

VISUAL COMMUNICATION PANELS FOR PRODUCTION CONTROL USING GAMIFICATION TECHNIQUES

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ABSTRACT

In recent years, the construction industry has shown significant interest in the adoption of new process improvement principles and practices that use visual management while also being integrated in the Production Planning and Control at construction sites. This need has led managers to seek new approaches in order to improve the involvement of their employees in compliance with the weekly plan.

This study aims to present a gamified web system for the dissemination of the work packages of the weekly plan and also exhibit the performance evaluation of the operational teams. Thus, it is expected to generate improvement in the transparency between the managerial and operational levels and to increase the engagement of the operational teams. Therefore, this web system proposes the use of visual management principles and gamification techniques.

The main research strategy used in this work was Design Science Research, a constructive methodology, in order to develop, implement and validate the gamified web system. An empirical study in Project A was carried out, involving a survey of the project situation in terms of transparency and engagement of operational teams, requirements gathering for the design of the web system and its development.

As a result, this innovation should act to generate the membership of workers' planning, drawing their attention to the weekly schedule as well as inducing the creation of a scenario with a healthy "competition" that can improve productivity and engagement in the process as a whole.

KEYWORDS

Gamification, Visual Management, Last Planner, Engagement and Transparency

INTRODUCTION

In the last years, the construction industry has faced several changes, which demands the development of innovative managerial solutions that aim to improve labor and

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material control, as well as to increase communication among several stakeholders in the construction supply chain. In this context, the adoption of Lean Construction principles, mainly the Last Planner System for several construction companies has contributed to stabilize the production process, maximizing value generation and eliminating waste of over-production (Ballard 2000).

However, experience in the implementation of Lean by using Last Planner System has shown that much more is needed than just a tool to ensure success (Ahrens, 2006). Alarcón et al. (2005) describe weak communication and transparency as a barrier to its progress. Since with the Last Planner system, information is exchanged and discussed in weekly meetings, it is often not possible for all participants and construction workers to be aware of important details if they were not present at the meeting (Brady et al. 2011, Brady et al. 2012). The elimination of noise and problems in communication is extremely important in a system of effective programming and for this, managers should seek dynamic forms, and even interactive ones, in the information dissemination process.

Therefore, technologies of the visual workplace represent a comprehensive strategy for installing vital information as close to the point of use as possible, generating new levels of employee inventiveness and contribution (Galsworth 2005). In this sense, using visual devices can enable immediate recognition of process status, making the process directly observable and incorporating information into the process (Koskela 1992). Visual elements create an information field for people to pull the necessary information from and help make sense of the organizational context at a glance by merely looking around (Grief 1991).

On the other hand, more recently the term gamification has been receiving important attention. Although gamification may be a new term, the idea of using game-thinking and game mechanics to solve problems and engage audiences is not exactly new (Zichermann and Cunningham, 2011). Deterding et al. (2011) summarize “Gamification” as (a) the use (rather than the extension) of; (b) Design (rather than game-based technology or other game related practices); (c) Elements (rather than full-fledged games); (d) Characteristic for games (rather than play or playfulness); (e) In non-game contexts (regardless of specific usage intentions, contexts, or media of implementation).

It is known that many of the barriers for Last Planner System implementation are related to the lack of involvement of construction workers, inadequate communication and lack of transparency in daily operations onsite. To address this problem, this work aims to conceive visual communication panels for weekly plans by using gamification techniques aiming to increase the transparency and the involvement of construction workers. The gamification is used along with a reward system in order to allow the generation of accession to planning and to evaluate the construction workers’ performance as a team and individually. This paper is part of an ongoing master’s dissertation research project.

VISUAL MANAGEMENT AND TRANSPARENCY

The principle of transparency is an important way to solve the challenge of communication failures among key players involved in the production process. According to Formoso et al (2002), process transparency is the ability of a production process (or its parts) to communicate with people.

For Koskela (1992), lack of process transparency increases the propensity to err, reduces the visibility of errors, and diminishes motivation for improvement. Thus, it is an objective to make the production process transparent and observable to facilitate control and improvement: “to make the main flow of operations from start to finish visible and comprehensible to all employees” (Stalk and Hout 1989). Koskela (1992) argues that this can be achieved by making the process directly observable through organizational or physical means, measurements, and public display of information.

Authors such as Santos et al. (1998) and Galsworth (1997) argue that just as in the case of the physical processes, management processes such as Production Planning and Control also depend on the effectiveness of this communication, for through it you can reduce a large number of non value-adding activities, and provide an increase in the capacity of supervision and control of the production teams.

However, the idea to make the production process more transparent goes beyond the transmission of information through panels, photographs and charts. The mere submission of a work schedule stuck on the office wall does not necessarily mean that there is transparency in the planning process, since the accession of the work teams to production plans often does not occur or is insufficient (Grief 1991). On the other hand, computer solution with a public interface may offer expanded visibility, playing a larger role in visual system (Grief 1991, Galsworth 1997). In this sense, the use of Visual Management and Gamification can be of great assistance in the generation of this aforementioned accession.

For Galsworth (1997) the visual system is a group of visual devices that are intentionally designed to share information at a glance, without having to say a word. The use of Visual Management can modify the traditionalist and often inefficient approach held by many builders. Taking as an example the weekly work planning, it is noted that the use of visuals and graphics elements in its dissemination can improve transparency, job facilitation, creating shares ownership, management by facts and simplification.

GAMIFICATION TECHNIQUE

Liu (2011) suggests that the ultimate goal of gamification is to incentivize a non-game system user to have the so-called game-like behavior: focus on the task at hand, multitasking under pressure, work overtime without a discontented attitude, always keep retrying when it fails, etc.

One of the most frequently leveraged frameworks of game design is referred to as MDA-which stands for: Mechanics, Dynamics and Aesthetics. The MDA framework is a postmortem analysis of the elements of a game. It helps us use systems thinking to describe the interplay of those game elements and apply them outside of games. (Zichermann and Cunningham 2011).

Zichermann and Cunningham (2011) state that the mechanics of a gamified system are made up of a series of tools that, when used correctly, promise to yield a meaningful response (aesthetics) from the players. For their purposes, they will focus on seven primary elements: points, levels, leader boards, badges, challenges/quests, on-boarding, and engagement loops. This game mechanics and structures are the essential building blocks of any gamified experience. This study has focused on the mechanics of points and ranking system, in addition to feedback.

Points are important and regardless of whether their accumulation is shared among players, or even between the designer and the player, they are an absolute requirement for all gamified systems (Zichermann and Cunningham 2011).

To Zichermann and Cunningham (2011), the "gamify" professional develops some characteristics such as leadership, cooperation, competitiveness, ability to work with targets and ability to make quick decisions. This is because human beings are competitive by principle and have the ability to better perform their duties if done in a playful and fun way or even if there is some social compensation involved, as a motivational aspect to overcome their own limitations.

Experimental social psychology is full of examples showing that positive emotional experiences have beneficial effects on the way people perceive and interpret social behaviors and how they initiate social interactions (Huppert 2005). A person can be said to be flourishing if they perceive that their life is going well. Individuals who are flourishing (or who have a high level of psychological well-being), learn effectively, work productively, have better social relationships, are more likely to contribute to their community, and have better health and life expectancy. (Huppert 2005).

Starting with this discussion about motivational incentive, recent work, such as, "The Future of Work is Play: Global Shifts Suggest Rise in Productivity Games" by Ross Smith (2011) indicate clearly that the prevalence of games will continue to grow. The study shows that, augmenting a business process with game mechanics has led to significant productivity improvements. These lessons support the notion that games can – and will – be an important component of the workplace in the future. Games are the future of work, fun is the new "responsible," and the movement that is leading the way is gamification.

RESEARCH METHOD

The main strategy used in this study is Design Science Research, which is related to the development and evaluation of artifacts in order to solve real problems. March and Smith (1995) and Van Aken (2004) defend that this approach helps to solve applied and relevant problems that occur in problem-solving disciplines, such as management, medicine and information technology. Van Aken (2004) defends that in those disciplines description and comprehension are not enough, but it is also necessary to develop and test solutions.

The design science research was chosen due to the need to solve a practical problem regarding a lack of transparency and engagement of the workers in last planner system, and also to provide a theoretical contribution to the field of visual management and gamification in construction. The artifact produced in this research is a web system for production control and reward program, consisting of visual communication panels using gamification techniques to disseminate the weekly plans and also to evaluate the performance of the workers.

The main research steps of this research involved an exploratory study, an empirical study, implementation and validation of the artifact and data analysis, as shown in Figure 1. The implementation, validation and data analysis are still being developed and are not the focus of this paper.

Initially, an exploratory study was carried out in Project A, which involved the development and construction of residential building in an upper-class neighborhood

in Salvador, from March 2013 to July 2013. The main author of this paper has worked as a junior engineer in the project for more than one year. This study investigated the level of workers' knowledge concerning the use of weekly plans, highlighting its dissemination, feedbacks, accomplishment of work packages, as well as motivation and commitment with goals and company rules. Data was collected through structured questionnaires in which 25 workers were interviewed (about 50% of the workers directly hired in the project). Data from PPC and causes of non-completion of project work packages were analyzed as well. And two meetings involving the project manager and the planning manager were also carried out aimed at discussing the planning process in advance, as well as the involvement of the construction workers in this process.

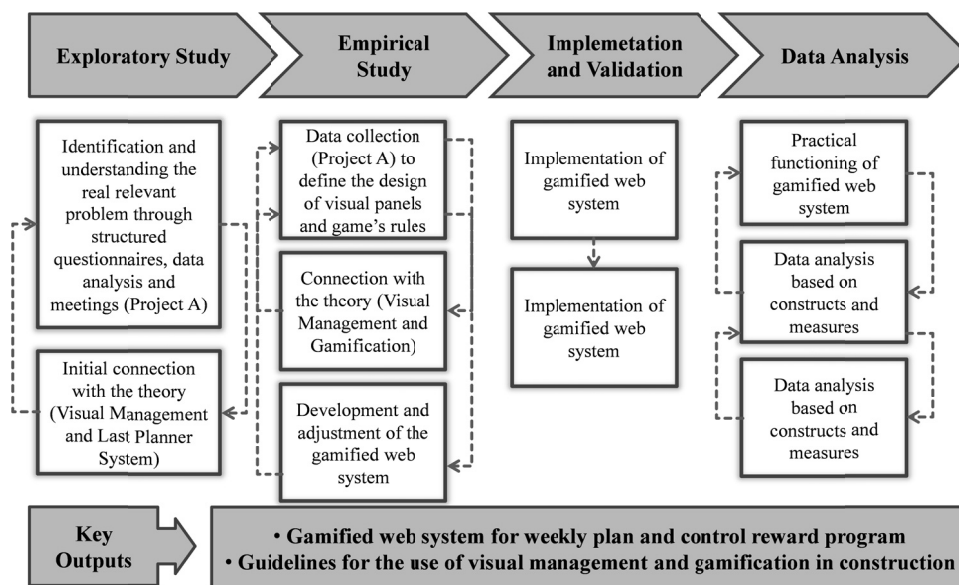


Figure 1: Design of the research

The empirical study aimed to conceive the gamified web system. The gamification technique was used in order to generate adherence of the workers to the weekly plans, as well as to promote an oriented behavior for the accomplishment of rules and deadlines using the mechanism of game and reward. As a consequence, better performance of the crews and of the individual workers is expected.

Initially, the architecture of the system was created and afterwards, a web master was hired to develop it. The system used a framework called Django, following the philosophy of agile web application. It was implemented in Python language, using a cloud service to store its database.

The aim of the system was to conceive a game through visual panels for weekly plans, establishing crew and individual workers' ranking which aimed to motivate them to be involved in the accomplishment of the production goals, in alignment with other necessary activities or behavior desired, such as work package completed on time and quality, cleaning and organization, accomplishment of safety rules, involvement in daily meetings, punctuality and attendance. Eight rules and score points criteria were established for the game. The proposal was to add score points for the accomplishment of the rules or to subtract score points for non-accomplishment. Five individual rules and two collective ones were established (see Table 1).

The score points were established together with the manager of Project A, and the weight was defined according to the importance of each rule for the Project, also balancing individual and collective rules (Table 1). Control worksheets were developed to collect data concerning the variables of each rule. Once the system was developed, an implementation plan was established in order to support the system implementation in Project A.

Table 1: Rules and points criteria of the production control and reward program

Rules	Points	Group coverage	Frequency	Responsible for assessment
1) Removal and return of work tools	-3	Individual	daily	Warehouse worker
Objective: To control the loan tools. Due to the fact that it is an activity that not all workers perform, it will not be given a score for its fulfillment, since there would be an advantage for these employees. To encourage the implementation of this task, a negative score for non-compliance will be assigned, using a framework of controls and control sheets. Assess the conservation status of the return.				
2) Use of individual safe equipment and compliance with safety regulations	3	Individual	Daily	Safety Technician
Objective: To assess compliance with individual protection equipment used and the care of safety standards for workers. In order to evaluate this rule, routine inspections of the workplace should be conducted to identify possible breaches of the rules, non-use or unreasonable use of individual protection equipment, using records of control and registration. Score for those who have no comment.				
3) Attendance to Daily Dialogue of Safety(DDS¹)	2	Individual	daily	Safety Technician
Objective: To evaluate the mandatory attendance of workers in the daily meetings concerning safety measures. The attendance of this meeting is already taken daily through a presence list, applied by the technical security work. To facilitate the processing of the data using a control chart.				
4) Attendance	-20	Individual	daily	Administrative Assistant and Interns
Objective: To monitor the attendance of employees. The presence of the employee is considered a minimum requirement for any performance analysis, therefore, it will not be given a score when fulfilled or not. However, the penalty for unexcused absence should reflect the seriousness of this lack of commitment. Use timecards and attendance sheet.				
5) Punctuality	15	Individual	Weekly	Administrative Assistant and Interns
Objective: To assess the degree of punctuality of employees. To encourage punctuality, to be credited with a score of 15 points per week per worker will only be allocated if the sum of the daily delays a week does not exceed 75 minutes. Analyze timecards.				
6) Subordination and Discipline	-5 to -20	Individual	daily	Foremen and Interns
Objective: To evaluate possible problems involving issues related to subordination and discipline. For this rule, review should be done by teams responsible, where there should be a sign of any problems related to the occurrence of insubordination and indiscipline issues. This is a very delicate and subjective norm, being unable to measure how many points should be discounted, since this will depend on the degree of seriousness of the situation.				
7) Order and Cleanliness of Workplace	20	Team	Daily and Weekly	Foremen and Interns
Objective: To assess the degree of organization and cleanliness of the work environment. Prizes for a Desktop ordered in the work, which contains only equipment and materials needed to service and is clean and free of waste and debris "during" and after the work. This evaluation should be done by trainees, with participation of those in charge. Credited to any team.				
8) Compliance of the work package on time and with quality	40	Team	Weekly	Interns
Objective: To improve compliance of the work package on time and with quality. The establishment of a score for the components of the teams that met their goals, aims to try to improve this scenario, the expectation that the rewards, be they intersects or extrinsic, generate a motivational factor. Weekly review at the time of PPC measurement.				

¹Daily Safety Dialogue or Safety Minute Meeting is a moment in which all workers have a brief discussion about daily procedures and feedbacks concerning problem or positive aspects that happened in the previous day related with safety and health. The Safety Officer is responsible to manage this meeting.

FINDINGS OF THE EXPLORATORY STUDY

The findings of the questionnaire applied in Project A were divided in the following items: (a) knowledge of the workers regarding the weekly work plan; (b) transparency, dissemination and feedback; (c) knowledge and accomplishment of company's policies and rules; (d) motivation and commitment with goals and rules (as seen in Figure 2).

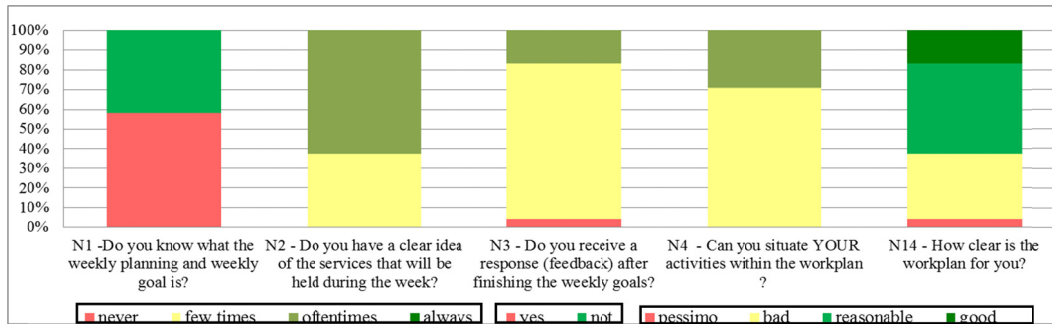


Figure 2: Main Survey Findings in Project A

Concerning the knowledge of the workers related to the weekly work plans (question N1 and N2), it was observed that 58% of the workers are not entirely aware about the weekly work plan or its goals, even though continuous quality training is given by the company. On the other hand, 63% of the workers answered that they always have a clear idea about the activities that have to be executed during the week. This indicates that there is an informal understanding regarding the goals and probably some workers have little knowledge about the terms of the Last Planner System developed in this Project.

A few workers argue that the uncertainties of necessary resources such as equipment acquisition, materials and change of plans for the execution of the activities is one of the reasons for the lack of clarity concerning the activities that they have to execute during the week.

The statement above is confirmed in Table 2 that shows the causes of non-accomplishment of work packages. 21% of the causes of non-accomplishment of work packages take place due to the lack or delay of material and equipment whereas 14% refers to the delay in the preceding activity. Also the average of PPC in the period was 56.8% and a high variability of the weekly PPCs was noted.

Table 2: Causes of non-accomplishment of worked packages in Project A

Causes of non-accomplishment (from January to October 2013)	Percentage
Adverse weather conditions	23%
Lack of material, equipment / Delayed	21%
Delay in the prior activity	14%
Problem with service management / Communication	11%
Fault / Problem in planning	10%
Problem not foreseen in the implementation	9%
Lack of project / Problem with revision	4%
Overestimation of productivity	4%
Lack of programming labor – House and outsourced	4%

These figures show that Project A also has major deficiencies in forward planning, besides problems with cash flow that made it difficult to acquire these resources. Other problems can also be minimized with the establishment of the gamifiedweb system, such as definition of work packages, transparency and communication for the workers and managerial team and productivity of the teams.

Observing the question N14, it is clear that most workers consider that the current way in which the weekly work plan is disseminated is hardly transparent. Although 62.50% of respondents consider that the clarity is good or fair, 37.5% agree that there is an opportunity for improvement in this aspect. Likewise, 83.33% said that they rarely or almost never receive a response (feedback) for the fulfillment of the weekly goals, which contributes to a lack of engagement in the PPC process as a whole, which can also be seen by analyzing the question N3 and N4.

The operational team was also questioned about the knowledge and level of commitment to the standards, safety, discipline, attendance and punctuality rules and motivation to fulfill these rules and the weekly goals. The results indicated a high degree of commitment and knowledge. However care must be taken in analyzing these data, because the questionnaires were administered by the researcher, who exercises a supervisory position at work, in other words, it was expected that many workers would have answered this set of questions with some uneasiness, wondering what the company expected them to respond. Participant observation and the evaluation meetings with the management of the project show an opposite position to that found by the operational team responses, and indicates that the workforce is poorly motivated and engaged only when financial resources are offered.

As one of the issues identified in the research problem was the low effectiveness of the short-term planning, the document analysis for diagnosing was based on the research of the weekly work plan and the PPC (Percentage of Packages Completed) which had already been computed by the project.

PROPOSAL OF VISUAL COMMUNICATION PANELS FOR PRODUCTION CONTROL AND REWARD PROGRAM USING GAMIFICATION

The gamifiedweb system developed is an adaptation of the commitment planning of the Last Planner System using a new approach for the dissemination and production control, as mentioned before, based on visual management system concepts and gamification techniques. In this approach, an evaluation and reward program was

included based on additional rules in addition to the accomplishment of the work packages, considering quality, safety and organization of the work packages.

A flexible web computing system was created, which would enable its adjustment to the reality of other rules and projects. This system has two interfaces. The first is the online viewer, used to display information regarding the weekly planning and control as well as performance evaluations for workers at the construction site, as well as being a tool for online control of the direction.

The second interface is the administrator mode, where responsibility for monitoring and power system planning data and the cast is listed. This is an architecture interface with simple handling and operation of the tool and the mastering of it is obtained with only a few hours of use. Basically the administrator will operate five modules supply data, which are: (a) planning, (b) workers, (c) teams, (d) rules and (e) score.

The "game's" idealized cycle consists of a total of one month with other four sub weekly cycles, as shown in Figure 3. The first week has a different dynamic from the others, since there is no data collected concerned with the rules yet to be launched. Therefore, this explanation will be given after the second week, when the complexity increases.

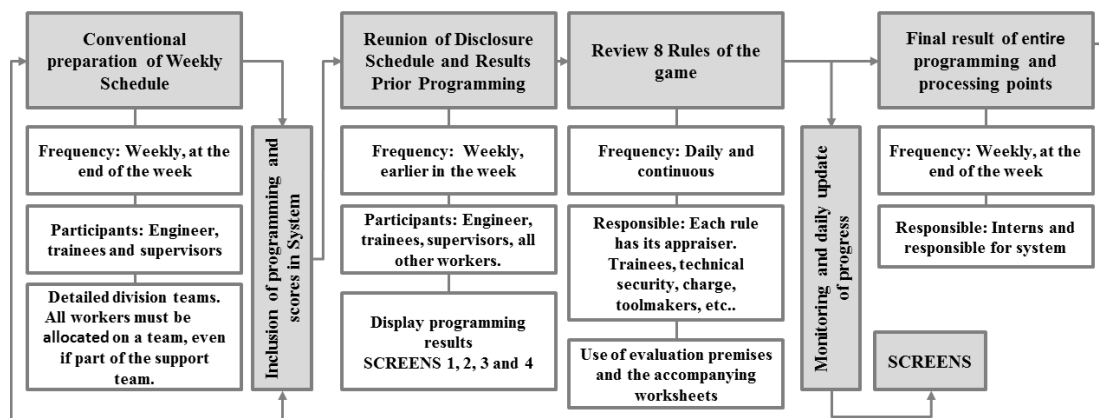


Figure 3: Overview of the gamifiedweb system

Initially, the short-term planning has to be prepared. Project A study has already used this tool to elaborate a weekly work plan which is distributed to the field by the foremen, in addition to displaying a copy thereof in the office on site. However, the work packages of the short-term (commitment) planning that will be launched in the web system (see Screen 1 in the Figure 4) should be well defined considering the quality criteria proposed for assignment regarding definition, sequence, soundness and size (Ballard 2000). The definition of the work packages should be carried out in weekly meetings involving project managers, junior engineer and producing foreman.

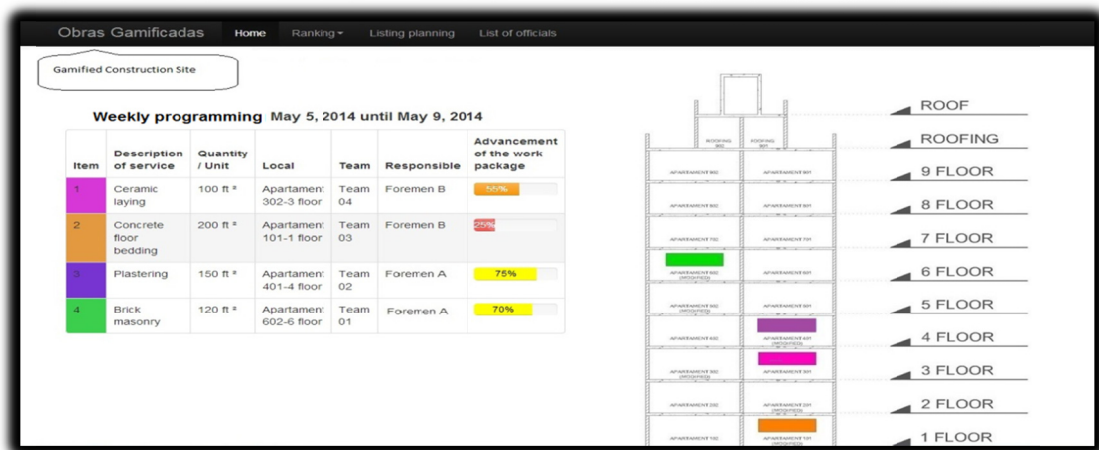


Figure 4: SCREEN 1 – Short-term planning

On the same day of the meeting, the data collected during the week must be processed, including the assessment of accomplishment of the work packages and performance evaluation of the operational team in order to upgrade the screen 1 and generate data for screen 2 (Figure 5), screen 3 (Figure 6), screens 4 and 5.

The junior engineer and the production foreman are responsible for evaluating the completion of the work packages in the field. Also, the reasons for non-accomplishment should be identified, which amounted to a requirement that learning be incorporated into the control process.

To identify the compliance with the rules 1-6 of all workers, it is necessary that all worksheets for data collection are properly filled out. In addition to these worksheets, the collective rules that measure if the work package was completed on time and quality, with organization and cleanliness should be scored with the aid of notes and observations of trainees, foremen and supervisors (rules 7 and 8).

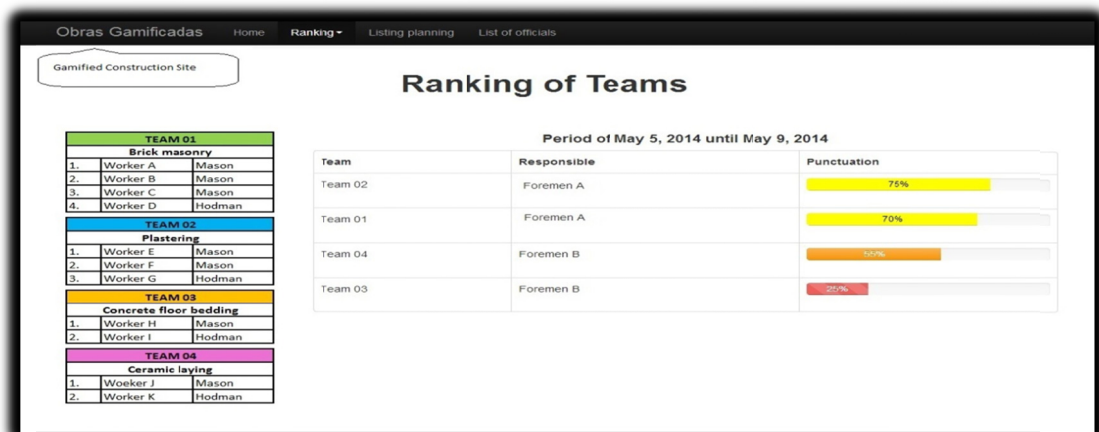


Figure 5: SCREEN 2 - Ranking of Teams

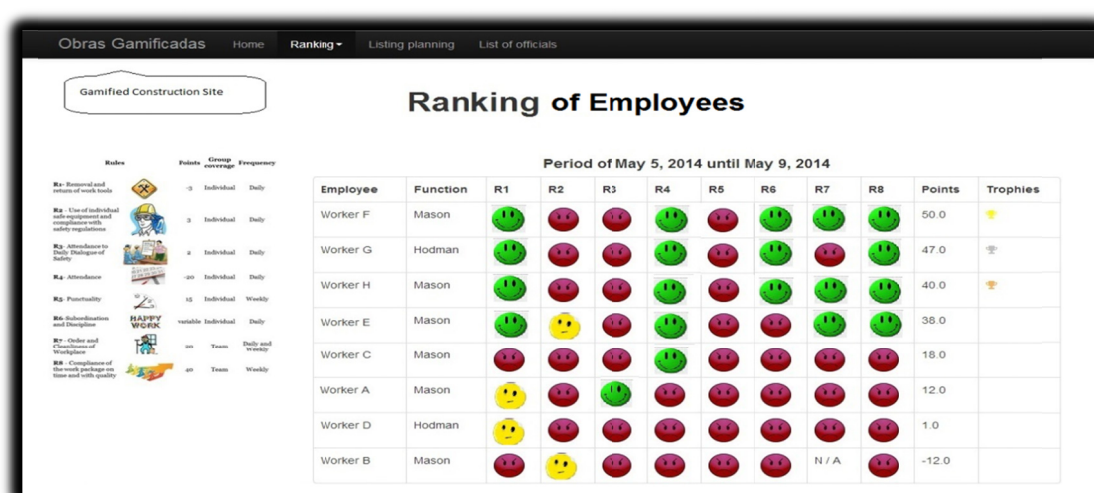


Figure 6: SCREEN 3 - Weekly ranking of Employees

After this stage, it is on to the dissemination of weekly work plan in Screen 1, which must occur at the beginning of each week in a meeting with the operational team work, and with the presence of the engineer, junior engineer, the foremen, in addition to the workers. Besides, in this meeting, the feedback screens from previous weekly work plan must be present as well as the team and individual performances.

During the course of the week, it is necessary to monitor the activities including assessment of established rules, as well as the approximate and daily fill of the advances obtained. The screens should be displayed daily, reserving about 5 minutes from Daily Dialogue of Safety to talk about the course of services. After performing these procedures in 4 sub cycles, one reaches the end of the monthly cycle, and a closing meeting should be held to present the final result of the game, for employee recognition and the reward of top performers.

In this viewer mode, it was sought to use visual aids to attract the attention of the workers for the important information, thus improving the clarity on how communication is performed. These screens also act as a "game board" of gamified weekly work plan, working as an integral part of the process of gamification, along with the mechanized process of games. Table 3 presents the summary of the screens, some of them already presented.

Table 3: Summary of the gamified system screens

SCREENS	Description
SCREEN 1 Weekly programming	Displays the schedule with a description of services, quantity to be executed, local, and responsible staff. Also presents the schematic section with the location of services.
SCREEN 2 Ranking of Teams	Presents a ranking by the percentage compliance of the weekly programming services team. It also presents a framework with components for each team.
SCREEN 3 Weekly the ranking of Employees	Presents a ranking of the score that week, including an assessment of compliance with each rule, signaling through images of faces the degree of fulfillment of each rule. It also presents the accumulated trophies and a summary table of the rules.
SCREEN 4 Cumulative ranking of Employees	Presents a ranking of the cumulative score in the game that will let you know at the end of one month cycle which were the workers with better performance. Displays the list together, a photo of each worker.
SCREEN 5 – The Best performance of the month	

The implementation of this system and its process has not yet been validated in Project A, but it is already scheduled to take place in May, 2014. Before executing the empirical study, it is important to highlight actions for its initial implementation. Initially, a campaign will take place to publicize the program through posters, discussions in the DDS or even at the time of the administration of the questionnaire. There will be training and orientation of evaluators in systematic and special meetings. All equipment such as television and internet must be provided and properly installed, in the week before the beginning of the "game". Also, it is necessary to hold a general meeting with the workers to present the assumptions, rules and reward, ensuring that all this information is clear and accessible.

IMPACTS OF GAMIFICATION TECHNIQUE IN THE CONSTRUCTION INDUSTRY

The workplace influences the motivation of the workers. The addition of gamification techniques on construction sites can have an important impact on the motivation of the workers to perform their tasks. There is an expectation that this technique encourages the workers to achieve the goals set in the weekly schedule, drive the team work to full completion of the services provided, improve communication of weekly goals through the visual management and keep the worker motivated. The feeling of work being recognized and the possibility of performing tasks collaboratively can lead to the improvement of worker productivity.

There are two ways to recognize employees meeting their goals, whether in terms of attendance, safety, productivity or quality. On the one hand, informal recognition through flexible schedules, praise, and training offered and career development, which motivates workers and has a low cost to the company. On the other hand, there is tangible recognition based on occasional benefits, gifts and financial aid, among others. This research adopts the two ways of recognition: tangible, when awards are offered for best performance in the game and informally, when the screen displays trophies and photos of employees who had the best performance of the week.

CONCLUSIONS

The visual management is gaining ground on construction sites and there are studies on how it can improve many aspects of the work. However, this study focused on how visual management can improve a specific aspect of the Last Planner System, that of short-term planning. The idea of the project was to bring the program information for those close to the matter, operating, exposing and making clear which activities, quantities, execution sites and teams. The lack of essential information and involvement in the process generates losses that contribute to low efficiency of planning. However, mere exposure of programming does not necessarily mean that there is transparency in the planning process and that the communication is effective. To counter this, the use of gamification may contribute in a positive way.

This innovation should act so as to generate the membership of workers' planning, drawing their attention to the weekly schedule as well as inducing the creation of a scenario with a healthy "competition" that can improve productivity and engagement in the process as a whole. The system of planning, control and evaluation teams were thought to use some mechanical gaming, exemplified by the system of points, ranking and feedback, as well as visual management itself, in order to generate a behavior-

oriented approach, and directed to achieving targets, the understanding of programming and greater participation at the operational level.

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