International Journal of Occupational and Environmental Safety

Testing and practical validation of an individual safety performance assessment methodology – the SSP System

R. Mira[a], C. Jacinto[b], B. Dias[c], M. Carrasqueira[d], A. Fundo[e]

[a]UNIDEMI, NOVA School of Science and Technology, Universidade Nova de Lisboa, PT (ar.mira@campus.fct.unl.pt), [b]UNIDEMI, NOVA School of Science and Technology, Universidade Nova de Lisboa, PT (mcj@fct.unl.pt), ORCID 0000-0002-1292-0782, [c]Qualiseg, Engineering and Management, PT (ceo@grupoqualiseg.com), [d]Qualiseg, Engineering and Management, PT (chairman@grupoqualiseg.com), ORCID 0000-0002-1697-4278, [e]Qualiseg, Engineering and Management, PT (manageraf@grupoqualiseg.com), ORCID 0000-0001-5430-1149

Article History

Received March 17, 2021
Accepted June 30, 2021
Published November 30, 2021

Keywords

Occupational safety and health
Behavior based safety
OHS performance
Safety behavior observations
Safety Score Permit

DOI: 10.24840/2184-0954_005.002_0004

ISSN:
2184-0954

Type:
Research Article

Open Access
Peer-Reviewed

Abstract

The "Safety Score Permit" (SSP) is a new tool that focuses on behaviour and is based on a point system which allows individual performance's tracking, thus encouraging safe actions. The present study aims at verifying the applicability and practical validation of the first SSP version; the ultimate goal is to evaluate its coverage within different industrial contexts and identify limitations and opportunities for improvement. A pilot implementation was conducted in three large companies, presented as three case studies. The records of safety behaviour observations (SBO) of each case were analysed to verify if all the "observed deviations" fitted into the classes and subclasses typified in the system. Although the study basis was the same in all three cases, in two of them the research was based on existing SBO records collected in 2019, whilst in the 3rd case there was a much higher interaction throughout the work. In this case, the process was started from scratch, including the SBO procedure, its monitoring and subsequent data analysis, to create the necessary conditions for the implementation of the full system. The results obtained revealed that, in general, the SSP platform has the ability to cover most deviations identified in an organization. The system has the potential to become a useful and transparent tool to monitor employees' safety performance at all hierarchical levels; it also helps to identify weaknesses in the companies' OHS processes. This work was essentially exploratory but it shed light on how to improve the system further and also unveiled new opportunities. A key issue to enhance SSP as a management tool is to expand its scope to all types of human errors, thus offering better support to strategic OHS decisions.

1. INTRODUCTION

The rate of occupational accidents has decreased over the years, but statistics continue to show a high number of fatal and serious accidents. The ILO[1] reports over 2.78 million deaths per year worldwide as a result of occupational accidents or work-related diseases. In Europe, in 2017, the EU costs of work-related accidents and illnesses amounted to 476 billion Euros, which is about 3.3% of the European GDP (Elsier, Takala, and Remes 2017).

Over the years, there have been many investments in the OHS (occupational health and safety) area related to equipment protection, and OHS management systems, among others. However, when changing towards a sustained reduction of occupational accidents, it is crucial to consider and integrate alternative approaches, capable of adjusting to the organization's context and today's society. Several experts argue that the focus needs to be directed to the behavioural aspect, investing in improving behaviours (Goh et al. 2018; Roy e Gupta 2020). This investment, moving from unsafe

[1]ILO, Safety & health at work, https://www.ilo.org/global/topics/safety-and-health-at-work/lang--en/index.htm, retrieved march 2021

to safe acts, is undoubtedly the strategy to achieve effective accident reduction and to work proactively. The behaviour-based approach has been increasingly taken into account for accident mitigation strategies, and many companies have been implementing this more proactive and preventive philosophy (Choudhry 2014; Jasiulewicz-Kaczmarek, Szwedzka, and Szczuka 2015).

The Behaviour-Based Safety (BBS) approach is recognized for its ability to influence both individual and collective behaviours and it provides a means to improve workplace safety (Jasiulewicz-Kaczmarek et al. 2015). Such approach promotes individual involvement, as well as employers' commitment (HSA, 2013). Moreover, it is in line with the new requirements of ISO 45001:2018 which is the most recent OHS Standard and is quickly replacing the well-known OHSAS 18001:2007 widely used for certification purposes. Within the novelties brought by the ISO 45001, is the way it reinforces the importance of effective Leadership commitment and Workers participation, requirements that are strongly considered in the SSP system.

Unlike the traditional safety programs, which allocate responsibility for accident prevention to top management, the BBS philosophy aims at educating employees and employers to examine the root causes of their accident-prone behaviours and learn from them (Guo, Goh, e Le Xin Wong 2018; Jasiulewicz-Kaczmarek et al. 2015).

In short, the BBS can be explained through the ABC model (acronym for Antecedent, Behaviour, Consequence) illustrated in Figure 1. It shows that behaviour consists of three components to identify the factors that led a worker to have a risky action; these factors are called "barriers" to safe behaviour. The antecedents (activation events) define the scenario or event for a behaviour; the behaviour itself corresponds to measurable or observable actions, while the Consequence is the positive or negative result of these actions (Meadan, Ayvazo, and Ostrosky 2016).

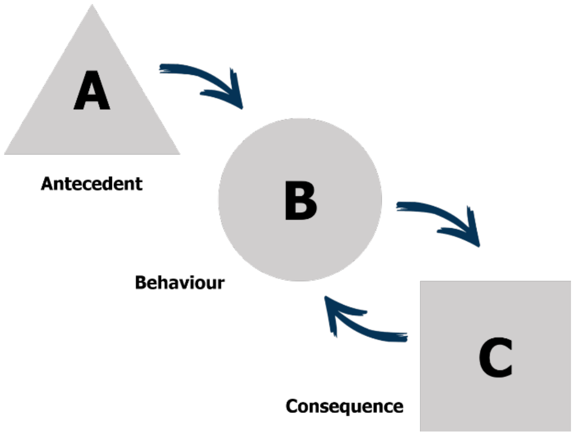

Figure 1. ABC Model (adapted from Meadan et. al. 2016)

This paper reports the second stage (field validation) of the development of new system – the Safety Score Permit (SSP) – based on three pillars: the BBS philosophy, the scorecards systems, and the “point system” for road safety. The first stage of the project, carried out in 2019, involved the design of the SSP tool by defining the criteria, methodology and the associated IT platform (Santos, 2019; Fundo et al, 2020).

There is evidence that scorecards have been applied in different ways, and across a range of activities, and have proven to be promising tools to help organizations address challenges and support strategic decisions (Tappura, Sievänen, Heikkilä, Jussila, & Nenonen, 2015). The first applications emerged in the area of Quality Management (Michalska, 2005), but soon these were followed by others within sustainability and integrated management systems, addressing the system’s performance as a whole (Journeault, 2016; Kalender & Vayvay, 2016). It should be highlighted, however, that scorecards applied to individual safety performance are rare, and they may not even use a scored system (Nunu, Kativhu, & Moyo, 2018).

The existing safety cards/docs for individuals, including safety passports or safety cards as those developed by Nunu et al. (2018), do not have any mechanism for gaining or losing points associated with both rewards and penalties, namely the need of compulsory (specific) training sessions when the loss of points occur. Moreover, none is based on the BBS philosophy and values. This is why the SSP system is an innovative tool, intended to encourage best practices, for supporting the progress of OHS management systems and their evolution to excellence level, in which the focus is directed to highlight the successes and the positive results achieved (safety-II approach), without losing insight on the root cause analysis of the situations that did not go so well (safety-I approach); the evolution from Safety-I to Safety-II mind set is explained by several contemporary authors (Hollnagel 2014; Bastan et al. 2019; Wang, Tian, and Lin 2020).

The main objective of this study was to verify the system's applicability and its potential to be a useful tool to complement OHS management systems. To this purpose, a pilot implementation of the SSP system was carried out in three manufacturing companies of different business areas (cement, food & beverages, and production of synthetic fibres/chemical industry). Such pilot run was designed to test SSP applicability and face value, namely, its underlying methodology and internal criteria. This meant, among other things, to check if the system had been well designed and customized and find out to what extent the classifications adopted – for infractions categories (9) and subcategories (83) – are adequate to classify the deviations observed in industrial workplaces. On the other hand, this experiment should allow to pinpoint potential limitations, or gaps in the tool, despite its inherent ability to allow customization of the subcategories according to the needs of each company.

2. STUDY DESIGN

The general methodology of this study, concerning the field validation of the SSP system in real industrial contexts, is illustrated in the diagram of Figure 2.

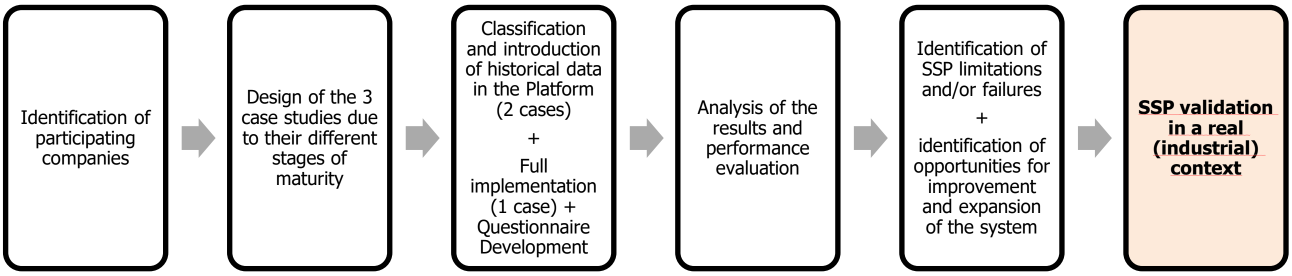

Figure 2. Diagram of the study methodology

Firstly, a few industries were invited to run a trial implementation of the SSP system and its associated digital *e*-platform; as a result, three companies from different business activities adhered to this project. Two of them were already using the BBS (Behaviour-Based Safety) methodology in their daily practices (cases A and B) whilst the third company (Case C) did not have any kind of behavioural observations.

Since companies A and B already had a system of behaviour observations, the need for supervision and follow up (by the research team) was not as intensive as in case C. Thus, in these two cases, the relevant information was retrieved directly from the records of *safety observations* (year 2019), provided by companies A and B. These records were analysed and classified (searching for human errors or violations)[2], then the findings were discussed with each company's safety staff, after which the pertinent data were entered into the SSP *e*-platform (i.e., whenever safety violations were involved) to understand to what extent the whole system was able to embrace different industrial environments.

[2] Errors versus Violations – the SSP system adopts Reason's (1990, p.207) definitions and classifications for Safety Violations and Errors (Slips, Lapses and Mistakes)

In the third case (C), conducted in a company without any kind of experience with BBS practices, it was necessary to implement the observational system from scratch – by training observers, following the observations and monitoring the whole process. Just as before, the records of these behavioural observations were then analysed, classified, and introduced in the platform (whenever they were violations) to verify whether all the registered violations fit into one of the 83 infraction subcategories embedded in the SSP system.

In parallel, a similar analysis was carried out in the three case studies for all situations classified as "errors"; this allowed to make a comparative study and, at the same time, to verify if the current subcategories defined on SSP system could also cover these situations (i.e.; *slips, lapses and mistakes*).

Additionally, in case C, the authors developed a short questionnaire to analyse the workers' perception about the safety practices currently in place. This was a rather "informal instrument" to allow the authors (external people) gaining a first insight on the robustness of this company's state of affairs regarding safety, since they had no experience with BBS observations.

Overall, the three case studies were expected to provide a realistic basis to identify limitations of the SSP system, especially to learn if its safety infractions' categories and subcategories are appropriate and sufficient when SSP is implemented in a variety of industrial environments. Possible "barriers" to its implementation were also scrutinised. This analysis also looked at opportunities for improvement and expansion of the tool itself.

3. SSP CONCEPT

This section gives background information and a brief description of the SSP system already described in detail in a previous publication (Fundo et al, 2020).

The main idea was to develop a personal safety scorecard system, designed to monitor and improve safety performance of employees at all hierarchical levels, by recognising good examples and active involvement in the one hand, but also by highlighting and discouraging unsafe behaviours. The SSP system is based on the identification and analysis, of both positive and negative contributions to safety, allowing the measurement of the individual and collective safety performance across the whole hierarchy of a company.

Behaviours are assessed by direct observation, either by OHS specialists, or by trained "observers" elected by their peers. Figure 3 depicts the point system; it starts with a virtual e-card with 12 points (where 20 is the maximum achievable) given to all employees of the organization, regardless of their function and position. There are bonus and penalty points, depending on the safe or unsafe behaviours observed, and whether the unsafe are errors or safety violations. The unsafe acts are analysed, since they can pinpoint weaknesses in the existing safety systems and practices of the organization, but only the violations are penalised. This approach strengthens OHS management, by playing an important role in improving risk perception and encouraging safe behaviour.

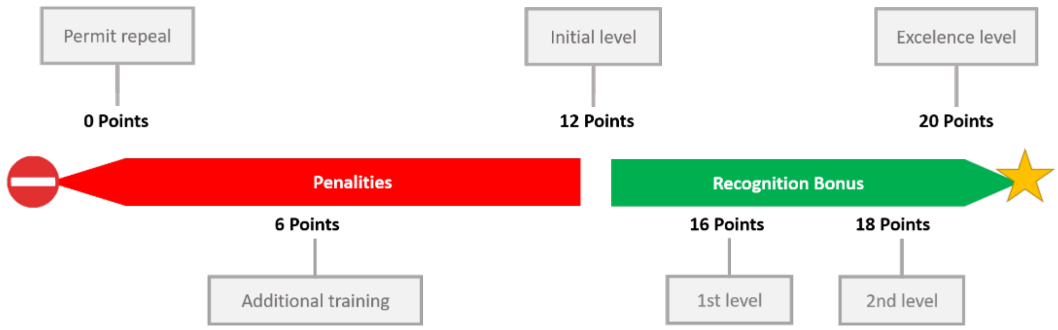

Figure 3. SSP System – scoring levels

The number of points to be removed depends on the seriousness associated with the type of infraction observed: light, serious or very serious, and it also depends on (re)incidence. In addition, the system has a decision tree (decision diagram) to help classifying the infraction either as an error or violation, and to allocate responsibility; responsibility can belong to the worker or to another hierarchy level (e.g.: team leaders, managers) if there is any influence or permissiveness in the practices observed.

The main objective, however, is to boost the safety culture of companies, through a transparent and fair system. On the recognition side, when a worker hits the excellence level (20 points), bonus/rewards must be awarded to highlight recognition for exemplary and proactive performance. There are, therefore, warning signs at different levels to help monitoring performance. Some of these signs are meant to encourage progress towards safety excellence, whilst on the other hand, when things still go wrong, the person can recover and is encouraged to do so. There are clear rules and criteria for both directions (Fundo et al, 2020), but companies can adjust them to meet their own policies on penalties and rewards.

The SSP scorecard applied to OHS brings innovation by introducing a new safety tool that merges together the benefits of other recognised good practices, namely the BBS approach (which is regaining notoriety), the general scorecard systems (which give an objective measure of performance), and the road safety point system (which allows establishing behavioural goals). Moreover, the electronic facet (e-platform) allows monitoring performance in real time.

The SSP system is materialised through an e-platform, which allows the input of data, its classification, and the management of points. As already mentioned, the SSP establishes 83 types of infractions., which in turn are clustered into nine main categories or classes, each one characterising main types of deviations (Figure 4). The 83 subclasses can be customised and adapted to the type of processes and requirements of each organization.

Figure 4. SSP Classification Categories/Classes

For illustrative purposes, a couple of examples are, for instance:

- "Protection Measures" main category:
  - ✓ Remove/disable alarm systems from an equipment (Very Serious infraction).
  - ✓ Not putting back the protective barriers (covers), after maintenance activity (Serious infraction).
  - ✓ Not complying with a safety sign (Light infraction)
- "Communication" category:
  - ✓ Not reporting the use of a fire extinguisher (Very Serious).
  - ✓ Not identifying/tagging a machine that breaks down or shows any abnormality (Serious infraction).

At the organizational level, it is expected that the use of this system may assist in the follow-up of management strategies/efforts towards better safety. At the individual level, it should leverage and reinforce positive attitudes and, subsequently, reduce the number and the severity of work accidents and work-related ill-health that frequently have a considerable weight on avoidable costs.

4. CASE STUDIES

As explained before (Section 2), the trial testing and practical validation of SSP was carried out during 2020 in three companies that agreed to participate. The main characteristics of these companies are summarised in Table 1.

Considering that two of the participating companies (cases A and B) already had a process of Safe Behaviour Observations (SBO) and given the many restrictions due to the corona virus pandemic during this period, it was decided to carry out this validation study using the 2019 SBO records of both companies. Moreover, in 2020 there was a smaller number of records due to prophylactic isolation, teleworking and “mirror teams”. Thus, the companies made their 2019 records available for analysis.

In the third case study (case C), however, the company did not have any SBO process and, therefore, it was necessary to initiate and monitor the whole process regarding this trial implementation. On this occasion, the research team had to start with the training of "internal observers" and to monitor the creation of SBO records, from where to launch the analysis step.

By this way it was possible to test whether the situations found fitted into one of the 83 typified subcategories or, if not, in which (new) subcategories should be added to the system to meet the needs of the company under analysis.

Table 1. Overview of the three companies participating in the study

	Sector	No. of employees	Certifications	Management Tools	SBO Process
Case study A	Food and Beverage Industry	159	**ISO 9001:2015 ISO 22000: 2018 ISO 14001:2015 ISO 45001:2018**	Preventive safety dialogues Preventive Observations System Suggestions by employees evaluation system Incident reporting system Unsafe conditions reporting system	Yes
Case study B	Cement Industry	111	**ISO 9001:2015 ISO 14001:2015 ISO 45001:2018**	Preventive safety dialogues SBO system Incident reporting system System for reporting unsafe conditions and behaviour	Yes
Case study C	Synthetic fibres industry	288	**ISO 9001:2015 ISO 50001: 2011**	*Gemba Walk*; Safety Minute; Accident /unsafe conditions reporting	No

5. RESULTS

5.1 Overall Results

Based on the records made available by Company A and B and the records collected directly at Company C, the safety deviations found (all unsafe acts and conditions) were classified either as Error, or Safety Violation or Unsafe Condition; then the errors and violations (infractions) were classified by class and subclass to verify if all infractions fitted, or not, in the system’s taxonomy. It is important to note that, although Reason's (1990) classification distinguishes between three basic types of error, on this occasion all lapses, slips and mistakes were grouped into a single group called Errors. The results obtained are shown in Figure 5. The good and safe practices observed were also registered.

On the right hand side of the figure, the SSP main categories are shown, indicating the number of deviations observed in each category. The red squares indicate that, in the corresponding infraction categories, there were a number of situations which did not fit into any of the pre-existing subcategories; in such cases, a new subcategory was created to allow registering the new type of deviation observed.

In case A, of the 104 deviations classified as errors and safety violations, 82 were easily registered into the e-platform using the taxonomy structure already typified in the system. The remaining 22 situations fitted in terms of main classes but required a more rigorous analysis at the subcategory level.

In case B, where a total of 188 deviations were identified, there was a sub-total of 138 situations that fell neatly into one of the SSP subcategories. The remaining 50, associated with deviations of a different nature, were analysed separately and inserted in new subclasses.

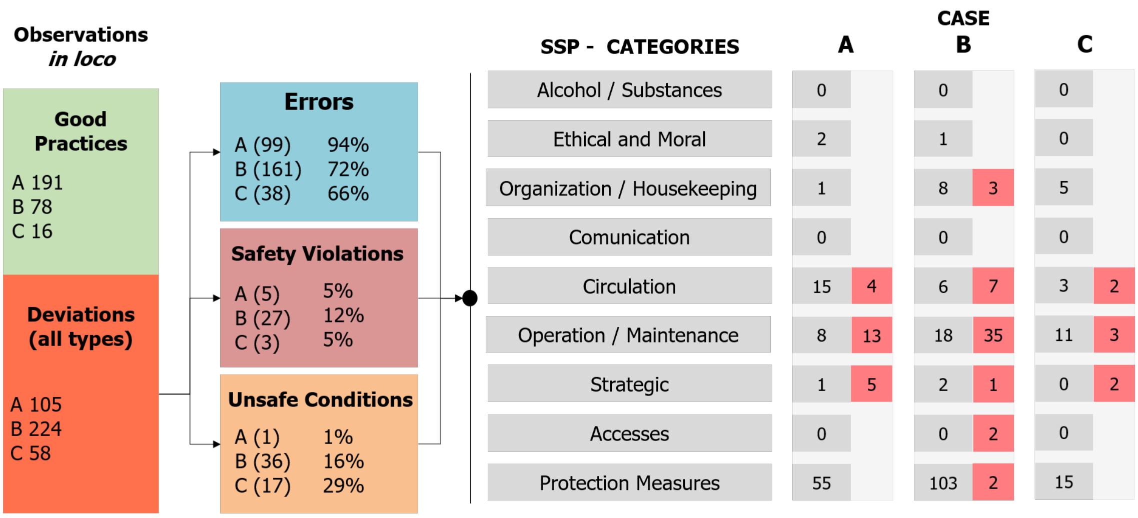

Figure 5. Classification and categorisation of Safe Behaviour Observations (SBO)

Finally, in case C, 41 deviations were found in total (amongst errors and safety violations); of these only seven situations had no direct correspondence and needed further analysis.

Lastly, all non-typical deviations that required the creation of new subcategories, were analysed. A few examples of such new subclasses are:

- Working alone in dangerous situations without "dead man's switch" - included in the Strategic category;
- Non-compliance with mandatory requirements when carrying out special work/increased risk - placed in the Operation/Maintenance category;
- Failure to park or stop vehicles and equipment only in areas defined for that purpose – included in the Circulation category.

5.2 Analysis of the Robustness of OHS practices - Case C

In the case of company C, where it was possible to develop the whole process, from the training and implementation phase to the real-time monitoring, it was decided to extend the study with a pre-assessment of current practices; the aim was, above all, to assess the perception of workers regarding OHS management. This way, in the future (say a 2-year period) it will be possible to re-evaluate and understand the impact of SBO practices, as well as the use of an OHS performance measurement tool, and what effect this may have had on the main indicators, namely on accidents.

The use of maturity models, viewed as especially opportune in this study, allows to identify the strengths and weaknesses of the practices/systems implemented. From a Safety point of view, it was considered useful to understand to what extent the OHS requirements, procedures, practices, etc., are consolidated in a company, since it may influence its organizational performance.

For this additional study, a questionnaire was developed as a support instrument to assess the workers' knowledge and perception of occupational safety and health practices. This (anonymous) questionnaire is presented in Annex. It has 20 questions addressing various aspects of current OHS practices structured into five dimensions, ranging from risk management, training, resources, and communication, to management's involvement and leadership. To keep a "manageable size", it is not an exhaustive questionnaire, but its main objective was to make a preliminary evaluation on the robustness of the OHS situation to identify this company's maturity stage, having the Bradley Curve as a reference (Jasiulewicz-Kaczmarek, Szwedzka, & Szczuka, 2015).

A total number of 51 answers were received, corresponding to 31% of the workforce in the operational area where the questionnaire was applied. After the treatment and analysis, it was found that OHS practices and systems are perceived differently by the various respondents, but it could be inferred that the robustness of OHS practices seem to be in a transition phase, from the Dependent state (where active supervision is needed) to the Independent state (where the individual is already autonomous). These results indicate a positive perception of management commitment with safety issues, the sense of being recognised, concern for working conditions, adequate training and the existence of procedures that help gain knowledge and skills that allow workers to move towards autonomy, with growing concern and awareness to take care of themselves. Figure 6 shows the Bradley Curve (Jasiulewicz-Kaczmarek et al., 2015) together with the relative distribution of the results for each maturity state.

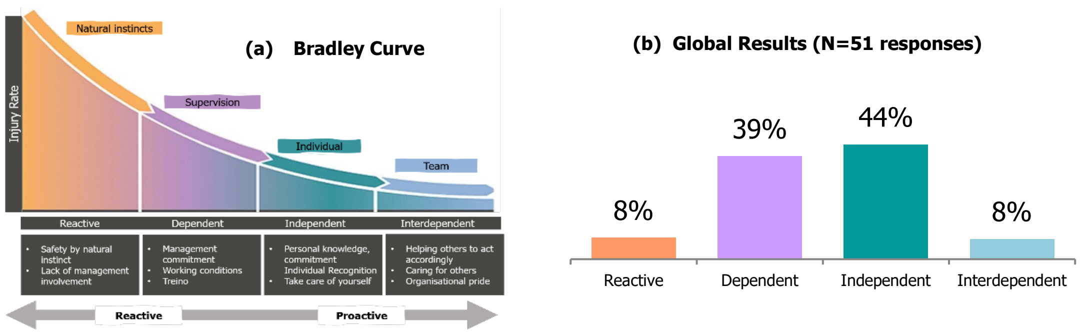

Figure 6. (a) Bradley Curve and (b) data obtained on the robustness of current OHS practices and systems in case study C

The five dimensions under scrutiny were also treated separately to identify which aspects contribute more to the relative distribution found at the different maturity levels (Figure 6b). This new step allowed to find out where the company's OHS system and practices can be improved further. The goal is to increase its robustness and push forward its maturity, thus, evolving from the current stages (dependence and independence) towards interdependence.

At each of the five dimensions, the stage identified was as follows:

- Training, Resources and Leadership – Dependent Stage
- Risk Management and Communication – Independent Stage

In any organisation, the key aspects for improving the robustness of OHS practices (and consequently reduce accidents), are proper risk management, effective risk communication, and training. These management functions give workers a better understanding of their workplace; at the same time, also provide them the necessary resources to perform their tasks, whilst promoting visible leadership and participatory communication.

In this sense, and despite company C having some OHS tools – such as risk charts posted at the workplaces, the weekly safety minute, the reporting of unsafe conditions and improvement suggestions, or the reporting of near misses – it is still necessary that the company stimulates an adequate communication/feedback and also that workers feel a closer relationship with managers to create a climate of trust and commitment.

6. CONCLUDING REMARKS

This study was developed with the main purpose of verifying the suitability of the Scored Safety Permit (SSP) tool. A pilot implementation in industrial environments was designed to perceive the applicability of the whole tool (i.e., the SSP system and its e-platform) in real situations, and to validate the classes and subclasses – i.e., the list of infractions – already existing and typified during the design of the system itself.

The practical validation of SSP was based on records of Safe Behaviour Observations (SBO) from three companies that agreed to participate in the project. However, the process was not uniform in the three cases, given the visiting restrictions imposed by the pandemic situation. There was, therefore, a need for adjustment of the project in two of the participating companies (cases A and B). In these cases, to reduce physical presence, and considering that both already had SBO processes, the validation of the SSP system was based on historical SBO records (year 2019), with no direct intervention of the research team in the collection of such records. In turn, in case C, a closer interaction was established throughout the project, since the process was initiated from scratch, including the implementation of SBO, its monitoring and subsequent analysis, to create the necessary conditions for the implementation and validation of the SSP system.

Despite the limitations mentioned above, it was possible to test the tool through the three cases, which allowed to assess and consolidate the practical side of SSP, as well as the methodology "embedded" in the system and the associated criteria. Moreover, these case studies allowed to reveal certain gaps in the system and also to identify opportunities for further improvement.

The results obtained over the trial period (app. 6 months) were quite satisfactory, in the sense that all the situations observed could be inserted, and classified, within the existing nine classes (or categories) of infractions in the SSP’s taxonomy. By contrast, in all three cases, the same “neat fit” was not verified at the level of the 83 subclasses (also typified in the system and respective e-platform), though the percentage of deviations that did fit was higher. Therefore, at subclass level, some items were added into the original list, to obtain a complete association. Twenty-nine new subclasses were added to the 83 pre-existing ones.

In any case, the above findings were not exactly a problem, since the system is “open” and it can be customised at subclass level, thus allowing companies to adjust it and make changes, i.e., they can add or remove, at any time, subcategories from the SSP electronic platform, according to the specific needs of each organization. The fact that these changes can be easily carried out makes the system quite versatile in terms of software suitability. In addition, two improvement opportunities were found for future work: to allow customisation of the main categories, and also of the taxonomy itself; such freedom would allow users to fully adapt the SSP to the “common terms” used in each company. Although terminology is not a limiting factor, introducing this flexibility, would certainly favour integration efforts with other systems.

Another improvement opportunity was identified during the study. As it is, the SSP is designed to value positive behaviours and active involvement (points gained), while still keeping track of negative deviations (points lost). At the moment, only conscious safety violations are recorded into the system, leading to lost points. However, the findings showed that a large majority of “unsafe acts observed” are errors (either slips, lapses, or mistakes), rather than violations. The “errors” can also be incorporated in the SSP database (separate from the points system), thus adding valuable information to identify other types of OHS weaknesses. Knowing all types of errors will help to pinpoint training needs of workers, to recognise ineffective practices and rules and, on an ongoing basis, to measure and monitor whether the established strategies and targets need to be adjusted.

The authors believe that SSP leads to the demystification of safety as an excess of requirements and rules, promoting a working environment with involvement and participation of all parts and encouraging the creation of a climate of trust and strengthening communication between the various hierarchical levels.

ACKNOWLEDGEMENTS

The authors are grateful to the three companies participating in the study. This work is part of a P2020 Project with financial support from FEDER (Ref: LISBOA-01-0247-FEDER-038309). Recognition is also due to Fundação para a Ciência e a Tecnologia (FCT-MCTES) for its support via the project UIDB/00667/2020 (UNIDEMI).

Conflict of Interest: No conflict of interest is declared.

REFERENCES

Bastan, Ondrej, Petr Fiedler, Tomas Benesl, and Jakub Arm. 2019. Redundancy as an Important Source of Resilience in the Safety II Concept. IFAC-PapersOnLine 52(27):382–387. doi: https://doi.org/10.1016/j.ifacol.2019.12.690

Choudhry, Rafiq. 2014. Behavior-based safety on construction sites: A case study. Accident Analysis & Prevention 70:14–23. doi: 10.1016/j.aap.2014.03.007.

Elsier Dietmar, Jukka Takala, and Jouko Remes. 2017. An international comparison of the cost of work-related accidents and illnesses - Safety and health at work - EU-OSHA. Retrieved February 2021 https://osha.europa.eu/en/publications/international-comparison-cost-work-related-accidents-and-illnesses/view.

Fundo A., Carrasqueira M., Dias B., Santos J., Antunes D., Dias J., and Jacinto C. 2020. Safety Score Permit (SSP) to Enhance Safety Performance. In: Arezes P. et al. (eds) Occupational and Environmental Safety and Health II. Studies in Systems, Decision and Control, vol 277. Springer, Cham. https://doi.org/10.1007/978-3-030-41486-3_1.

Goh, Yang Miang, Chalani U. Ubeynarayana, Karen Le Xin Wong, and Brian H. W. Guo. 2018. Factors Influencing Unsafe Behaviors: A Supervised Learning Approach. Accident Analysis & Prevention 118:77–85. doi: 10.1016/j.aap.2018.06.002.

Guo, Brian H. W., Yang Miang Goh, and Karen Le Xin Wong. 2018. A System Dynamics View of a Behavior-Based Safety Program in the Construction Industry. Safety Science 104:202–15. doi: 10.1016/j.ssci.2018.01.014.

Hollnagel, Erik. 2014. Is Safety a Subject for Science? Safety Science 67:21–24. doi: 10.1016/j.ssci.2013.07.025.

Jasiulewicz-Kaczmarek, Malgorzata, Katarzyna Szwedzka, and Marek Szczuka. 2015. Behaviour Based Intervention for Occupational Safety – Case Study. Procedia Manufacturing 3:4876–83. doi: 10.1016/j.promfg.2015.07.615.

Journeault, M. (2016). The Integrated Scorecard in support of corporate sustainability strategies. Journal of Environmental Management, 182, 214–229. https://doi.org/10.1016/j.jenvman.2016.07.074.

Kalender, Z. T., & Vayvay, Ö. (2016). The Fifth Pillar of the Balanced Scorecard: Sustainability. Procedia - Social and Behavioral Sciences, 235, 76–83. https://doi.org/10.1016/j.sbspro.2016.11.027.

Meadan, Hedda, Shiri Ayvazo, and Michaelene M. Ostrosky. 2016. The ABCs of Challenging Behavior: Understanding Basic Concepts. Young Exceptional Children 19(1):3–15. doi: 10.1177/1096250614523969.

Michalska, J. (2005). The usage of The Balanced Scorecard for the estimation of the enterprise's effectiveness. Journal of Materials Processing Technology - J MATER PROCESS TECHNOL, 162, 751–758. https://doi.org/10.1016/j.jmatprotec.2005.02.227.

Nunu, W. N., Kativhu, T., & Moyo, P. (2018). An evaluation of the effectiveness of the Behaviour Based Safety Initiative card system at a cement manufacturing company in Zimbabwe. Safety and Health at Work, 9(3), 308–313. https://doi.org/10.1016/j.shaw.2017.09.002.

Reason, James. 1990. Human Error. Cambridge University Press, UK. ISBN 0-521-31419-4.

Roy, Sandip, and Ankit Gupta. 2020. Safety Investment Optimization in Process Industry: A Risk-Based Approach. Journal of Loss Prevention in the Process Industries 63:104022. doi: 10.1016/j.jlp.2019.104022.

Santos, João. 2019. Development of an individual safety performance evaluation tool. MSc Thesis on Industrial and Management Engineering, NOVA School of Science and Technology, Universidade NOVA de Lisboa, Portugal (thesis available online in Portuguese).

Tappura, S., Sievänen, M., Heikkilä, J., Jussila, A., & Nenonen, N. (2015). A management accounting perspective on safety. Safety Science, 71, 151–159. https://doi.org/10.1016/j.ssci.2014.01.011.

Wang Feng, Jin Tian, and Zheying Lin. 2020. Empirical Study of Gap and Correlation between Philosophies Safety-I and Safety-II: A Case of Beijing Taxi Service System. Applied Ergonomics 82:102952. doi: 10.1016/j.apergo.2019.102952.

Annex A - Questionnaire

Occupational Health and Safety (OHS) Questionnaire

Preliminary Note: This brief questionnaire is completely anonymous and its main objective is to support a preliminary study on the robustness of the OHS system and practices in place.

Individual Information - Sample Characterisation

Gender	**F**	**M**			
Age range	<25 years	26-35	36-45	46-55	>55 years
Level of education	Basic (4 years)	Intermediate (9 years)	High School (12 years)	University	
For how long have you been working in your current company?	<1 year	1-3	4-6	7-9	>10 years
In how many companies in this sector (or a similar activity) have you worked?	1	2	3	>4	
Hierarchy Level	**Operational** (e.g. production, maintenance, warehouse, valet, etc.)	Supervisor / Shift leader	**Middle management** (e.g: Senior Officer, Area or Department Coordinator, etc.)	**Senior management** (e.g. Director or equivalent, CEO, Chairman)	

In your opinion, with regard to OHS-related situations, do you consider that:	1 **NEVER happens**	2	3	4	5	6 ALWAYS **happens**
1. Does the company care about OHS issues?						
2. Does the company take quick action(s) to solve/control unsafe situations?						
3. Are you informed, periodically, about the existing risks in your workplace?						
4. Does the OHS training, provided by the company, meet the needs of your work?						
5. Does the company give you enough technical knowledge to perform your tasks?						
6. Do you have adequate tools to perform your tasks?						
7. Are the personal protective equipment (PPE) adequate to perform your tasks?						
8. Do you consider that your workplace (lighting, noise, dust) meets existing regulations?						
9. Is there a good working relationship with your colleagues, supervisors, managers, etc.?						
10. Do you have the necessary conditions to perform your work safely?						
11. Is there an internal system for communicating dangerous occurrences and accidents occurred in the plant?						
12. Do you usually inform your supervisor/manager when you find any unsafe/hazardous situation?						

13. Is there a reporting system/procedure for communicating risk situations/improvement suggestions?						
14. Do workers receive feedback about the situations they report/suggest?						
15. Is the discussion and solution of problems done only between managers and supervisors?						
16. Is the discussion and solution of problems done/shared with the whole team (workers and managers)?						
17. Is OHS management dealt together with other aspects (e.g. Production, Process, Quality, Environment, etc.)?						
18. In your opinion, the responsibility to solve OHS situations belongs solely to the company's OHS Technicians/experts?						
19. Is there a process to sanction non-compliances with OHS rules and requirements?						
20. When it comes to strategic decisions in your work area, do you think that OHS issues are (also) taken into account?						

Please turn over the page →→→

Comments (fill in, in case you want to specify or share any situation related to the questions of the survey, or others you consider relevant)