

## A disruptive approach to non-technical skills and situational awareness competencies

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### Abstract

Research has shown that lack of non-technical skills contributes to most safety incidents in high-risk industries. Situational awareness is the most influential non-technical skill. Authors developed a disruptive program to generate situational awareness competencies and improve employees' non-technical skills. The process is called: Permanent Attention.

The program combines best practices from high-risk industries and industrial psychology science to generate statistically significant improvements in situational awareness competencies through a sustainable and cost-effective approach. The paper shows real case applications from organizations where the program has generated significant improvement in the participants' competency acquisition and retention.

The Permanent Attention program is executed with the learner at the centre of the competency acquisition and retention process. The Situation Awareness Global Assessment Technique (SAGAT) is used to measure the levels of competency before and after the training and determine the impact of the program. Statistical models are used to demonstrate the significant impact of the process in the three elements of situational awareness: Attention, Comprehension and Anticipation.

The training sessions in-between SAGATs use gamification to practice attention, comprehension, and anticipation skills. Simulations of critical operational situations complement the training, so employees practice their leadership, communications, teamwork, decision-making skills in group and learn how to manage stress in such situations.

Two case-studies are presented in the paper, Latin America and the Middle East.

### Keywords

Human Performance, situational awareness, human factors, statistical significance, high risk industries, andragogy, instructional design, crew resource management, non-technical skills, teamwork, leadership, communications, decision making, stress, fatigue, personal safety, process safety, service quality, reliability, risk management, repeated measures statistical model, adult learning, situation awareness global assessment technique, attention, comprehension, anticipation, competency, disruptive solution.

## 1. Introduction

Research has shown that lack of non-technical skills contributes to most personal and process safety incidents in high-risk industries. Non-technical skills are also called ‘crew resource management’, or CRM in the aviation and oil and gas industries. CRM encompasses six skills: leadership, teamwork, communications, situational awareness, decision-making, and performance shaping factors, such as fatigue and stress.

Situational Awareness is the most influential non-technical skill, as it impacts all other skills and is determinant in the quality of the decision-making process. Authors developed the Permanent Attention program to generate situational awareness competencies and improve non-technical skills of front-line employees.

‘Permanent Attention’ is an elegant approach to manage employees’ non-technical skills. It combines science and hands-on experience to master employees’ skills, which are measured both in terms of competency improvement and business impact. Truly disruptive’

Juan Carlos Lopez

The program combines industrial and organizational psychology science and best practices from high-risk industries to generate statistically significant improvements in non-technical skills through a sustainable and cost-effective approach. The ‘Repeated Measures’ (Field, 2018) statistical model is used to demonstrate the significance of the program. Knowles’ andragogy theory (2015), instructional design and gamification were used to structure an interactive and enjoyable learning experience for the students, based on learning-by-doing and learning-by-playing.

The program starts with the measurement of a competency baseline. Authors adapted Endsley and Garland’s (2000) Situational Awareness Global Assessment Technique (SAGAT) to establish employees’ initial levels of competency against the three elements of situational awareness: attention, comprehension, and anticipation.

After measuring the individual and group initial levels of competency through a pre-training SAGAT, employees take an interactive training given by expert facilitators in two stages: 1) theoretical concepts practiced in the classroom (virtual or presential), and 2) simulation of work-related crises. Once employees finish the training, a post-training SAGAT is conducted to determine the impact of the training with a statistically valid model, designed to compare the levels of competency of the individual and the group before and after the training. SAGAT is then repeated periodically to ensure competency attainability.

The uniqueness and disruptiveness of this approach comes from integrating best practices from high-risk industries and scientific principles from organizational psychology to improve non-technical skills competencies and measure its impact in terms of competency acquisition, attainability, and organization’s human performance.

The paper prepared for the ORP Conference 2023 shows two case studies from organizations where the Permanent Attention program has generated significant improvement in the participants’ situational awareness competency improvement and retention. Authors acknowledge that the time it takes to get measurable business impact is the main limitation of the paper to date. The presentation at the conference will include updated results.

## 2. Method:

### 2.1 Why Situational Awareness and non-technical skills

A long-lasting management belief states that one can only manage what one can measure. The extensive experience of the authors and the academic studies they have done in human performance, confirms that non-technical skills are far from being managed using scientific and statistically valid and reliable models.

Research shows that non-technical skills – or lack of them – contribute to most personal and process safety incidents in high-risk industries (ATSB, 1999, Manna, 2007, Airbus, 2007). Authors have experienced frustration because they know what the problem is (e.g., human error), invest time, money, and effort in tackling it with campaigns and programs, and get unreliable, inaccurate, and unsustainable results. In fact, authors have experienced that after having implemented a multi-year program, employees fail to attain non-technical skills, and performance becomes a vicious cycle, in which the preventative intervention elicits human performance improvement for some time, and once the campaign is finished, awareness drops, and safety and service quality incidents come back.

The huge negative impact of human errors in the performance of authors' organizations, and the lack of sustainability of preventative programs, elicited their interest in developing a methodology that combines scientific research in organizational psychology, and pragmatic evidence from experience.

This is, in the authors' belief, a complex problem that required a disruptive approach. An approach that is adaptable to different business scopes, is practical and affordable, and -above all- is sustainable.

### 2.2 Permanent Attention is based on scientific research

The authors used two main references to design a practical and scientifically sound method. The first source of knowledge is the extensive work done by Doctors Endsley and Garland in this specific area, in the aviation industry and other high-risk industries, such as the army, medical practice, nuclear and chemical (Endsley and Garland, 2000). Their rigorous research allowed them to develop a repertoire of measurement techniques, focused on situational awareness, as it is the non-technical skill with the most influence in human performance. They describe these techniques in their book 'Situation Awareness Analysis and Measurement' which is extensively used in airlines to generate and attain pilots and control tower agents' non-technical skills.

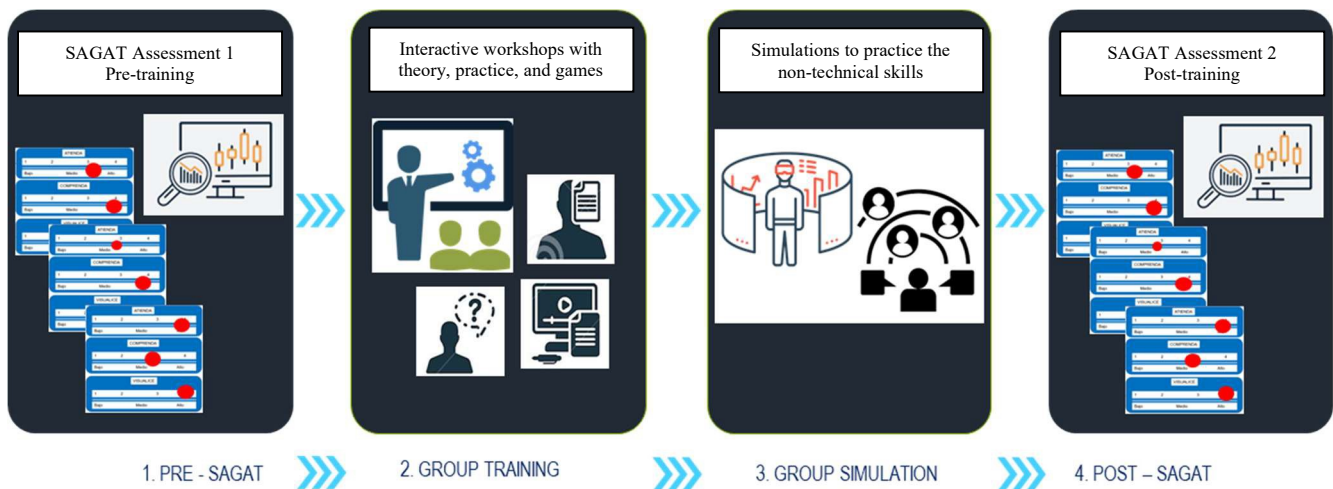
The reference author of the paper represented the largest oilfield services company in the IOGP Human Factors Sub-committee between 2012 and 2021. This sub-committee worked on adapting the aviation crew resource management experience to the oil and gas industry, which resulted in the IOGP Report 501, Crew Resource Management in Well Operations (2020).

The reference author was also the 'Applied behavior science subject matter expert' in this oilfield services company for the last ten years. Under the coaching from PhD Human Behavior Professors from the University of Nevada, Reno, he conducted in-house quasi-experimental research. His master's in organizational and industrial psychology at Harvard University allowed his team to combine science with experience and create pragmatic solutions to improve human performance. Permanent Attention was developed out of this academic and hands-on experience.

### 2.3 Permanent Attention process: learning while doing (and playing)

The training uses Knowles’ adult learning theory, also known as andragogy (2020). It follows instructional design practices that puts the learner at the center of the competency acquisition and retention. Simulations allow team-based practice of the non-technical skills using scenarios strongly related to the daily challenges faced by the students in their workplace.

In practical terms, andragogy means that instruction for adults needs to focus more on the process and less on the content being taught. Strategies such as case studies, role playing, simulations, and self-evaluation are most useful. Instructors adopt a role of facilitator or resource rather than lecturer or grader.



Graphic 1 – Instructional Design of the Program

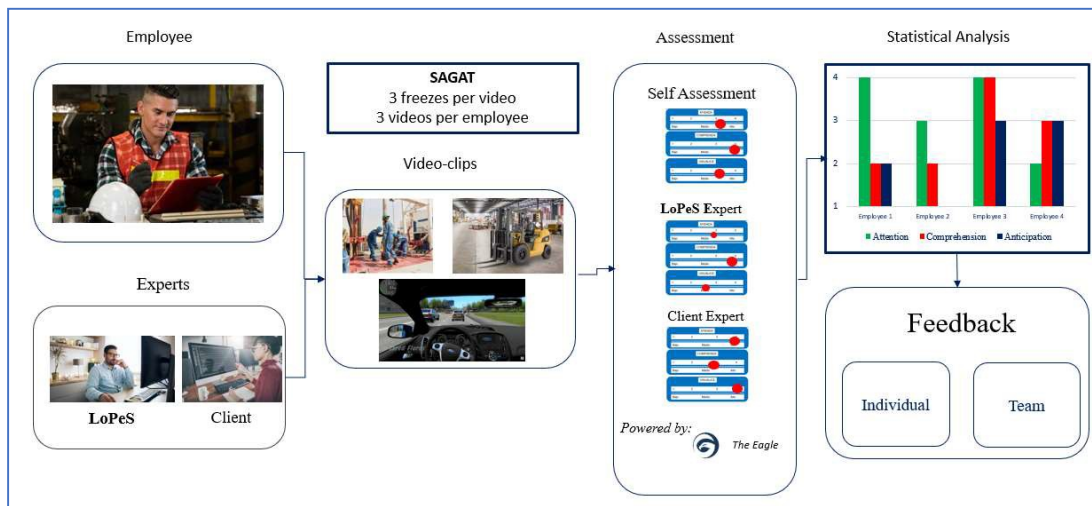
A disruptive element of the competency assurance program is the use of the Situation Awareness Global Assessment Technique (SAGAT) recommended by Endsley and Garland. Students’ levels of situational awareness competency are measured before and after the training, to determine whether a statistically significant impact was achieved through the program.

SAGAT is administered through a fit-for-purpose digital platform. The assessment is presented to the employees as a game, to put them at ease and enjoy the experience. Research has demonstrated that adults learn faster and retain longer when the knowledge is acquired through joyful experiences (Knowles, 2020).

Video clips extracted from regular operations are shown to the delegates who are asked to demonstrate their attention, comprehension, and anticipation competencies by using verbal narrative. Company and consultant experts freeze the videos at pre-defined moments to ask questions and judge the levels of situational awareness of the student, which are scored in the fit-for-purpose platform. The delegate is also asked to self-assess his/her level of competency, which is an effective mechanism to motivate improvement.

At the end of the SAGAT exercise, an individual and confidential report is given to each employee with recommended improvement actions. Team-based reports are also generated by the platform, including statistical analysis and recommendations to improve organizational behavior (Lopez et al, 2021).

Graphic 3 shows the SAGAT workflow used to measure situational awareness competencies before and after the learning experience to determine whether a statistically significant improvement was achieved individually and within the work teams.



Graphic 2 –Situational Awareness Global Assessment Technique

### 3. Case results and discussion of results

Two case studies are presented to exemplify the effectiveness of the Permanent Attention solution. Authors selected one case from the Middle East and one from Latin America, which are the most advanced applications to date and allow a comparison from the statistical standpoint. The ‘repeated measures’ statistical model was selected to verify statistical significance, using the Spearman coefficient.

#### 3.1 Case Study 1 – Saudi Arabia

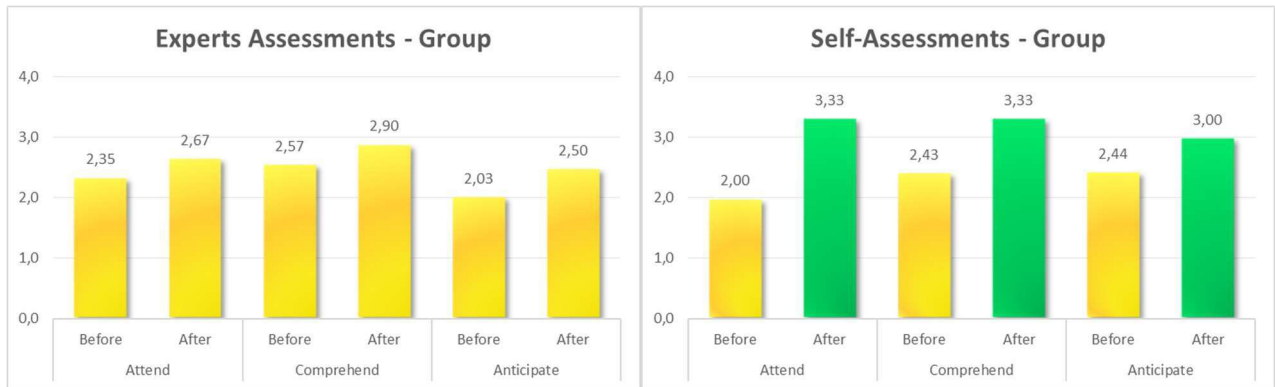
The largest drilling company in Saudi Arabia, with a fleet of over 45 drilling and workover rigs has initiated the Permanent Attention competencies program, as part of a multi-year human performance improvement project. The company has more than 55 years of operations and has developed a mature integrated management system. Top management is leading a transformation initiative, aiming to expand operations across the Middle East. They adopted the human performance improvement project as a key pillar to achieve the corporate vision of excellence.

The project started in September 2022 with the selection of future trainers within the organization. The training materials were adapted to the company operations, including video clips and the use of a state-of-the-art drilling simulator.

##### 3.1.1 Group Results:

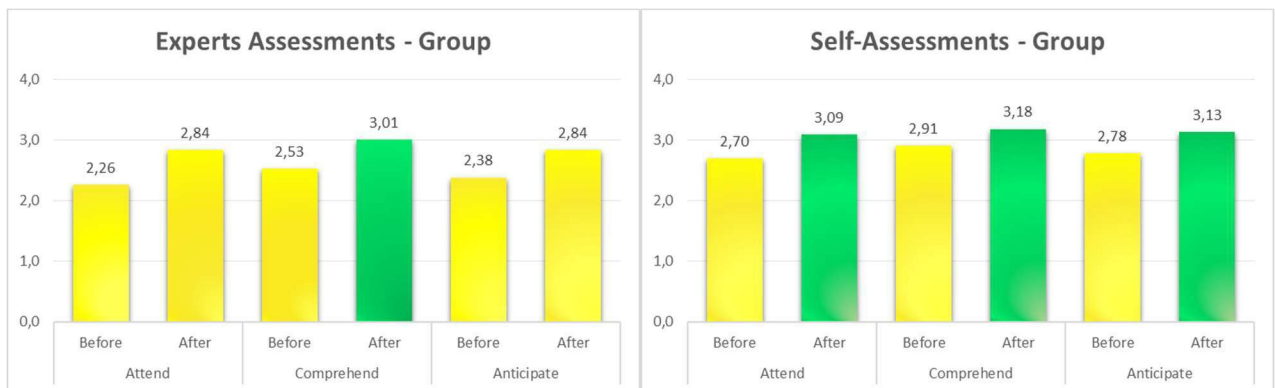
Authors used SAGAT to measure the competency of 14 trainers and 23 employees. An overall improvement of 40% in the situational awareness levels of competency has been achieved for trainers and employees by the end of February 2023. Data will be updated for the presentation at the Conference in April.

The first Train the Trainers session was conducted in November 2022. Graphic 3 shows the results for the group of trainers. Columns show the levels of situational awareness competencies before and after the learning experience as the feedback was presented in the same language of the trainees (Arabic Language). As seen in the graphic, based on the results of both the self-assessments and experts’ assessments, all Situational Awareness elements improved significantly. A remarkable average improvement of 42% was measured for the group of trainers.



Graphic 3 – Results for the Group of Trainers

As for the three groups of employees trained until the end of February, an overall average improvement of 21% has been achieved. Graphic 4 shows the results for the three groups of employees combined.



Graphic 4 – Results for Employees Trained

### 3.1.2 Individual Results

Using the SAGAT assessments done by the experts, data shows that 90% of the employees who have taken the training improved the three elements of situational awareness competency, 5% maintained the same overall level before and after the training, and 5% showed a lower level of competency in the post-training SAGAT.

SAGAT assessments will be re-scheduled for the ones who did not show improvement in their levels of competency three months after the training, to reinforce the knowledge. Employees who showed an improvement in the three elements will repeat the SAGAT one year after the training to ensure attainability and sustainability of the competencies.

### 3.2 Case study 2 – Colombia

A global leader in drilling and technology services in the oil and gas industry decided to implement a pilot project of the Permanent Attention solution in Colombia. The company operates in more than 20 countries around the world, owns the world's largest fleet of onshore drilling rigs and has a sizeable fleet of offshore drilling rigs and workover rigs.

The company has a mature, world-class integrated management system, which has brought a continuous performance improvement over the last two decades. Statistics show that most incidents related to personal injuries, process safety and non-productive times are directly related to employees not detecting change, or not understanding the risk associated with the change, or not anticipating where the situation is leading to.

The objective of the Permanent Attention pilot project is to adapt the solution to the corporate culture, so it can be scaled up to all operations in the world once convincing results are achieved in Colombia.

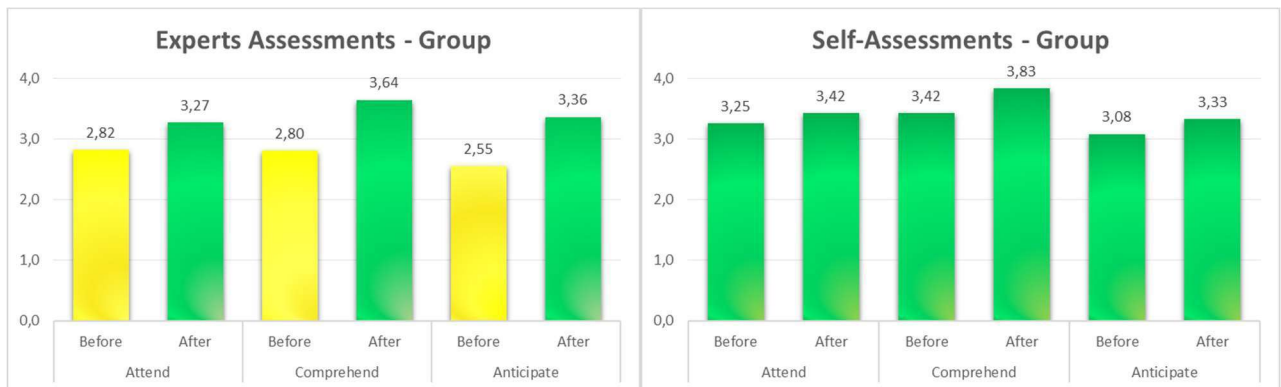
The program began with a call-for-volunteers within the company to participate in the program. Seventeen volunteers applied and were given study material to demonstrate willingness to learn. A knowledge test and professional profile were used to select the final group of candidates. Twelve participants were chosen to participate in the Train the Trainers program.

Training materials were adapted to the company scope, including operational video clips for the SAGAT and a case study. Fourteen videos that record the day-to-day operations on the rigs were selected from a large database and six of them were adapted for the training.

All candidates were assessed using the SAGAT methodology, which is the base line to be used to validate statistical significance using the repeated measures model. The pre-training SAGAT assessments were conducted virtually.

The training modules were practiced by the candidates in a four-day workshop and a state-of-the-art drilling simulator was used to exercise the CRM / non-technical skills of the group.

Once the theoretical-practical training sessions and the simulations were completed, the participants were assessed again by company and consultant experts. Candidates were also asked to self-rate their levels of attention, comprehension, and anticipation.



Graphic 5 – Results for the Group of Trainers

Graphic 5 shows the significant improvements achieved in both the self-assessment and experts' assessments for the group of trainers. SAGAT showed a 10% average improvement in the trainees' self-assessments. Feedback was presented in the same language of the trainees (Arabic and Spanish). More noticeable was the improvement assessed by the experts, with a 20% average improvement. Based on the assessments results, all trainees improved the three elements of Situational Awareness. Feedback from the newly certified company trainers was excellent, with a 5/5 rating of the training content, 5/5 rating of the facilitators and 4.9/5 rating of logistics.

The results presented in the paper reflect the progress as of the end of February 2023. A six-months training schedule has been defined to cascade down the knowledge to the entire field population, starting with the drillers and toolpushers, because they have the largest influence in the entire field population. Authors will update the data for the Conference presentation.

### 3.3 Discussion of results

The statistical reliability and validity of the program was verified with the repeated measures ANOVA statistical method. Repeated measures was selected because of the homogeneity of the groups and the repetition of the competency measures before and after the training. In fact, as recommended by Field (2018), 'repeated measures is a term used when the same entities participate in all conditions of an experiment or provide data at multiple points'. It fits well with a linear model. The following null hypothesis was formulated to test the statistical reliability and validity of the model:

Ho: The pre-training SAGAT average is equal to the average obtained in the post-training SAGAT for each group.

Discussion of results from the statistical standpoint are presented for each case-study.

#### 3.3.1 Saudi Arabia Case

Using the Spearman correlation, Saudi Arabia groups of trainers and employees show statistically a significant correlation, with a rho = 89%. This means that there is a strong correlation between the training of the employees (dependent variable) and the SAGAT assessments (independent variable).

As shown in Table 1, based on the Standard Deviations for the Saudi case, there is homogeneous behavior between the training sessions. Also, no outliers were detected.

AD Permanent Attention L2 - 001						AD Permanent Attention L2 - 002					
GRUPO		STANDARD DEVIATION		ARITHMETIC AVERAGE		GRUPO		STANDARD DEVIATION		ARITHMETIC AVERAGE	
		Before	After	Before	After			Before	After	Before	After
Experts	1. Attend	0,15	0,11	2,38	2,96	Experts	1. Attend	0,17	0,13	2,73	2,36
	2. Comprehend										
	3. Anticipate										
Self-Assessment	1. Attend	0,18	0,07	2,81	2,95	Self-Assessment	1. Attend	0,09	0,11	3,02	2,67
	2. Comprehend										
	3. Anticipate										

AD Permanent Attention L2 - 003						Total AD Permanent Attention TTT - 001					
GRUPO		STANDARD DEVIATION		ARITHMETIC AVERAGE		GRUPO		STANDARD DEVIATION		ARITHMETIC AVERAGE	
		Before	After	Before	After			Before	After	Before	After
Experts	1. Attend	0,05	0,07	2,43	2,32	Experts	1. Attend	0,22	0,17	2,44	2,57
	2. Comprehend										
	3. Anticipate										
Self-Assessment	1. Attend	0,14	0,16	2,97	2,29	Self-Assessment	1. Attend	0,21	0,16	2,57	2,57
	2. Comprehend										
	3. Anticipate										

Table 1 – Saudi Arabia Arithmetic Averages and Standard Deviations

Table 2 shows the results of the repeated measures (ANOVA) analysis.

Origin of variations	Sum of squares	Degrees of freedom	average of the squares	F	Probability	Critical value for F
between groups	440,4963	1,0000	440,4963	703,9716	7,17E-145	3,8434
within groups	3006,0075	4804,0000	0,6257			
Total	3446,5037	4805,0000				

Table 2 – Saudi Arabia Repeated Measures Statistical Analysis

Since the results show a p value = 7.17085918904821E-145, which is less than 0.05 for the different groups, the null hypothesis is rejected. This means that sufficient evidence allows analysts to say that there is a statistically significant difference between the average of pre-training vs. post-training SAGAT scores. In other words, it is highly probable that the improvement in the SAGAT scores can be explained by the training and simulations they were exposed to.

### 3.3.2 Colombia Case

Data analyzed for the Colombian group of trainers show a statistically significant correlation, through the Spearman coefficient, with a rho = 84%. This means that there is a strong correlation between the training of the employees (dependent variable) and the SAGAT assessments (independent variable).

As shown in Table 3, based on the Standard Deviations for the Colombia pilot project, there is homogeneous behavior between the training sessions. Also, no outliers were detected.

GRUPO		STANDARD DEVIATION		ARITHMETIC AVERAGE	
		Before	After	Before	After
Experts	1. Attend	0,12	0,14	2,72	3,39
	2. Comprehend				
	3. Anticipate				
Self-Assessment	1. Attend	0,14	0,21	3,25	3,46
	2. Comprehend				
	3. Anticipate				

Table 3 – Colombia Arithmetic Averages and Standard Deviations

Table 4 shows the results of the repeated measures (ANOVA) analysis.

Origin of variations	Sum of squares	Degrees of freedom	average of the squares	F	Probability	Critical value for F
Entre grupos	417,2030	1	417,2030	650,9647	1,09E-120	3,8473
Dentro de los grupos	1021,5940	1594	0,6409			
Total	1438,7970	1595				

Table 4 – Colombia Repeated Measures Statistical Analysis

Since the results show a p value = 1,09143607380468E-120, which is less than 0.05 for the group of trainers, the null hypothesis is rejected. This means that sufficient evidence allows analysts to say that there is a statistically significant difference between the average of pre-training vs. post-training SAGAT scores. In other words, it is highly probable that the improvement in the SAGAT scores is explained by the training and simulations they were exposed to.

#### 4. Conclusions

The Permanent Attention Program has demonstrated a statistically significant improvement in the levels of Situational Awareness competencies of both trainers and employees who have taken the training in Saudi Arabia and Colombia. The repeated measures (ANOVA) statistic model shows a strong correlation between the training of the delegates and the SAGAT assessments.

Dynamic and hands-on training modules using andragogy and instructional design helps students understand the attention, comprehension and anticipation concepts, and practice how to improve these elements. The use of case-studies from the company, simulations and gamification contributes to an enjoyable experience, which impacts the learning and retention of the competencies.

The Train the Trainers approach represents a challenge for the organizations, as trainers are rarely fulltime dedicated to giving the training sessions. In fact, most of them have operational roles that make it difficult to schedule the training sessions. Nonetheless, this logistical difficulty is worth the effort, as drillers, rig managers and toolpushers become excellent trainers due to their expertise in operations and the authority they have in front of the rig crews. It also helps anchoring the best practice into the organization's management system, to grant sustainability of the program and avoid dependency on the consultant company.

The use of scientific research developed by most advanced industries in non-technical skills has been instrumental in creating a program that delivers sustained improvements in the competencies of employees. Time shall demonstrate its impact in business, reflected in less human suffering due to industrial accidents, as has been the case in the aviation and nuclear industries, the military and medical practice.

#### 5. Limitations and recommendations

There is no statistically significant data yet to demonstrate a reduction in accidents and service quality indicators yet. Authors will share further results with the industry, as tangible results come up, in terms of accident reduction and efficiency improvement.

Due to the logistics required to run the program properly, organizations are tempted to challenge the schedules and request changes in the program that can undermine the effectiveness and sustainability of the results. Authors recommend sticking to the scientific rigor associated with the SAGAT assessments and instructional design.

Authors are working on incorporating the VAK learning style /model - Visual-Auditory-Kinesthetic learning model - which uses the different communication channels between the trainers and the trainees. The main advantage of applying the VAK learning style model is that both students and teachers can adjust their behaviors according to their preferences and make their learning and teaching more effective.

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