International Journal of Organizational Leadership 7(2018) 300-308

INTERNATIONAL JOURNAL OF ORGANIZATIONAL LEADERSHIP

WWW.AIMIJOURNAL.COM

Leadership and Organization for the Companies in the Process of Industry 4.0 Transformation

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Keywords:
Leadership, Disruptive Technology, Industry 4.0, Analytical Hierarchy Process, Quality Function Deployment, Smart Factories

Received
16 May 2018

Received in revised form
22 August 2018

Accepted
25 August 2018

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ABSTRACT

The global effect of disruptive technology has brought about huge productivity improvements in manufacturing. The changing and differentiated demand of the customers pushed the industry to improve its production systems in the Industry 4.0 concept to be more responsive to the changing conditions. The increased knowledge level of data science made data analytics possible and more meaningful. There is an urgency in the manufacturing companies to change their technology, knowledge, and workforce skills for the Industry 4.0 understanding in order to stay competitive. The transformation process to the Industry 4.0 concept is a strategic decision and it requires leadership to deploy the strategy all through the organization by training from the top to the bottom of the organization.

Information and communication technology advancements are having a significant impact on a number of economic sectors. Industry paradigms are changing as a result of the availability of connection, networked things, real-time data, and ubiquitous information (Santos et al., 2017).

Industry 4.0 envisions a smart industrial environment in which machines are capable of autonomously exchanging information and regulating one another at a global scale so that cyber-physical systems, the smart factories, can operate independently (Tjahjono et al., 2017).

Leaders have the potential to significantly impact their organizations' performance. According to upper echelons theory, top management's judgments and choices, including their evaluation of the environment, strategic decision-making, and encouragement of innovation, can have a good or negative impact on the organization's success (Tidd & Bessant, 2014, p. 62).

Even with the best of intentions, a lot of product development projects end in failure and result in the release of subpar goods. On the other side, a lack of communication between the various roles engaged in product development leads to a lot of product development projects having a very disorganized process and wasting resources (Matzlera & Hinterhuberb, 1998).

A systematic implementation of Cyber-actual Systems, which closely monitor and synchronize information from all associated perspectives between the actual factory floor and the cyber computational environment. Industry 4.0, the next generation of production, is being ushered in by this trend (Lee et al., 2015)

In their study, Faller and Feldmüller (2015) noted that in order to maximize their own production, regional SMEs require further training in contemporary technologies that enable Industry 4.0 scenarios and techniques.

According to Rennung et al. (2016), the advancement of "Industry 4.0" is becoming more and more prevalent. The project is inadequate and manifests as a problem. Prior studies on the idea of "Industry 4.0" have concentrated on manufacturing settings. The significance of services for the next project is investigated through expert interviews

Customized production is replacing mass production in the manufacturing sectors. Productivity rises as a result of the industries' quick development of production technologies. A new degree of organization and control over the whole value chain of a product's life cycle is known as Industry 4.0, or the fourth industrial revolution, and it is focused on meeting the needs of increasingly customized customers (Vaidya et al., 2018).

Supply chains in the modern world need to be adaptable. The capacity to handle a wide range of products, fulfill short lead times, and respond to a wide range of quantities in order to thrive. Since industrial value creation has seen significant growth in recent years, the capacity to generate value is predicated on an organization's ability to make decisions and execute Industry 4.0 performance initiatives (Velinov et al., 2018).

In this global world, understanding the customers is a must. Pull strategy all through the supply chain must be applied and data should be shared among the upstream. An agile and responsive strategy can only be applied if the customers are listened to. In today's industry, where the growing distance between producers and users is a concern, the Quality Function deployment method links the needs of the customer with design, development, and manufacturing with the Industry 4 concept. This is the only way to survive in this highly competitive world. Digitalization, or so-called Industry 4.0, will help companies to have more responsive operations and supply chains. The determination of the transformation requires a strategic plan and a good organization till the end of the life cycle.

Organization design enables creativity, learning, and interaction, shared vision, leadership, and the will to innovate, appropriate structure, key individuals, effective team working, high involvement innovation, creative climate, external focus, and a clearly articulated and shared sense of purpose stretching strategic intent (Tidd & Bessant, 2014, p. 62). The deployment of this strategy requires the organization of the right trainings. The aim is to increase the understanding of Industry 4.0 all through the organization and to stay responsive and competitive and it can only be done by understanding the customer.

Method

The study was done in four phases:

1. The understanding of the manufacturing firms on Industry 4.0 transformation was measured by the analytical hierarchy process technique. The three groups assigned importance weights to the criteria under industry 4.0.
2. The trainings were performed to the 30 people who had masters and PhDs and they were called academics, to 30 engineers who were called white colored workers and 30 students who were apprentices in the manufacturing company. Later on the three groups' scores on the training were analyzed to find if there was significance in their learning.
3. In the third phase the effectiveness of the training was measured to see if there was a significant difference between before and after the training in the white color workers.
4. The white color workers, who had a good learning from the training, applied Quality Function Deployment (QFD) technique to the customers to bring this customer interface to modern manufacturing and business. Where the growing distance between producers and users is a concern, QFD links the needs of the customer with design, development, and manufacturing with the Industry 4 concept.

When multiple objectives are important to a decision maker, it is often difficult to choose between alternatives. Thomas Saaty's Analytic Hierarchy Process (AHP) provides a powerful tool that can be used to make decisions in situations where multiple objectives are present. AHP has been used by decision makers in many areas including accounting, finance, marketing, energy resource planning, sociology and political science (Winston & Albright, 2011).

The AHP is a theory of relative measurement on absolute scales of both tangible and intangible criteria based both on the judgment of knowledgeable and expert people and on existing measurements and statistics needed to make a decision. The four main steps of the AHP can be summarized as follows (Tzeng & Huang, 2011):

Step 1: Set up the hierarchical system by decomposing the problem into a hierarchy of interrelated elements;

Step 2: Compare the comparative weight between the attributes of the decision elements to form the reciprocal matrix;

Step 3: Synthesize the individual subjective judgment and estimate the relative weight;

Step 4: Aggregate the relative weights of the elements to determine the best alternatives/strategies.

The first step in AHP is to create a pairwise comparison matrix for each alternative on each criterion. The values shown in Table 3 are used in AHP to describe the decision maker's preferences between two alternatives on a given criterion.

Application

Phase 1: The understanding of the manufacturing firms on Industry 4.0 transformation was measured by the analytical hierarchy process technique. Figure 1 shows the hierarchy view of the criteria and sub criteria that are prepared based on the Turkish roadmap for the Industry 4.0 from Tubitak. The three groups were assigned importance weights to the criteria under industry 4.0.

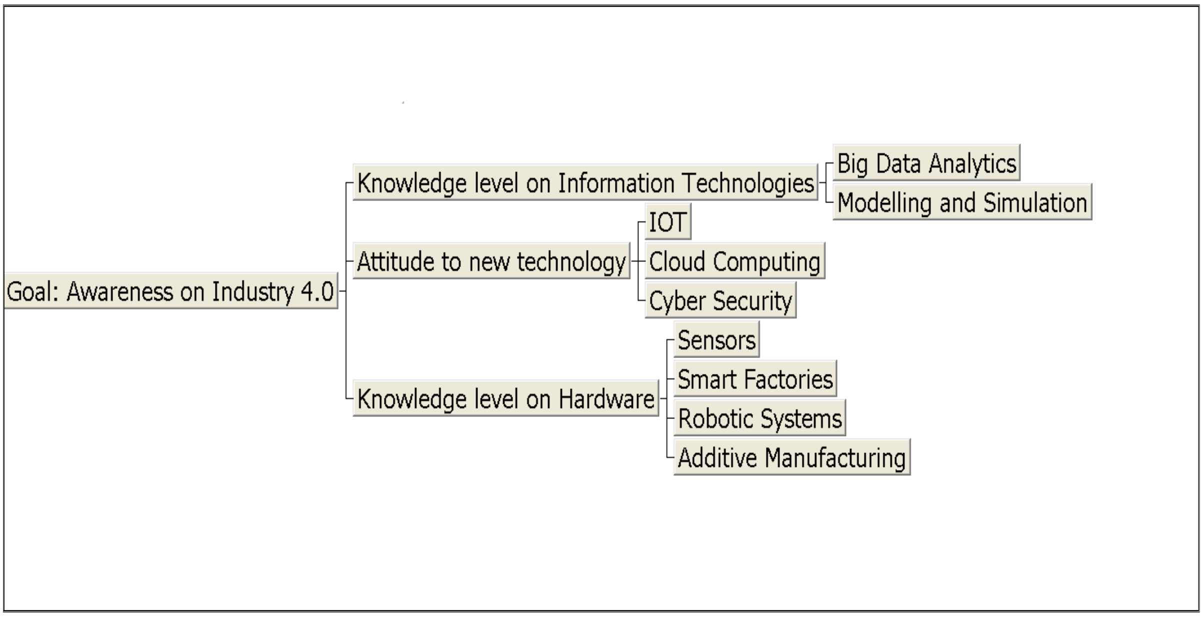

Figure 1. Hierarchy view of the criteria on awareness on Industry 4.0

Pairwise comparisons for the main criteria which are given in the hierarchical view of AHP were calculated. Academic personnel overall priorities for the main 3 criteria "Knowledge level on the information technologies" is .635, "Attitude to the new technologies" is .287, "Knowledge level on hard ware" is .78. Industry white color workers 'overall priorities for the main criteria "Knowledge level on the information technologies" is .487, "Attitude to the new technologies" is .078, "Knowledge level on hard ware" is .435. Students' overall priorities for the main criteria "Knowledge level on the information technologies" is .131, "Attitude to the new technologies" is .561, "Knowledge level on hard ware" is .208. The industry white color workers' overall priorities on awareness for the Industry 4.0 with analytical hierarchy process are presented in Figure 2.

Figure 2. Industry white color workers' overall priorities on awareness for the Industry 4.0 with analytical hierarchy process

Phase 2: The statistical analysis for the comparison of three groups for learning.
The training is applied to the three groups and their learning levels were tested.

Hypothesis for the Test of the Homogeneity of Variances
H_0: There is homogeneity of variances between groups
H_1: There is no homogeneity of variances between groups

Table 1
Test of Homogeneity of Variances

Levene Statistic	df1	df2	p
8.79	2	87	.001

The Comparison of Three Groups for Learning
H_0: There is no significant difference between the learning level of the three groups
H_1: There is a significant difference between the learning level at least at one of the three groups

As shown in Table 2, we reject the null hypothesis. There is a significant difference between the learning level at least at one of the three groups.

Table 2
One Way ANOVA

	Sum of Squares	df	M	F	p
Between Groups	3246.66	2	1623.33	7.62	.001
Within Groups	18513.33	87	212.79		
Total	21760.00	89			

Post hoc tests were conducted to see the difference among the groups. As presented in Table 1, we reject the null hypothesis because the significance values are smaller than the p-value of .005. We conclude that there is no homogeneity of variances between groups; therefore, the Tamhane Test is selected under The Post Hoc tests, as presented in Table 3.

Table 3
Multiple Comparisons

	(I) kategoric	(J) kategoric	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tamhane	Sector	Students	8.33	4.41	.18	-2.54	19.21
		Academics	-6.33	3.04	.12	-13.91	1.25
	Students	Academics	-14.66*	3.70	.001	-23.94	-5.40

The mean difference is significant at the 0.05 level. Dependent Variable is notes after training

In Table 4, means for groups in homogeneous subsets are displayed. It used Harmonic mean Sample Size of 30.00. The students and industry sector are in one group; their learning level is similar but academics learning level is higher. The score of all groups is higher than 70; thus, their learning is good. The white color workers learning effectiveness is in the middle while students and are the lowest but still higher than 70 as a score. The training is more effective on the personnel who had masters and PhDs and the engineers than the trainee students.

Table 4
Homogeneous Subsets

	N	Subset for alpha = 0.05	
		1	2
Students	30	73.00	
Sector	30	81.33	81.33
Academics	30		87.67
Sig.		.092	.249

Phase 3: In the third phase, the differences before and after the training were tested in the engineers' group coded as white color workers.

Hypothesis:

H_0: There is no significant difference in the scores of the group after the training. H_1: There is a significant difference in the scores of the group after the training.

As shown in Table 5, the mean values of the scores are higher; training was performed to the 30 people from the engineers group coded as white color workers. Before training, the mean value was 59.67, while it was 81.33 after training.

Table 5
Paired Samples Statistics

		N	*M*	*SD*	Std. Error Mean
Pair 1	BT	30	59.67	16.07	2.93
	AT	30	81.33	15.02	2.74

Table 6
Paired Samples Test

		M	SD	Std. Error Mean	t	df	p
Pair 1	BT – AT	-21.66	23.93	4.37	-4.95	29	.000

As shown in Table 5 and 6, the significance value is smaller than .05; therefore, the H_0 hypothesis is rejected. İt is concluded that there is a significant difference before and after training. The engineers group coded as white color workers learned from the training and they were found sufficient enough to make the quality function deployment analysis.

Phase 4: Quality Function Deployment
As displayed in Figure 3, the priorities to the criteria found from the AHP technique of the white color workers as engineers are embedded to the quality function deployment technique to match the customer preferences with the industry for 4.0 requirements. In the first column, one can see the customer needs in today's world, they want more responsive and agile systems. This column is called critical customer requirements (CCRs). (What's) are listed vertically in the first column and all are related. CTQs (How's) are listed horizontally across the top.

The Findings

		Hows or CTQs internal to the company/process/engineering->								
Customer Needs or CCRs or Whats	Importance to Customer	modelling and simulation 5>	smart factories 5>	robotic systems 5>	sensors 5>	big data analytics 5>	additive manufacturing 5>	cyber security 5>	cloud computing 5>	internet of things 5>
Need Quick Response	0.125	5	5	4	5	4	3	3	3	3
Sustainable production	0.386		5			4	2		1	
High service level	0.386	3	5	4	2	3	2	2	2	2
Perfection on the quality	0.165	3	4	4	3	4	2	2	2	3
Accurate decisions	0.875	3	1	1	3	5	1	1	5	2
Rapid prototyping	0.063	4	2	1	1	1	5	2	2	1
Data security	0.185	1	1	1	1	1	1	5	1	1
Agile procurement	0.156	3	5	4	4	3	3	2	4	3
Customized products	0.656	5	4	3	3	3	3	2	2	2
Score		**9.1**	**9.7**	**6.4**	**7.4**	**11**	**6.1**	**5**	**8.5**	**5.4**
Current Avg Value of CTQ		2.5	3.1	2	3	6	0	1	2	7

Figure 3. The quality function deployment

Discussion and Conclusion

AHP technique applied to the industrial sector. The academic people and students and the importance weights of the topics under industry 4 concept were determined. According to the importance values, the training materials were organized by management and the success of the groups were compared. Before and after the training analysis was conducted to the engineers and it is found that the training is effective on them. Those trainings were performed only under the leadership of the managers for the digitalization initiation.

In the QFD technique, the customers' quick response, sustainable production, high service level, perfection on quality, accurate decisions, rapid prototyping, data security, agile procurement and customized products requirements were matched with the company's capabilities under the industry 4.0 skills. In the analysis, it was found that the company should focus on smart factory concept with the 9.7 score and then modelling and simulation with 9.1 should be conducted. This would help the company for the responsiveness, customization and quality requested from the customers.

There is an urgency in the manufacturing companies to change their technology and knowledge and the workforce skills for the Industry 4.0 understanding in order to stay competitive. The transformation process to the Industry 4.0 concept is a strategic decision and it requires leadership to deploy the strategy all through the organization by training from the top to the bottom of the organization.

Agile and responsive strategy can only be applied if the customers are listened. In today's industry, where the growing distance between producers and users is a concern, Quality Function deployment method links the needs of the customer with design, development, and manufacturing with the Industry 4 concept. This is the only way to survive in this highly competitive world. Digitalization or so-called Industry 4.0 will help the companies to have more responsive operations and supply chains.

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