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INTITUIONISTIC FUZZY TLX (IF-TLX): IMPLEMENTATION OF INTITUIONISTIC FUZZY SET THEORY FOR EVALUATING SUBJECTIVE WORKLOAD

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ABSTRACT

The determination of subjective workload (SWL) imposed on an employee plays an important role in designing and evaluating an existing work and work environment. Additionally, it is a hard problem since SWL evaluation is typically a multi-dimensional problem involving several work demands on which employee's evaluation is usually vague and imprecise. In this study, NASA TLX (National Aeronautics and Space Administration Task Load Index) method used widely in different work types combined with intuitionistic fuzzy set (IFS) theory to determine SWL in an industrial sailing firm. The integrated method is named as Intuitionistic Fuzzy TLX (IF-TLX). IFS theory is a powerful tool to model the uncertainty because of degree of hesitation in human decision system. It is worth pointing out that proposed method also considers work experience effect on SWL evaluation. This improves objectivity of final SWL scores for the whole work. This paper also develops a new intuitionistic evaluation scale for rating of SWL dimensions and work experience. As a result of this study it is determined that industrial salespeople who have more than 15 years of work experience feel the highest SWL with the effect of increasing age.

Introduction

The subjective workload (SWL) is the perceived degree of difficulty that plays an important role for the desire and loyalty of the employees towards their jobs. The performance, reactions, attention, stress, fatigue and work satisfaction levels of the employees are affected directly by SWL. The evaluation of the SWL level is very important for determination of the stress degree caused by the work upon the employees and assigning the employees to the jobs which are much more suitable for their capacities. Additionally, the SWL is a key factor to establish comfortable, efficient, effective, and secure working environments [1]. There are various methods performed to measure the SWL in the literature. These are Subjective Workload Assessment Technique (SWAT), Subjective Workload Dominance (SWORD), NASA Bipolar Index, Hart and Hauser Rating Scale, Crew Status Survey, National Aeronautics and Space Administration Task Load Index (NASA TLX) etc. [2-7]. The one which most commonly used and adapts most to different fields of work successfully, is the NASA TLX method. The NASA TLX is a practical tool for determination of SWL levels of employees working with various human-machine systems. NASA-TLX is a multi-dimensional rating procedure that derives an overall workload (OWL) score based on a weighted average of ratings on six dimensions as mental demand (MD), physical demand (PD), temporal demand (TD), frustration level (FL), effort level (EL) and performance level (PL) [7]. The validity and reliability of the method were verified in number of studies [7-8].

But there are some directions which should be improved in this method. First, the NASA TLX assumes that all dimensions of SWL and their respective ratings are expressed in crisp values and, thus, that the rating of the dimensions can be carried out without any problem. In that manner, the method uses

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discrete scale (0 to 100 with 5 units increase) for rating of dimensions. This scale is not suitable for human decision structure. In real-world evaluation situation, the application of this approach may face serious practical constraints from the dimensions perhaps containing imprecision and vagueness. In many cases, evaluation of the dimensions can only be expressed qualitatively or by using linguistic terms, which certainly demands a more appropriate method. Second; when employee rates any of six dimensions according to his/her job, he/she can give “0” point anyone. In this situation, the dimension or dimensions rated as “0” points are not considered in OWL. So when two employees’ SWL levels are compared, the number of dimensions using in evaluation are different. Third, the employees may make different evaluations about SWL according to their experience levels. Experienced employee can easily understand how a workplace or business works, find out what an employer expects of his/her and may make more accurate SWL assessment for the whole work [9].

In this study in terms of these directions, the NASA TLX method is modified by using intuitionistic fuzzy set theory (IFS) for improving performance of the method. The theory of fuzzy sets (FS) proposed by Zadeh has been used successfully in various fields [10]. However the theory of IFS introduced by Atanassov (1986) is a powerful tool and has been found to be highly useful to deal with vagueness and imprecision [11]. The concept of IFS can be viewed as an alternative approach to define a FS in cases where available information is not sufficient for the definition of an imprecise concept by means of a conventional FS. In SWL analysis, the employee makes his/her evaluations in IFS format. For example, in rating process, employee may have complex feelings about scores of SWL dimensions and he/she cannot determine whether giving 5, 10 or 15 points for any dimension in a crisp manner (Pei and Zheng, 2012). Additionally, in some real-life situations, employees may not be able to accurately express their perceptions in terms of job difficulty as they may not possess a precise or sufficient level of knowledge related to their jobs or the employees may provide their perceptions for their jobs to a certain degree, but it is possible that they are not so sure about it [12]. Namely, there may exist some hesitancy degree, which is a very important factor to be taken into account when trying to construct really adequate scores of SWL. Such a kind of hesitancy degree is suitably expressed with IFS rather than exact numerical values. Thus, it is very suitable to express employees’ perceptions with the use of intuitionistic fuzzy values rather than exact numerical values or linguistic variables [9,13].

The aim of the study is to propose a modified method based on IFS theory to satisfy the need of SWL analysis with imprecision and hesitancy. Also, another aim of the study is to obtain more objective SWL assessments for the whole work considering employees’ working experience levels. There has been no study in the literature assess SWL due to experience levels with NASA TLX by implementing IFS theory. In the context of the study proposed method is performed for the assessment of the industrial salespeople’ SWL.

The rest of the paper is organized as follows. In the second section of the study definitions and properties of IFSs and triangular intuitionistic fuzzy numbers (TIFNs) are presented. The third section describes the NASA TLX method. Forth section includes the proposed Intuitionistic Fuzzy Rating Scale. The proposed Intuitionistic Fuzzy TLX (IF-TLX) Method is defined in fifth section. The sixth section contains implementation of the proposed IF-TLX Method on industrial salespeople and results. Conclusions and future research options are presented in the last section.

Definitions and Properties of Intuitionistic Fuzzy Sets and Triangular Intuitionistic Fuzzy Numbers

In this section, some basic concepts of IFS and TIFNs are presented.

Definition 1. Let X be a universe of discourse, then a FS is shown as Eq. (1) [10].

$$A = \{x, \mu_A(x) | x \in X\} \tag{1}$$

A FS is represented by membership function μ_A:X→[0,1], where $\mu_A(x)$ indicates the degree of membership of the element x to the set of A. In addition, IFS is a generalized form of FS. In conventional FS a membership function assigns to each element of the universe of discourse a number from the unit interval to indicate the degree of membership to the set under consideration. The degree of non-membership is just automatically the complement to "1" of the membership degree. However, a human being who expresses the degree of membership of given element in a FS very often does not express corresponding degree of non-membership as the complement to "1". This is a well-known psychological fact that the linguistic negation not always identified with logical negation. Thus Atanassov (1986) introduced the concept of IFS which is characterized by two functions expressing the degree of belongingness and the degree of non-belongingness, respectively [11]. This idea, which is a natural generalization of usual FS, seems to be useful in modelling many real life situations, like negotiation processes, etc. [14] An IFS is demonstrated by Eq. (2) [11].

$$A = \{x, \mu_A(x), \vartheta_A(x) | x \in X\} \tag{2}$$

It is defined by a membership function μ_A:X→[0,1] and non-membership function ϑ_A:X→[0,1] providing that $0 \le \mu_A(x) + \vartheta_A(x) \le 1$, $\forall x \in X$. $\mu_A(x)$ indicates the degree of membership and $\vartheta_A(x)$ presents the degree of non-membership of the element x to the set of A.

Definition 2. Besides for each IFS A in X if

$$\pi_A(x) = 1 - \mu_A(x) - \vartheta_A(x), \forall x \in X \tag{3}$$

where $\pi_A(x)$ is called the degree of non-determinacy or hesitation or intuitionistic index of x to A. For ordinary fuzzy sets the degree of hesitation $\pi_A(x)=0$. Principally, if

$$\pi_A(x) = 1 - (1 - \mu_A(x) - \vartheta_A(x)) = 0, \forall x \in X \tag{4}$$

Then, IFS is converted to a fuzzy set [10]. If $\pi_A(x)$ value is small, the information about x element is relatively more accurate. If $\pi_A(x)$ value is big, the information about x element is relatively more uncertain. If $\pi_A(x)$ value is equal to 0, the information about x element is accurate.

Since the IFSs can give an additional possibility to represent imperfect knowledge, they can make it possible to describe many real problems in a more adequate way [15].

Definition 3. Let $A=\{x,\mu_A(x),\vartheta_A(x)|x\in X\}$ and $B=\{x,\mu_B(x),\vartheta_B(x)|x\in X\}$ be two IFSs, then

(1) $A \subset B$ if $(\forall x \in X)\ (\mu_A(X) \le \mu_B(x) \,\&\, \vartheta_A(x) \ge \vartheta_B(x))$
(2) $A=B$ if $A \subset B$ and $B \subset A$
(3) $A \cup B = \{<x, \min((\mu_A(x), \mu_B(x)), \max(\vartheta_A(x), \vartheta_B(x))> | x \in X\}$
(4) $A \cap B = \{<x, \max((\mu_A(x), \mu_B(x)), \min(\vartheta_A(x), \vartheta_B(x))> | x \in X\}$

Definition 4. An intuitionistic fuzzy number (IFN) is denoted as $A= ((\mu_A(x),\vartheta_A(x),\pi_A(x))$, where

$\mu_A(x)\in[0,1], \vartheta_A(x)\in[0,1]; \mu_A(x)+\vartheta_A(x) \le 1, \pi_A(x)=1-\mu_A(x)-\vartheta_A(x)$.

Definition 5. The TIFN was offered by Dubois and Prade (1980) as follows [16]:
A TIFN $\tilde{A}=<(\underline{A},A,\overline{A});w_{\tilde{A}},u_{\tilde{A}}>$ is a special IFS on a real number R whose membership function and non-membership function are defined as Eq. (5) and Eq. (6).

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{(x-A)w_{\tilde{A}}}{(A-\underline{A})} & if\ \underline{A} \leq x \leq A, \\ w_{\tilde{A}} & if\ x = A, \\ \frac{(A-x)w_{\tilde{A}}}{(\overline{A}-A)} & if\ A < x \leq \overline{A}, \\ 0 & if\ x < \underline{A}\ or\ x > \overline{A}, \end{cases} \tag{5}$$

$$\vartheta_{\tilde{A}}(x) = \begin{cases} \frac{[A-x+u_{\tilde{A}}(x-A)]}{(A-\underline{A})} & if\ \underline{A} \leq x \leq A, \\ u_{\tilde{A}} & if\ x = A, \\ \frac{[x-A+u_{\tilde{A}}(\overline{A}-x)])}{(\overline{A}-A)} & if\ A < x \leq \overline{A}, \\ 0 & if\ x < \underline{A}\ or\ x > \overline{A}, \end{cases} \tag{6}$$

$w_{\tilde{A}}$ is defined as the maximum degree of membership and $u_{\tilde{A}}$ is specified as the minimum degree of non-membership. These fulfil the $0 \leq w_{\tilde{A}} \leq 1$, $0 \leq u_{\tilde{A}} \leq 1$ and $0 \leq w_{\tilde{A}} + u_{\tilde{A}}$ conditions.

Definition 6. Let $\tilde{A} = (\mu_{\tilde{A}}(x), \vartheta_{\tilde{A}}(x))$ and $\tilde{B} = (\mu_{\tilde{B}}(x), \vartheta_{\tilde{B}}(x))$ be two TIFNs, then

(1) $\tilde{A} + \tilde{B} = \{< x, (\mu_{\tilde{A}}(x) + \mu_{\tilde{B}}(x) - \mu_{\tilde{A}}(x) \times \mu_{\tilde{B}}(x), \vartheta_{\tilde{A}}(x) \times \vartheta_{\tilde{B}}(x)) > | x \in X\}$

(2) $\tilde{A} \times \tilde{B} = \{< x, (\mu_{\tilde{A}}(x) \times \mu_{\tilde{B}}(x), (\vartheta_{\tilde{A}}(x) + \vartheta_{\tilde{B}}(x) - \vartheta_{\tilde{A}}(x) \times \vartheta_{\tilde{B}}(x)) > | x \in X\}$

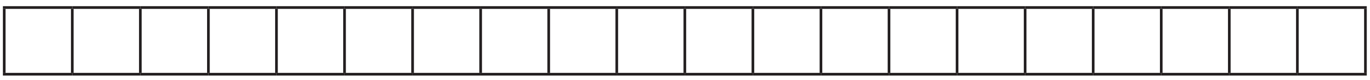
(3) $\lambda\tilde{A} = (1 - (1 - \mu_{\tilde{A}}(x))^{\lambda}, \vartheta_{\tilde{A}}(x)^{\lambda})\ \lambda > 0$

(4) $\tilde{A}^{\lambda} = (\mu_{\tilde{A}}(x)^{\lambda}, 1 - (1 - \vartheta_{\tilde{A}}(x))^{\lambda}), \lambda > 0$

The NASA TLX Method

NASA TLX estimates workload felt by employee by considering six dimensions of SWL as mentioned in introduction section. The dimension of PD is evaluated according to the amount as physical activity necessary for the completion of the work. The dimension of MD is defined as the mental and sensory activity level required for during the completion work. In the dimension of TD, the level of working pace and time stress caused by the completion of the work are estimated. The PL dimension is the degree of success and sufficiency that the employee feels him/her in the completion of the work on time. The EL dimension demonstrates that the amount of physical and mental exertion for the achievement of the performance level predetermined. The dimension of FL indicates that the level of insecurity, disenchantment and anger during the work [4].

NASA TLX consists of two parts. In the first part each of six dimensions are rated between 0-100 with considering work done by employee. The rating scale of NASA TLX is shown in Figure 1.



Very Low Very High

Figure 1. NASA TLX rating scale

The second part includes the 15 pairwise comparisons (MD vs. PL, EL vs. FL and so on) to find which dimension is the superior over the others as a workload source. At the end of this comparison process, by counting the number of comparisons where each dimension ranked first, divided by 15 for normalization purpose, the relative weight of each dimension is computed. By multiplying relative weights with ratings for each dimension, the effect score of each dimension to OWL is obtained. Then, these effects scores are summed and weighted sum is computed for identifying OWL. OWL is named as TLX and it demonstrates SWL level of employee. The TLX gets values between “0 and 100”. This range is divided into seven degree from “very low” to “very high”. The mathematical definition of OWL is given in Eq. (7) [17].

$$TLX=MD\times W\_MD+PD\times W\_PD+TD\times W\_TD+FL\times W\_FL+EL\times W\_EL+PL\times W\_PL \quad (7)$$

where;

W_{xx} is the weight of the rating for a dimension XX.

NASA TLX Method has been widely implemented to compute the SWL in various sectors. SWL of the pilots during the flight is measured by Lee and Liu (2003) using physiological and multi-dimensional subjective parameters [18]. Cumulative SWL imposed by three different types of cellular phones on drivers is determined by Mathews et al. (2003) using NASA TLX [19]. For analyzing SWL in the treatment and surgical methods in medicine sector, NASA TLX has been performed in various studies [20, 21, 22, 23, 24, 25]. Park et al. (2009) identified relation between the SWL and task complexity degrees of fast train conductors [26]. NASA TLX is used for examining the SWL arising from utilization of touch screens from frontal and parallel positions for motor control disorder people by Kuehn et al. (2013), for evaluation of SWL emerged in newly proposed Humane-Machine Interface (HMI) design concepts for improving the ergonomics of hydraulic excavators by Akyeampong et al. (2014) [27, 28].

The Proposed Intuitionistic Fuzzy Rating Scale

SWL evaluation consists of linguistic data which reflects natural language of employees. This assessment deals with imprecise, undefined and complex expressions. Due to this, quantitative expressions cannot define SWL assessment sufficiently [29, 30]. For the rating of each dimension of SWL, TIFNs can be used to modeling employees’ expressions. In this study, a new norm-based evaluation scale considering the hesitation degree of TIFNs is proposed for assessment of SWL towards Lazim (2014)’s approach [30]. The conversion of NASA TLX traditional rating scale into TIFNs, the each rating is averaging with respect to the total of the NASA TLX rating scale. A conversion table based on seven rating class of NASA TLX to membership and non-membership degree is utilized to define new SWL assessment scale of NASA TLX.

The NASA TLX evaluation scale is converted to TIFNs $x=(\mu_x,\vartheta_x,\pi_x)$, by averaging data scaling $\mu''(x)_{lower}$ and $\mu''(x)_{upper}$ according to $Score_{lower}$ and $Score_{upper}$ of membership degrees.

This conversion is presented in Table 1.

Table 1. Conversion of SWL scores to membership degrees

Class Nu	$Score_{lower}$	$Score_{upper}$	Linguistic Terms of Ratings	π(x)	$\mu''(x)_{lower}$	$\mu''(x)_{upper}$
1	0,00	14,00	Very Low	1,00-0,86	0,00	0,14
2	15,00	29,00	Slightly Low	0,85-0,71	0,15	0,29
3	30,00	44,00	Low	0,70-0,56	0,30	0,44
4	45,00	59,00	Medium	0,55-0,41	0,45	0,59
5	60,00	74,00	Slightly High	0,40-0,26	0,60	0,74
6	75,00	89,00	High	0,25-0,11	0,75	0,89
7	90,00	100,00	Very High	0,10-0,00	0,90	1,00

$\mu''(x)_{lower}$ and $\mu''(x)_{upper}$ values given in Table 1 can be computed by Eq. (9) and Eq. (10) [30].

$\mu''(x)_{lower} = Score_{lower}/m$ (9)

$\mu''(x)_{upper} = upper/m$ (10)

where;

$Score_{lower}$: Crisp lower score of any rating class of NASA TLX,
$Score_{upper}$: Crisp upper score of any rating class of NASA TLX,

m: Total of scale measurement of any dimension of SWL. Then, membership degree, non-membership degree and hesitation degree are computed for $\mu''(x)_{lower}$ and $\mu''(x)_{upper}$ values by Eq. (11),

Eq. (12), Eq. (13), Eq. (14) and Eq (15) [30].

$\mu(x) = \mu''(x)_{lower}\,[1-\pi(x)]$ (11)

$\vartheta(x) = \mu''(x)_{lower}\,][1-\pi(x)]$ (12)

$\mu(x) = \mu''(x)_{upper}\,[1-\pi(x)]$ (13)

$\vartheta(x) = \mu''(x)_{upper}\,[1-\pi(x)]$ (14)

$\pi(x)=1-\vartheta(x)-\mu(x)$ (15)

An example is given to clarify the conversion below.
Let $Score_{upper}$=14 for the first evaluation class "very low" of NASA TLX and m=100, then

$$\mu''(x)_{upper} = \frac{\text{Score}_{upper}}{m} = \frac{14}{100} = 0{,}14$$

As seen from Table 2, the hesitation degree (π(x)) of 0,14 (□μ^'' (x)□_upper) is 0,86. Then, membership and non-membership degree can be calculated by Eq. (13) and Eq. (14).

$\mu(x)=0{,}14(1-0{,}86)$
$\mu(x)=0{,}02$,
$\vartheta(x)=(1-0{,}14)(1-0{,}86)$
$\vartheta(x)=0{,}12$

By using these values, the $TIFN_{upper}$ for evaluation of any dimensions of SWL is 0,02-0,12-0,86 for "very low" class of the proposed NASA TLX scale. These calculations are repeated for all $Score_{lower}$ and $Score_{upper}$ values in each class and Table 2 is formed.

Table 2. $TIFN_{lower}$ and $TIFN_{upper}$ values for $Score_{lower}$ and $Score_{upper}$ evaluations

Rating Class Nu	Scores		Linguistic Terms of Ratings	$TIFN_{lower}$			$TIFN_{upper}$		
	$Score_{lower}$	$Score_{upper}$		μ(x)	ϑ(x)	π(x)	μ(x)	ϑ(x)	π(x)
1	0,00	14,00	Very Low	0,00	0,00	1,00	0,02	0,12	0,86
2	15,00	29,00	Slightly Low	0,02	0,21	0,77	0,08	0,13	0,79
3	30,00	44,00	Low	0,09	0,25	0,66	0,19	0,21	0,60
4	45,00	59,00	Medium	0,20	0,25	0,55	0,35	0,24	0,41
5	60,00	74,00	Slightly High	0,36	0,24	0,40	0,55	0,19	0,26
6	75,00	89,00	High	0,56	0,19	0,25	0,79	0,10	0,11
7	90,00	100,00	Very High	0,81	0,09	0,10	1,00	0,00	0,00

Then, $TIFN_{lower}$ and $TIFN_{upper}$ values are combined according to IFS theory by using combination property given in Definition 3. Due to this, new intuitionistic fuzzy scale is developed. Additionally, the working experience level of employees is determined with the same scale, to obtain more objective results about SWL levels. Working experience is divided in to seven classes same as SWL. The proposed scale is depicted in Table 3.

Table 3. Proposed Intuitionistic Fuzzy SWL Scale

Rating Class Nu	Linguistic Terms of Ratings	Linguistic Terms of Experience	TIFN		
			μ(x)	ϑ(x)	π(x)
1	Very Low	No experience	0,02	0,00	0,98
2	Slightly Low	1-3 years	0,08	0,13	0,79
3	Low	3-6 years	0,19	0,21	0,60
4	Medium	6-9 years	0,35	0,24	0,41
5	Slightly High	9-12 years	0,55	0,19	0,26
6	High	12-15 years	0,79	0,10	0,11
7	Very High	More than 15 years	1,00	0,00	0,00

The Proposed Intuitionistic Fuzzy TLX (IF-TLX) Method

The steps of proposed Intuitionistic Fuzzy TLX (IF-TLX) Method are presented below.

Step 1. Implement the SWL Assessment Survey to the employees.

This questionnaire consists of three parts. First part includes demographic features of employees like age, gender, work experience etc. Second part contains rating of six dimensions of SWL by using new intuitionistic fuzzy scale depicted in Table 4. The employees asked to specify rating using seven linguistic terms varying from "very low to very high" according to their jobs. Third part comprises fifteen pairwise comparisons of six dimensions. In this part, the employees asked to identify the dominance of dimensions over each other.

Step 2. Compute the each dimension's workload score for each employee considering rating of six dimensions and weightings obtained by pairwise comparisons.

The intuitionistic fuzzy ratings of each dimension and weightings are multiplied based on Definition 6 which represents arithmetic operations of IFNs.

Step 3. Weight the each dimension's workload score according to employees' experience levels.

In this step, the proposed intuitionistic fuzzy scale is used for weighting in terms of working experience of employees. The intuitionistic workload scores of each dimensions are multiplied with intuitionistic fuzzy experience weights depicted in Table 4 based on arithmetic operations in Definition 6.

Step 4. Sum the experience weighted intuitionistic fuzzy workload scores of each dimension for computing intuitionistic fuzzy OWL.

This step is implemented with summation operation of IFNs based on Definition 6.

Step 5. Defuzzyfy the intuitionistic fuzzy OWL values of each employee.

For conversion of intuitionistic fuzzy OWL values to crisp values, a new defuzzification approach is proposed based on intuitionistic fuzzy scale forming procedure given in “The Proposed Intuitionistic Fuzzy Scale” section. The intuitionistic fuzzy values of OWLs are converted to crisp values by Eq. (16).

$$OWL=(100\times\mu(x))/(1-\pi(x)) \quad (16)$$

Implementation of the Proposed IF-TLX Method on Industrial Salespeople

Participants

The working sample was formed by the industrial salespeople working in a large size firm which was among the first three firms in the machinery tools sector. The positive attitude towards experienced salespeople is the main reason for the choice of machinery sector. In this sector, the technical knowledge increases with the experience. The machinery tools sold by the firm have been used in various types of manufacturing firms.

Application of The Proposed Method Steps

The steps defined in section “The Proposed Intuitionistic Fuzzy TLX (IF-TLX) Method” are followed as below.

Step 1. Industrial salespeople asked to assess their SWL via the “Subjective Workload Assessment Survey”. The salespeople responded the survey at the end of the working day. The survey was performed with paper-pencil system by them. Before performed, the important points were decelerated to them in a face to face manner. All participants started to response the survey at the same time around 05.45 pm at the end of the working day. The survey forms of participants were left in the boxes in predetermined areas in order to provide anonymity. The survey was distributed to 300 salespeople and 207 (69%) of them returned it. The survey sample size determined that those responding to the questionnaire had a homogenous structure and the probability of the phenomena taking place was calculated as 0.50 and the probability of not taking place was taken as q=0.50. The sample error was d=0.10 and the significance level was α=0.05. The sample size was found to be 153 taking the fact that the population size was known. The sample size was considered to be sufficient at the 95% confidence level. 65.4% of the employee who participated in the study was men and 34.6% of them were women. 24.15% of industrial salespeople have no working experience. %17.39 of them have 1-3 years, 5.79% have 3-6 years, %13,52 have 6-9 years, 0.08% have 9-12 years, 13,52% have 12-15 years, 16.90% have more than 15 years working experience in this sector. 17,80% of the participated employee are less than 21 years old, 7,10% are 21-30 years old, 14,20% are 31-40 years old, %18,20 are 41-50 years old, 15,00% are 51-60 years old, 27,7% are more than 60 years old.

Step 2. For computing workload scores of each dimension for each of 207 participants, multiplication operation is implemented to intutionistic fuzzy ratings and crisp weightings obtained from pairwise comparisons. Intuitionistic fuzzy workload scores of each dimension according to experience levels are depicted in Table 5.

Table 5. Intuitionistic fuzzy workload scores of each dimension according to experience levels

Experience Level	IF-MD* Scores			IF- PD Scores			IF- TD Scores			IF- FL Scores			IF- EL Scores			IF- PL Scores		
	$\mu_{(x)}$	$\vartheta_{(x)}$	$\pi_{(x)}$	$\mu_{(x)}$	$\vartheta_{(x)}$	$\pi_{(x)}$	$\mu_{(x)}$	$\vartheta_{(x)}$	$\pi_{(x)}$	$\mu_{(x)}$	$\vartheta_{(x)}$	$\pi_{(x)}$	$\mu_{(x)}$	$\vartheta_{(x)}$	$\pi_{(x)}$	$\mu_{(x)}$	$\vartheta_{(x)}$	$\pi_{(x)}$
No experience	0,09	0,32	0,59	0,16	0,74	0,09	0,48	0,44	0,08	0,25	0,60	0,16	0,44	0,51	0,05	0,47	0,45	0,08
1-3 years	0,16	0,29	0,55	0,22	0,69	0,09	0,41	0,53	0,06	0,36	0,54	0,09	0,57	0,39	0,04	0,40	0,50	0,10
3-6 years	0,14	0,70	0,16	0,18	0,76	0,05	0,28	0,62	0,10	0,27	0,64	0,09	0,64	0,33	0,03	0,42	0,50	0,08
6-9 years	0,16	0,65	0,19	0,16	0,79	0,04	0,29	0,34	0,07	0,34	0,55	0,10	0,65	0,32	0,03	0,52	0,40	0,08
9-12 years	0,06	0,70	0,24	0,12	0,82	0,06	0,56	0,38	0,06	0,34	0,54	0,11	0,68	0,30	0,02	0,47	0,44	0,09
12-15 years	0,13	0,67	0,20	0,19	0,78	0,04	0,49	0,45	0,06	0,37	0,55	0,08	0,62	0,35	0,03	0,56	0,37	0,07
More than 15 years	0,19	0,64	0,17	0,29	0,68	0,04	0,45	0,49	0,07	0,31	0,60	0,09	0,64	0,32	0,04	0,52	0,41	0,08

*IF-MD: Intuitionistic fuzzy mental demand score

Table 5 shows that according to $\mu_{(x)}$ values of intutuionistic fuzzy ratings of dimensions, more than 15 years experienced employees feel the highest mental and physical workload. According to TD dimension, 9-12 years experienced employees feel the highest time pressure and effort level. Additionally, 12-15 years experienced employees have the highest frustration level and performance pressure. If $\mu_{(x)}$ values increase, the intutuionistic fuzzy ratings of dimensions increase.

Step 3. For weighting intuitionistic fuzzy workload scores of each dimension for each employee according to their experience levels, the proposed Intuitionistic Fuzzy Scale depicted in Table 4 is used. Table 6 represents experience weighted intuitionistic fuzzy workload scores for each dimension.

Table 6. Experience weighted intuitionistic fuzzy workload scores of each dimension according to experience levels

Experience Level	IF-MD* Scores			IF- PD Scores			IF- TD Scores			IF- FL Scores			IF- EL Scores			IF- PL Scores		
	$\mu_{(x)}$	$\vartheta_{(x)}$	$\pi_{(x)}$	$\mu_{(x)}$	$\vartheta_{(x)}$	$\pi_{(x)}$	$\mu_{(x)}$	$\vartheta_{(x)}$	$\pi_{(x)}$	$\mu_{(x)}$	$\vartheta_{(x)}$	$\pi_{(x)}$	$\mu_{(x)}$	$\vartheta_{(x)}$	$\pi_{(x)}$	$\mu_{(x)}$	$\vartheta_{(x)}$	$\pi_{(x)}$
No experience	0,00	0,32	0,67	0,00	0,75	0,25	0,01	0,44	0,55	0,00	0,60	0,40	0,01	0,51	0,48	0,01	0,45	0,54
1-3 years	0,01	0,38	0,61	0,02	0,73	0,25	0,03	0,59	0,38	0,03	0,60	0,37	0,05	0,47	0,48	0,03	0,56	0,40
3-6 years	0,03	0,76	0,21	0,04	0,81	0,15	0,05	0,70	0,25	0,05	0,71	0,24	0,12	0,47	0,41	0,08	0,61	0,31
6-9 years	0,03	0,72	0,25	0,03	0,84	0,13	0,12	0,48	0,40	0,07	0,65	0,28	0,13	0,46	0,41	0,11	0,53	0,37
9-12 years	0,04	0,76	0,21	0,06	0,85	0,08	0,31	0,50	0,19	0,19	0,63	0,18	0,37	0,43	0,19	0,26	0,55	0,19
12-15 years	0,10	0,70	0,20	0,15	0,80	0,05	0,39	0,51	0,11	0,29	0,59	0,12	0,49	0,41	0,10	0,44	0,43	0,13
More than 15 years	0,19	0,64	0,17	0,29	0,68	0,04	0,45	0,49	0,07	0,31	0,60	0,09	0,64	0,32	0,04	0,52	0,41	0,08

As seen from Table 6, when reflecting experience level to employees' workload evaluations, experienced employees's evaluations have more weights in determining each dimensions' workload levels. In this way, more objective SWL level for the whole work can be obtained.

Step 4. Experience weighted intuitionistic fuzzy workload scores of each dimension are summed for computing intuitionistic fuzzy OWL for each employee. These scores according to experience levels are shown in Table 7.

Table 7. Intuitionistic fuzzy OWL scores according to experience levels

Experience Level	Intuitionistic Fuzzy OWL		
	$\mu_A(x)$	$\vartheta_A(x)$	$\pi_A(x)$
No experience	0,04	0,02	0,94
1-3 years	0,17	0,03	0,81
3-6 years	0,32	0,09	0,58
6-9 years	0,39	0,07	0,54
9-12 years	0,74	0,06	0,19
12-15 years	0,88	0,04	0,07
More than 15 years	0,94	0,03	0,03

As seen from Table 7, the highest $\mu_{(x)}$ value is emerged for more than 15 years experienced employees. It can be said that, more than 15 years experienced employees feel the highest OWL. Additionally, it can be seen from Table 7, $\pi_{(x)}$ gets nearly "0" value in more than 15 years experienced employees. This means that experienced employees can make more accurate SWL assessments.

Step 5. By using Eq. (16), experience weighted intuitionistic fuzzy OWL values are converted to crisp OWL values. These values are depicted in Table 8.

Table 8. Crisp scores of OWL values according to experience level

Experience Class	OWL
No experience	92
1-3 years	88
3-6 years	78
6-9 years	85
9-12 years	90
12-15 years	94
More than 15 years	96

As seen from Table 8, employees have more than 15 years of experience in this sector feel the highest (96) SWL and the 3-6 years experienced employees fell the lowest SWL.

Conclusions

In this study, a modified approach named as IF-TLX for dealing with SWL evaluation under the intuitionistic fuzzy setting is proposed. The IF-TLX method consists of a new scale that easy to implement and consistent with human recognition. Also, work experience considered for SWL determination in order to obtain more objective results for the whole work.

According to obtained results, more than 15 years experienced employees feel the highest SWL. This result may be existed from increasing age with experience. At the same time, no experienced employees possess high SWL. This may be originated not having sufficient information about work and sector. In this study, it is tried to balance the SWL scores of no experienced employees and the most experienced

employees to get more objective SWL levels.
As a future study option, proposed method should be implemented other sectors and different types of work environment.

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