effectively met	(Number of priority commitments fulfilled)/(Total number of priority commitments) × 100	Review of priority commitment agreed previously
	% of verification of availability of performers in agreements	KPI measures the percentage of commitments that verify the availability of performers in the negotiation stage and agreements	(Number of commitments that verify availability of performers in agreements)/(Total number of commitments) × 100	Verification of the availability of performers in the negotiation stage and agreements. The executor's (workers) agenda can be requested from the foreman
	% of verification of availability of performers in execution	KPI measures the percentage of commitments that verify the availability of performers in the execution stage	(Number of commitments that verify availability of performers in execution)/(Total number of commitments) × 100	Compliance with the verification of the availability of performers in the execution stage

Table 1. *Cont.*

Aim	Measure Name	Description	Formula	Means of Verification
Measurement and Control of Petitions and Promises	% of specified deadlines	KPI measures the percentage of commitments that specify the deadline	(Number of commitments that specify the deadline)/(Total number of commitments) $\times$ 100	Specific deadline: date and time (AM, PM)
	% of unnecessary requests	KPI measures the percentage of commitments that make unnecessary requests	(Number of commitments that make unnecessary requests)/(Total number of commitments) $\times$ 100	When the client declares that the deadline specified in the request does not correspond to the last responsible moment and/or requested something that was not necessary (does not add value)
	% of incomplete requests and promises	KPI measures the percentage of requests and promises that do not comply with explicit conditions of satisfaction, background of obviousness and/or specific term	(Number of commitments that make requests and incomplete promises)/(Total number of commitments) $\times$ 100	Explicit conditions of satisfaction, background of obviousness and specific deadline
Measurement and Control of Fundamentals of Trust	% of compliance of the performer's competence	KPI measures the percentage of commitments where the performer is able to perform in the required domain	(Number of commitments where performer is competent)/(Total number of commitments) $\times$ 100	Performer is able to perform in the required domain (recurring performance according to accepted standards)
	% of reliability compliance (complementary to PPC)	KPI measures the percentage of commitments where the performer is able to perform reliably and timely in the required domain	(Number of commitments fulfilled + number of commitments revoked + number of counteroffers)/(Total number of commitments) $\times$ 100	Performer keeps his promises on time (PPC), counteroffer or revokes
	% of engaged participants	KPI measures the percentage of meeting participants who are engaged to it	(Number of participants engaged to the meeting)/(Total number of attendees) $\times$ 100	Participant attends the meeting, arrives at the time and remains in an attitude that suggests concentration (does not interact with the cell phone, looks at the speaker, takes notes, etc.). (Failing to comply with any previous aspect, justify it before or during)

Table 1. borrows the Indicators System found in Salazar et al. 2018 [24]

2.4.2. Second Round Villego® Simulation

After giving the new rules of the simulation, we asked students to redefine the roles and responsibilities of each member, according to the lessons learned from the initial round [24].

2.5. Indicators Validation: Version 1.0

Once the simulation ended, we analyzed the videos to determine the feasibility of observing the proposed indicators system. With this, not only did we manage to validate our indicators system, but we also analyzed the main differences between the results obtained in the Villego® Simulation and the expected results (according to preliminary field studies) in a real planning meeting. Given the nature of this simulation, we could only able to verify the indicators of commitment: compliance network or chain of commitments, definition of roles and responsibilities of the performers, fulfillment of the roles and responsibilities of the performers, specification of the deadline, compliance of the performer's competence and engaged participants. On the other hand, indicators of declaration of the importance of the commitment, compliance with priority commitments, verification of the availability of performers in agreements, verification of the availability of performers in execution, unnecessary requests, incomplete promises and promises and reliability compliance, were under verification process in construction projects in Chile. In the end, the authors consider that this first generation of validated Key Indicators is a useful tool to measure, control and improve the management of commitments in planning meetings, as they provide fast and specific feedback on these aspects, which undoubtedly enriches Last Planner® System. More details are provided in Salazar et al. [24].

2.6. Creation of Indicators: Version 2.0

After the publication of the first version of the Indicators System, the authors decided to evaluate the feasibility of its application, but this time in real construction projects in the field. The purpose of this was to observe which elements of LAP are intrinsically applied in LPS and which ones need to be taught and incorporated in order to improve the management of commitments in weekly planning meetings.

Furthermore, we realized that we had to delve into the explanation of the LAP movements, explaining that variations can occur in the basic movements shown in Figure 1. Specifically, if we observe the third movement, "Execution and declaration of compliance," we can renegotiate (generate a new commitment), revoke (performer suspends), and cancel (client suspends). These do not decrease reliability; it is increased [24,25]. Due to the fact that it is preferable that the performer or client suspends the original commitment and then they generate a new agreement in the field instead of what is currently happening, which is that they wait for the next weekly planning meeting to report that the initial agreement was not fulfilled. See Figure 5.

For all the above, we decided to carry out the study in Chile, due to the access to projects through the Collaborative Group of the Center of Excellence in Production Management (GEPUC), and also because we found previous studies of LPS in which it has been demonstrated that the incorporation of more actors in the planning process generates less variability, more reliable promises and higher productivity [48].

For the creation of the second version of Indicators System, we carried out five key steps, after having asked ourselves how to measure elements of LAP in real projects, as detailed in Salazar et al. [36]:

1. Deepen the study of Linguistic Action Perspective and Last Planner® System to generate a Knowledge Base mainly on Flores [25] and Ballard [47].
2. Identify the main elements of this Perspective that could be quantifiable and applied in LPS, taking the Indicators 1.0 as reference.
3. Develop Indicators System 2.0 from the improvement of version 1.0 through the Design Science Research.

4. Measure the proposed indicators in four construction projects in Chile to evaluate them through the Environment in a typical construction situation. Researchers recorder analyzed videotapes of weekly meetings and interviewed participants when necessary to assess each commitment for each proposed indicator.

5. Validate the proposed Indicators System, comparing with version 1.0, and analyzing the results.
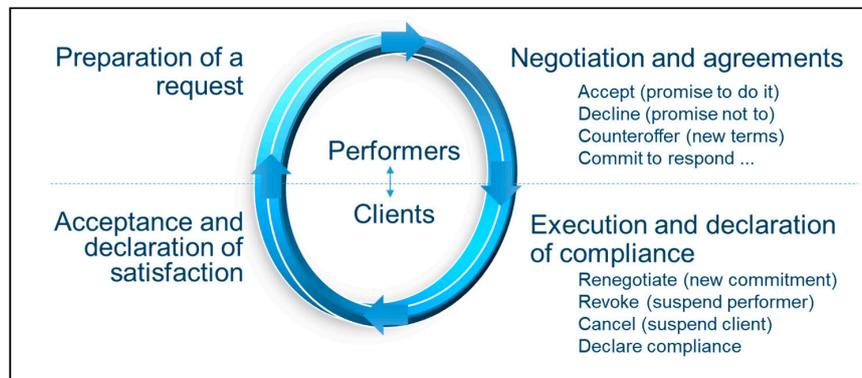
Figure 5. Network or Chain of Commitments with advanced movements.

In this second version of the Indicators System, the authors found deficiencies in functionality and in its inherent qualities (ease of use) that limited its usefulness in practice [45], given that they proposed a new set of indicators measured in the field according to the LAP to measure and control the fundamental aspects of the commitments, requests, promises and foundations of trust [36], by replacing some of the indicators and adding new ones based on the analysis of four case studies in construction projects in Santiago, Chile. We quote the results indicated in Salazar et al [36]:

1. Proposal to eliminate indicators:

    -   The authors proposed not to measure the percentage of verification of the availability of performers in execution because most of the foremen verify the availability of their workers after the weekly meeting and in the field huddle, and these indicators are designed to be measured exclusively in weekly planning meetings.

    -   We proposed to eliminate the percentage of incomplete requests and promises because it is confusing to measure it in the field.

    -   Finally, we proposed to eliminate the percentage of compliance of the performer's competence because it is associated with the worker's curriculum vitae, and it is not possible to measure in the weekly meeting. It can only be associated with the correct fulfillment of each commitment or PPC (Percent Plan Complete).

2. Proposal to change the indicators:

    -   The authors proposed modifying the percentage of declaration of the importance of each commitment because they consider it more appropriate to use the word "priority," so the indicator should be renamed as percentage of declaration of the priority of commitment. This change is proposed because it is necessary to deepen the conditions of satisfaction of the most relevant commitments. For more details, see Table 2, which borrows the Indicators System found in Salazar et al. 2019 [36].

    -   Further, we proposed modification of the percentage of reliability compliance because we found a point of confusion in the formula of the indicator regarding the concept of counteroffers since counteroffers occur in the same meeting, whereas the concept after the meeting is "renegotiation." Additionally, we add "cancel" a commitment. See Table 2.

3. Measurement of original indicators:

- Table 2 shows the average results of the indicators in the four projects measured during three weeks, which incorporate the changes that we mentioned in version 1.0.

4. Newly proposed indicators:

- Finally, we proposed seven new indicators, which complement version 1.0. See Table 3, which borrows the Indicators System found in Salazar et al. [36].

This new Indicators System seeks to analyze the management of commitments in weekly planning meetings, so the measurement frequency is always every seven days. However, it is necessary to hold at least two weekly meetings to analyze the results, as mentioned in the version 1.0.

2.7. Application in Construction Projects

The strategy for selecting the case studies was based on "information-oriented selection" to establish "extreme cases/deviations" Flyvbjerg [49]. The units of the analysis were three multi-story building projects and an extension housing project with the LPS implemented with different degrees of maturity, in the Metropolitan Region of Santiago, Chile. The number of four projects were determined according to the recommendation of Hernández et al. [50], who recommend a maximum of eight cases when a multiple in-depth study is carried out [51], since the survey does not represent a "sample," as if an experiment does since it is a validation method.

Regarding the work methodology, the researchers used the "information-oriented selection" selecting four projects, one for each company, according to the preferences of the managers, recording availability and the degree of implementation maturity of the Last Planner® System due to the feasibility of research with construction companies and projects that belong to the Collaborative Group of GEPUC. As a result, projects with a primary degree of maturity (short-term planning system) up to projects with an advanced level were obtained (systematic use of an Workable Backlog) [52]. Through video recording of three consecutive weekly planning meetings, the researchers carried out the LAP in LPS practices survey, analyzing the indicators of the second and third meeting, since the objective was not to modify the "behavior" of the participants in the studio (we observed "strange" behavior by the team in the first meeting, probably because they knew they were being videotaped).

2.8. Indicators Validation: Version 2.0

To validate this new Indicators System, the authors measured the application of LAP in four construction projects, comparing and analyzing the results of version 1.0. We proposed improvements to the Indicators System: Version 1.0, eliminating indicators (percentage of verification of the availability of performers in execution, percentage of incomplete requests and promises, and % of compliance of the performer's competence) changing indicators (percentage of declaration of the importance of commitment and percentage of reliability compliance) and proposing new indicators for the measurement and control of the management of commitments in construction projects. Additionally, the researchers consulted contractors who participated in the weekly planning meetings about their perceptions. They stated that these measurements improved the ability to provide reliable promises since they understood the importance of speech acts, satisfaction conditions and trust in the management of commitments [36]. In this second version, we created new metrics to make the percentage compliance network or chain of commitments (four movements for coordination) and percentage reliability compliance (complementary to PPC) clearer, defining the latter as:

$$\text{Reliability} = \text{PPC} + \text{Revoke} + \text{Renegotiate} + \text{Cancel}, \tag{1}$$

Besides, we added Figure 5 and the results of the indicators: % of revoked commitments, percentage of renegotiated commitments, and percentage of canceled commitments.

Table 2. Results of indicators from the Linguistic Action Perspective in Last Planner®System.

Aim	Measure Name	Description	Formula	Results	General Comments
Measurement and Control of Commitments	% of compliance network or chain of commitments	KPI measures the percentage of compliance with the chain of commitments; that is to say, that the 4 movements for the coordination are fulfilled	(Number of commitments in which the 4 movements for coordination are fulfilled)/(Total number of commitments) × 100	0%	• The preparation of the petition is observed • There is no negotiation process, but rather an imposition by the client • The declaration of compliance is verified • The declaration of satisfaction is not observed
	% of definition of roles and responsibilities of the performers	KPI measures the percentage of commitments that define roles and responsibilities of performers	(Number of commitments with defined roles and responsibilities)/(Total number of commitments) × 100	83%	• In general, roles are defined intrinsically: client requests and performers agree. Regarding responsibilities, the scope of the commitment is not always clearly established
	% of fulfillment of roles and responsibilities of performers	KPI measures the percentage of commitments in which the roles and responsibilities of previously defined performers are met	(Number of commitments that fulfilled previously defined roles and responsibilities)/(Total number of completed commitments) × 100	15%	• In general, in the construction works the performer does not commit, the one who commits is the head of the performer (foreman) • Performer is engaged in administrative aspects (management team)
	% of declaration of the priority of commitment	KPI measures the percentage of commitments that declare the priority (importance) of this, explicitly	(Number of commitments declaring priority)/(Total number of commitments) × 100	10%	• In general, the priority of the commitments is not declared. This does not allow the foremen to carry out an adequate planning regarding the execution order of the assumed commitments
	% of compliance with priority commitments	KPI measures the percentage of commitments that were declared priority and that are effectively met	(Number of priority commitments fulfilled)/(Total number of priority commitments) × 100	100%	• The few commitments that were declared a priority were completed. The foregoing demonstrates the importance of making the priority statement
	% of verification of availability of performers in agreements	KPI measures the percentage of commitments that verify the availability of performers in the negotiation stage and agreements	(Number of commitments that verify availability of performers in agreements)/(Total number of commitments) × 100	18%	• There is a low percentage of verification of the availability of performers in the stage of negotiation and agreements

Table 2. *Cont.*

Aim	Measure Name	Description	Formula	Results	General Comments
+ M. and C. PP	% of specified deadlines	KPI measures the percentage of commitments that specify the deadline	(Number of commitments that specify the deadline)/(Total number of commitments) × 100	10%	• In general, only the date is specified, but it is not scheduled in detail, or if it will be completed in the morning or in the afternoon
+ M. and C. PP	% of unnecessary requests	KPI measures the percentage of commitments that make unnecessary requests	(Number of commitments that make unnecessary requests)/(Total number of commitments) × 100	3%	• Low percentage in weekly meetings • According to the workers, the foremen often make unnecessary requests on the field
Measurement and Control of Fundamentals of Trust	% of reliability compliance (complementary to PPC)	KPI measures the percentage of commitments where the performer is able to perform reliably and timely in the required domain	(Number of commitments fulfilled + number of commitments revoked + number of counteroffers)/(Total number of commitments) × 100	81%	• It must always be a percentage equal to or greater than the PPC • Complements the PPC with additional movements, which happen after the initial agreement
Measurement and Control of Fundamentals of Trust	% of engaged participants	KPI measures the percentage of meeting participants who are engaged in it	(Number of participants engaged to the meeting)/(Total number of attendees) × 100	48%	• High degree of participation (only 10% left the meeting) • No meeting started at the agreed time • A lot of interaction with the cell phone during the meeting (calls, chat and e-mail) • Interruptions by radio • In some moments two or more people spoke at the same time • 60% of the team takes note (everyone should take note) • Non-verbal language indicates fatigue and lack of attention

Table 2. Borrows the Indicators System 2.0 found in Salazar et al. 2019 [36]. **+ M. and C. PP:** Measurement and Control of Petitions and Promises.

Table 3. Results of new indicators from the Linguistic Action Perspective in Last Planner®System.

Aim	Measure Name	Description	Formula	Results	General Comments
Measurement and Control of Commitments	% of fulfillment of a request	KPI measures the compliance percentage of the first movement; preparation of a request by the client	(Number of commitments in which the petition is prepared)/(Total number of commitments) × 100	100%	• Client is clear about the request (what) and to whom it will be entrusted (performer)
	% of compliance negotiation and agreements	KPI measures the compliance percentage of the second movement; negotiation and agreements	(Number of commitments in which a negotiation and agreement is made)/(Total number of commitments) × 100	20%	• In general, there is no negotiation before the agreement. The performer assumes the order established by the client. Sometimes he does not answer if he can or cannot comply with the agreement
	% of declaration of compliance with the commitment	KPI measures the percentage compliance of the third movement; execution and declaration of compliance with the commitment by the performer	(Number of commitments in which compliance is declared)/(Total number of commitments completed) × 100	78%	• It is verified by questions to clients and performers before the weekly meeting that there is a high percentage of declarations of compliance with the commitments. However, there are performers who do not inform clients that they finished with the assigned task
	% of fulfillment declaration of satisfaction	KPI measures the percentage of compliance of the fourth movement; acceptance and declaration of satisfaction by the client	(Number of commitments in which satisfaction is accepted and declared)/(Total number of commitments completed) × 100	5%	• There is a low percentage of commitments in which satisfaction is declared by the client. In general, it is only indicated if the commitment is fulfilled or not, without giving feedback to the performer
++ M. and C. FT	% of revoked commitments	KPI measures the percentage of commitments revoked	(Number of commitments revoked)/(Total number of commitments) × 100	4%	• Minor percentage of commitments are revoked after the weekly meeting
	% of renegotiated commitments	KPI measures the percentage of renegotiated commitments	(Number of renegotiated commitments)/(Total number of commitments) × 100	2%	• Practically no renegotiation of commitments after the weekly meeting
	% of canceled commitments	KPI measures the percentage of canceled commitments	(Number of canceled commitments)/(Total number of commitments) × 100	1%	• Practically no cancellation of commitments after the weekly meeting

Table 3. Borrows the Indicators System 2.0 found in Salazar et al. 2019 [36]. **++ M. and C. FT:** Measurement and Control of Fundamentals of Trust.

Finally, we conclude that this second generation of key indicators measured in the field (eliminating, changing and proposing the Indicators System from the first generation) generate a powerful tool to measure, control and improve the management of commitments in weekly planning meetings since they enable quick feedback that undoubtedly enriches the Last Planner® System [36].

2.9. Creation of Indicators: Final Version

After the publication of the Indicators System: Version 2.0, the authors decided to carry out the last iteration to achieve continuous improvement (Kaizen) and analyze the feasibility of application in another context, thus determining the scope of this artifact.

Ergo, we measured these indicators in two new projects in Santiago, Chile, thanks to the Collaborative Group of GEPUC and two projects in Bogotá, Colombia, thanks to the Engineering and Construction Management Research Group (INGECO).

For the creation of the final version of the Indicators System, we carried out five key steps, after having asked ourselves: Is it applicable in other countries?

1. Deepen the analysis of the implementation of the Last Planner® System and the Linguistic Action Perspective to generate a Knowledge Base.
2. Identify the key elements of this Perspective and which ones are redundant, taking the Indicators of version 2.0 as a reference.
3. Develop Indicators System 3.0 from the improvements of version 2.0 through the Design Science Research.
4. Measure the proposed indicators in four construction projects, two in Chile (a project of 24 houses and 22-story building) and two in Colombia (a 21-story building and a 23-story building), to evaluate them through the different construction Environment. For the above, the authors recorded and then analyzed videotapes of weekly meetings and interviewed participants when necessary to evaluate each commitment for each proposed indicator.
5. Validate the proposed Indicators System, comparing with version 2.0, and analyzing the results.

In this version, the authors found limitations in functionality and in its inherent qualities (ease of use) in practice [45] that must be optimized, so we propose the elimination of some of the indicators and the expansion of others based on the analysis of the four construction projects in Chile (2) and Colombia (2), which carry out weekly meetings using LPS.

This field test led to the following changes:

1. Proposal to eliminate indicators:

    - The authors propose not to measure the percentage of definition of roles and responsibilities of the performers because we realized that the roles (Who) are intrinsically established in the LPS weekly meeting structure. Concerning the responsibilities (What), this should be part of the correct fulfillment of the request, so it is incorporated into the % of fulfillment of a request.
    - Plus, we propose to eliminate the percentage of fulfillment of roles and responsibilities of performers, where the performer and not another one fulfills the promise and declares compliance to the client, because it is not possible to measure it directly. In general, in construction works, the performer does not commit, the one who commits is the head of the performer (foreman) [36].
    - Finally, we propose to eliminate the percentage of verification of the availability of performers in agreements because this verification should be carried out in the stage of negotiation and agreements. The client must request the agenda of the executor (workers) form the foreman. Therefore, it is incorporated into percentage of compliance negotiations and agreements.

2. Proposal to expand indicators:

- The authors propose to clarify the indicator percentage of engaged participants, providing that in the previous publications it was not defined precisely what would be considered as "engaged." Thence, we want to mention the key aspects to consider in this indicator, participants must:

  ○ Arrive on time (maximum 5 min late);
  ○ Avoid interaction with the cell phone (do not check, speak or ring the cell phone);
  ○ Remain in the room;
  ○ Avoid interacting with a walkie-talkie (not talking, hopefully off or at a volume that does not interrupt others);
  ○ Intervene in the meeting;
  ○ Take notes;
  ○ Look at the person who is speaking.

To see the final proposal of Indicators System to analyze the management of commitments in weekly planning meetings, see Table 4, while to measure the percentage of engaged participants, see checklist in Appendix A.

2.10. Application in Another Country

The units of the analysis were three multi-story building projects and an extension housing project with the LPS implemented with different degrees of maturity, in different countries, Chile and Colombia. We determined four projects according to the recommendation of Hernández et al. [36,50]. We used the work methodology based on the "information-oriented selection," selecting four projects, one for each company, according to the agreements established with the managers, availability of recording, and the degree of implementation maturity of Last Planner® System, as in version 2.0.

To measure the proposed indicator system, the principal investigator attended and videotaped three consecutive weekly planning meetings. In these meetings, the people who participated were the last planners, whose positions range from construction managers to foremen. We had a variable participation in each meeting: minimum 13, maximum 43 and an average of 25 participants. The researcher took notes of the meeting through the checklist (see in Appendix A) to measure the percentage of engaged participants and note down what was observed during the meeting, such as observations regarding the implementation of the room, topics discussed, adequate space, visual management, observed moods, among other comments that allowed feedback to the leaders and thus improve the implementation of LPS and LAP like a synergy. As well, after the meeting, the researchers analyzed the videos to complete the system of indicators, based on the means of verification and the proposed formula. For example, to determine the percentage of specified deadlines, according to the means of verification the number of commitments that specify the deadline are those in which date and time are set (AM, PM); For that reason, it is necessary to determine the number of commitments that meet the above, divide it by the total number of commitments and multiply it by 100, to obtain the result (see Table 4).

Table 4. Key Indicators for Linguistic Action Perspective in the Last Planner®System.

Aim	Measure Name	Description	Formula	Means of Verification
Measurement and Control of Commitments	% of compliance network or chain of commitments	KPI measures the percentage of compliance with the chain of commitments; that is to say, that the 4 movements for the coordination are fulfilled	(Number of commitments in which the 4 movements for coordination are fulfilled)/(Total number of commitments) $\times$ 100	That the 4 movements for coordination are fulfilled
	% of fulfillment of a request	KPI measures the compliance percentage of the first movement; preparation of a request by the client	(Number of commitments in which the petition is prepared)/(Total number of commitments) $\times$ 100	To determine that the petition was prepared, it must be verified that the following are established: • Roles (Who): Client and Performer • Responsibilities (What): Definition of the promise of which the performer takes charge
	% of compliance negotiation and agreements	KPI measures the compliance percentage of the second movement; negotiation and agreements	(Number of commitments in which a negotiation and agreement is made)/(Total number of commitments) $\times$ 100	- There must be an agreement and not an imposition by the client (Conversations for action are generated) - In addition, the client must consult the executor's (workers) agenda with the foreman
	% of declarations of compliance with the commitment	KPI measures the percentage compliance of the third movement; execution and declaration of compliance with the commitment by the performer	(Number of commitments in which compliance is declared)/(Total number of commitments completed) $\times$ 100	- Performers execute and inform clients that they are done with the assigned task (immediately) in the field huddle - Verification is done at the next weekly meeting
	% of fulfillment declaration of satisfaction	KPI measures the percentage of compliance of the fourth movement; acceptance and declaration of satisfaction by the client	(Number of commitments in which satisfaction is accepted and declared)/(Total number of commitments completed) $\times$ 100	- Client verifies compliance and reports if the commitment is satisfactory in the field huddle - Verification is done at the next weekly meeting
	% of declaration of the priority of commitment	KPI measures the percentage of commitments that declare the priority (importance) of this, explicitly	(Number of commitments declaring priority)/(Total number of commitments) $\times$ 100	Declare the priority (importance) of commitment in the first two movements: Request or Negotiation and agreements
	% of compliance with priority commitments	KPI measures the percentage of commitments that were declared priority and that are effectively met	(Number of priority commitments fulfilled)/(Total number of priority commitments) $\times$ 100	Review of priority commitment agreed at the previous weekly meeting

Table 4. *Cont.*

Aim	Measure Name	Description	Formula	Means of Verification
+ M. and C. PP	% of specified deadlines	KPI measures the percentage of commitments that specify the deadline	(Number of commitments that specify the deadline)/(Total number of commitments) × 100	Specific deadline: date and time (AM, PM)
	% of unnecessary requests	KPI measures the percentage of commitments that make unnecessary requests	(Number of commitments that make unnecessary requests)/(Total number of commitments) × 100	When the client declares that the deadline specified in the request does not correspond to the last responsible moment and/or requested something that was not necessary (does not add value)
Measurement and Control of Fundamentals of Trust	% of reliability compliance (complementary to PPC)	KPI measures the percentage of commitments where the performer is able to perform reliably and timely in the required domain	(Number of commitments fulfilled + number of commitments revoked + number of renegotiations + number of commitments canceled)/(Total number of commitments) × 100	Indicator is the sum expressed in the formula. It is essential to measure it because it provides a higher degree of reliability than the current PPC (Percent Plan Complete)
	% of revoked commitments	KPI measures the percentage of commitments revoked	(Number of commitments revoked)/(Total number of commitments) × 100	Performer informs the client immediately after the meeting (ASAP) that he will not be able to fulfill his commitments
	% of renegotiated commitments	KPI measures the percentage of renegotiated commitments	(Number of renegotiated commitments)/(Total number of commitments) × 100	Client and/or performer wishes to change the satisfaction conditions immediately after the meeting, a new agreement is generated in the field huddle (between weekly meetings)
	% of canceled commitments	KPI measures the percentage of canceled commitments	(Number of canceled commitments)/(Total number of commitments) × 100	Client informs the performer immediately after the meeting (ASAP) that the commitment made is no longer necessary
	% of engaged participants	KPI measures the percentage of meeting participants who are engaged to it	(Number of participants engaged to the meeting)/(Total number of attendees) × 100	- Participants must arrive on time (max 5 min late) - Avoid interaction with the cell phone and walkie-talkie - Remain in the room and intervene in the meeting - Take notes and look at the person who is speaking

Table 4. Own elaboration, based on Salazar et al [24,36]. **+ M. and C. PP:** Measurement and Control of Petitions and Promises.

As we did with Version 2.0, the researchers presented the average results of the indicators measured during the three weeks, this time in a list and not in a table:

- 25% of compliance network or chain of commitments: (1) The preparation of the petition is observed. (2) Although a negotiation process is observed, it must be improved. (3) There is a declaration of compliance although it must be measured in the field. (4) The declaration of satisfaction must be worked out by the team.
- 93% of fulfillment of a request: In general, roles are defined intrinsically: client requests and performers agree. Regarding responsibilities, the scope of the commitment is not always clearly established.
- 55% of compliance negotiation and agreements: The generation of agreements must be strengthened and the imposition by the client avoided. Currently, the performer assumes the order established by the client. We did not delve into the fact that the client must consult the executor's (workers) agenda with the foreman.
- 66% of declarations of compliance with the commitment: Before each weekly meeting, the investigators verified that there was a considerable percentage of declaration of compliance with commitments, through several questions to the clients and performers. However, there were performers who did not inform clients that they had finished with the assigned task.
- 48% of fulfillment declaration of satisfaction: We consider that work should be done on this indicator, since we observed that in general, it only indicated if the commitment was fulfilled or not, without giving feedback to the performer.
- 6% of declaration of the priority of commitment: In general, the priority of the commitments was not declared. This must be worked on to allow the foremen to carry out adequate planning regarding the order of execution of the assumed commitments.
- 20% of compliance with priority commitments: We consider this result exceptional because it is very important to comply with the commitments declared as priorities. In this case, what happened was that a contractor did not comply with the commitments, despite the fact that they had been informed as priorities (a contractor who presented delays throughout the project and had problems with the management). It is very important to note that we expect this percentage to always be close to 100%.
- 66% of specified deadlines: In general, only the date is specified, but not if it will be completed in the morning or in the afternoon.
- 0% of unnecessary requests: No unnecessary requests on the meetings. According to the workers, the foremen often make unnecessary requests on the field.
- 68% of reliability compliance: This indicator complements the PPC with additional movements, which occur after the initial deal. In this case we consider that there is important room for improvement.
- 0% of revoked commitments: No commitments revoked after the weekly meetings.
- 1% of renegotiated commitments: Practically no renegotiation of commitments after the weekly meetings.
- 0% of canceled commitments: No commitments cancelled after the weekly meetings.
- 61% of engaged participants: Regarding this indicator, we can detail by the average percentages obtained with the Check List—Meeting participants (see Appendix A): 75% of the participants arrived on time, 18% checked the cell phone, 2% of them had their walkie-talkie make sounds, 19% left the meeting room, 22% did not intervene, 50% made notes and 100% looked at the person who was speaking.

2.11. Indicators Validation: Final Version

This final version of indicators was validated by applying this LAP in LPS Indicator System in four construction projects, two in Chile and two in Colombia. Comparing and analyzing the results

of version 2.0, proposing improvements to this system in order to achieve a refined system of key indicators of LAP in LPS.

Whence, we eliminated an indicator that could not be measured directly in the weekly meeting, percentage of fulfillment of roles and responsibilities of performers. We mix two indicators: (1) percentage of definition of roles and responsibilities of the performers, and (2) % of verification of the availability of performers in agreements; Because the first can be measured in % of fulfillment of a request, and the second can be measured in percentage of compliance negotiations and agreements. As well, we explained in detail the indicator percentage of engaged participants, because we consider that it was not evident in the previous versions and we consider it fundamental for the improvement of LAP. Finally, we want to mention that this Indicators System has metrics with the high expected value and low expected value; In other words, it is desirable that most indicators have high values (close to 100%, for example, percentage of compliance network or chain of commitments). In contrast, only some indicators like % of declaration of the priority of commitment, percentage of unnecessary requests, percentage of revoked commitments, percentage of renegotiated commitments, and percentage of canceled commitments, should have low values (close to 0%).

We decided to incorporate only the average results obtained during the three weeks, because the objective was to improve the proposed Indicators System through the optimization in the measurement and means of verification of each indicator. It is relevant to mention that we did not observe differences in the measurement system, but we did in the organizational culture (sociocultural of both countries), which will be analyzed in another document.

3. Analysis of Results

According to the parsimony of theory; that is, the number of constructions and statements that it requires to achieve its explanatory power [53], we have developed this "artifact" (Indicators System) trying to increase the explanatory power, but with fewer constructions or statements to contribute to the theoretical investigation (optimization).

The main criterion for this new contribution to Applied Science/Engineering (AS/E) knowledge is its practical utility. Because this artifact not only contributes theoretically but it is an AS/E contribution because it is original, generalizable, and validated [46]. Originality can be established by comparing contributions to state of the art, while a generalization can be established through the demonstration of the applicability of the artifact to a variety of contexts (different projects in different countries); in the end, the validity may be justified by the evaluation of the results (comparison of the three versions of indicators) [54]. Thus, researchers have reinforced efforts to justify these elements, including pilot tests in natural environments [55] (Villego® Simulation, projects in Chile and projects in Colombia), expert evaluations (including the creator of LPS) and feedback provided by the scientific community (two IGLC conferences).

Else, all DSR activities have been carried out to make these findings scientifically rigorous, meaning that there is no need for a separate Rigor Cycle [46] since all DSR activities have the potential to contribute to the Knowledge Base (theoretical contribution). Finally, since stakeholders participated in all DSR activities, we established a constant interaction with the Environment.

4. Discussion

4.1. Comments on the Results Obtained

We consider that our scientific research design was framed in a precise application context that not only managed to provide the requirements for the research (opportunity and/or problems) but also defined the acceptance criteria for the final evaluation of the results of the investigation [45].

Furthermore, through the DSR methodology, we demonstrated the usefulness of the proposed Indicators System, measuring and controlling the management of commitments in different

situations: simulation with students, construction projects in a country, different construction projects (extension and height) and in different countries.

Through the effort made in the indicator design process (42 iterations in total, creation of two preliminary versions and a final proposal), we were able to meet the initial objective of this research, in terms of responding to the need to measure the elements of LAP, to control and improve the management of commitments in the weekly LPS meetings, and thus give the kick-off to the development of an LPS 2.0 that focuses on the social dimension (people).

4.2. Lessons Learned from the Methodology Used

The authors consider that the Design Science Research (DSR) methodology used was adequate because it allowed us to solve the problem of measuring and controlling the management of commitments in different situations, managing to produce an Indicators System (artifact) reliable (tested) as an outcome. For us, it was essential to use the updated model proposed by Briggs and Schwabe [46], since our study phenomenon varies according to time, contexts and conditions of application; for the same reason, we carry out a constant iteration applying Kaizen (continuous improvement) in each of the versions, based on the relevance cycle between discovery and design activities, and the design cycle between design and validation activities, always considering the knowledge base as the central axis of the research.

We believe that the five main activities that we proposed and developed applying the DSR method, are a contribution to the knowledge and updating of this method in constant evolution and not yet fully understood by the entire scientific community. Furthermore, we believe it is necessary to mention that as we implemented each system in new scenarios, we obtained more feedback, achieving an increasingly optimal result, although not perfect.

At the end of our research, we realized, thanks to the feedback from other researchers, that the process of having to analyze our indicators through video recording was a very slow and inefficient process, except for the "% of engaged participants" that we had already resolved with our checklist proposal. So we decided to propose a first version of a "Notebook for Last Planners" (see Appendix B) that allows the same last planners to write down their commitments and fill in the necessary data to directly measure seven of our indicators percentage of compliance network or chain of commitments, percentage of fulfillment of a request, percentage of compliance negotiation and agreements, percentage of declaration of compliance with the commitment, percentage of fulfillment declaration of satisfaction, % percentage of declaration of the priority of commitment and percentage of specified deadlines) and indirectly 2 of our indicators (percentage of compliance with priority commitments and percentage of unnecessary requests), leaving only the indicator pending "% of reliability compliance" (and the metrics that depend on it: percentage of revoked commitments, percentage of renegotiated commitments and percentage of canceled commitments) since as these actions occur in the third movement of "Execution and declaration of compliance" in the field huddle. It is recommended that it is discussed openly in the meeting where the PPC and the Reason for Missed Commitment (RMC) of the previous week are analyzed.

4.3. Scope of the Research

With respect to the scope of the proposed artifact, we can mention that it has already been validated in Villego® Simulation, in extension and height construction projects in Chile, and in height projects in Colombia that used LPS. Therefore, we consider that it could be generalizable to this type of construction projects all over the world since the culture may be different and the degree of maturity of LPS as well, but the methodology should be the same unless LPS is not implemented correctly.

Moreover, the research was focused on creating this Indicators System for projects that had LPS implemented and thus optimizing it. Still, we consider that adapting the indicators, according to the Linguistic Action Perspective, could measure and control aspects of commitment management in any construction project, without necessarily having LPS implemented, having as a requirement

that the project has a formal meeting structure (ideally weekly) and that this meeting is based on the management of commitments and planning activities. According to the experience of the researchers, this system should not be applied in technical meetings, where work problems are solved without a defined structure, since we tried to measure in these types of meetings and it was very confusing to know who committed. Since even if solutions were given, the person in charge or the deadline was not specified.

As a result, the entire community linked to the construction industry is invited to use the proposed indicators to compare with the "location dimension" (Flyvbjerg 2006). The differences and similarities among different projects around the world, with the objective of determining the effect of the culture of the people and organization in the management of commitments and the general performance of construction projects. Because a theory is more useful if it explains more variations in a phenomenon in more contexts.

5. Conclusions

5.1. Summary

In 2001, Ballard and Howell, creators of LPS, raised a link between the Last Planner® System and Linguistic Action Perspective. However, to date, a system of quantitative instruments or methodologies had not been developed to carry out adequate management of the commitments.

Consequently, the authors wanted to respond to the need of measuring the main elements of LAP, in order to control and improve the management of commitments in the weekly LPS meetings, and thus contribute to the development of an LPS 2.0 that focuses its attention on the social dimension (people) in the context of Lean Construction, creating an Indicators System to measure and control commitments, requirements, promises, and reliability, through the Design Science Research methodology.

The authors used the Design Science Research (DSR) because this method manages to solve practical problems and produce artifacts as results, thus solving problems found in the real world, and in this way it also contributes theoretically in the discipline in which it is applied. Hence closing the gaps among the contextual environment of the research project (people, organizational systems, technical systems, problems and opportunities), design science research (artifacts and processes) and the knowledge base of scientific foundations (scientific theories, methods, experience and expertise), iterating between the activities of construction and evaluation of research design artifacts and processes.

5.2. Contributions

The main contributions of this document are: on the one hand, the proposal of five main activities where the DSR method can be applied, which allowed us to carry out an artifact (indicators system), managing to update this research method, which is continuously evolving, but unfortunately still is not fully understood by the entire scientific community.

Otherwise, we developed a checklist to analyze the engagement of meeting participants, a proposal of notebook for last planners, to simplify the measurement of this Indicators System, ergo avoiding the use of video recordings that require the informed consent of the participants and that can often be invasive.

Additionally, we delved into the Linguistic Action Perspective by creating a figure that details the variations that can occur to basic movements, which do not decrease reliability but increase it. It is important to note that these additional movements in the execution phase (revocation, renegotiation and cancellation of commitments) must be carried out as soon as possible after the commitment is established (once the meeting is over) because if the last planner notifies the client that the commitment will not be fulfilled one day before the meeting, it is no longer considered reliable.

Finally, our main contribution is the creation of an Indicators System that allows to measure and control the main aspects of Linguistic Action Perspective in Last Planner® System, updating the PPC

(Percent Plan Complete) with an updated indicator of Reliability (PPC + Revoke + Renegotiate + Cancel) and a detail of the indicators of engagement of meeting participants.

5.3. Limitations

The main limitations of this research are in two main aspects. The first aspect is that the Indicators System was validated only in projects that had the Last Planner® System implemented, which implies that they are not validated nor are they completely suitable for construction projects that do not have LPS implemented. However, we believe that they can be adapted. The second aspect is that the Indicators System was only validated in two South American countries, which could mean that it is not generalizable to everyone. Still, because LPS has a defined implementation methodology, if it is correctly implemented, differences in the result of the indicators according to the socio-cultural aspects of each country will probably be found. Still, the measurement and verification system should be the same.

At last, this Indicators System seeks to analyze the management of commitments in weekly planning meetings, so the measurement frequency was always every seven days. Nonetheless, it is necessary to hold at least two weekly meetings to analyze the results, since the first two movements will be seen in the first meeting: (1) preparation of a request and (2) negotiation and agreements; and in the second meeting, the last two: (3) execution and declaration of compliance and (4) acceptance and declaration of satisfaction.

5.4. Future Research

The authors see an opportunity to carry out case studies in different types of construction projects and different countries, to carry out a management benchmarking of project commitments with this new Indicators System, measuring and comparing different indicators of planning, production, term, cost, productivity, quality and safety of works, among others.

As well, in future studies, the authors propose to apply case studies in weekly planning meetings in other industries worldwide and to determine the recommended values to improve communication and achieve the proper implementation of LAP with LPS and without LPS (other planning systems).

Appendix A

CHECKLIST - MEETING PARTICIPANS

Instructions:
In each item, detail the number of people who perform the described action

	Item	Number of people	Observations
	Arrive on time		
	Person is late		
*	Check the cell phone		
*	Cell phone rings		
*	Talk by cell phone		
*	Leaves the room		
*	Walkie-talkie sounds		
*	Talk on walkie-talkie		
	Does not intervene in the meeting (does not speak)		
	Take notes		
	Does not look at the person who is speaking		

* Record in column "observations":
Cases in which the same person is persistent. Indicate approximate number of repetitions and other comments.

Other comments:
_____
_____
_____
_____
_____

Figure A1. Checklist to analyze engagement of meeting participants.

Appendix B

NOTEBOOK FOR LAST PLANNERS												
Name:					Measurement start date:		___/___/2020		Measurement end date:		___/___/2020	
Position:					Symbology	-- (Very low)		- (Low)	0 (Mean)	+ (High)	++ (Very High)	
Company:						W: Well		N: Normal			P: Poor	
Week 1								**Week 2**				
Who asks for it	Activity and / or Task	(%)	Sector	Day (AM or PM)	Task Priority	Clarity in the Petition (request)	Negotiation and Agreement	% Completed	PPC	Declaration of compiance	Declaration of satisfaction	Comments (CNC)
Name and / or Position					--, -, 0, +, ++	W - N - P	W - N - P	%	Does it comply?	Yes - No	Yes - No	
Administrator	Floor slab installation -1	80%	Quadrant A and B	Tuesday (AM)	-	W	N	70%	NO	YES	NO	bla bla bla
Week 2								**Week 3**				
Who asks for it	Activity and / or Task	(%)	Sector	Day (AM or PM)	Task Priority	Clarity in the Petition (request)	Negotiation and Agreement	% Completed	PPC	Declaration of compiance	Declaration of satisfaction	Comments (CNC)
Name and / or Position					--, -, 0, +, ++	W - N - P	W - N - P	%	Does it comply?	Yes - No	Yes - No	

Figure A2. Proposal of Notebook for Last Planners.

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