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Effect of Different Concentrations of Titanium Dioxide Nanoparticles on the Potential Barrier of Organic Device

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Abstract

Present work has studied potential barrier of Phenosafranin dye based organic device and has observed influence of different concentrations of titanium dioxide nanoparticles on this parameter. We have made different devices by taking different weight ratios of the dye – nanoparticles blend which are 1:1, 1:2, 1:3 and 1:4. These organic devices have been formed by varying the concentrations of titanium dioxide nanoparticles keeping same dye content. One device is also formed without any nanoparticle to compare influence of nanoparticle on potential barrier of the device. These devices are formed by sandwiching the dye – nanoparticle blend in between the Indium Tin Oxide coated glass and Aluminium coated mylar sheet. The potential barrier is measured from device's I-V plot and also by Norde function. These two methods remain in good agreement showing that potential barrier is mostly decreased when the concentration of the titanium dioxide nanoparticles is highest in the blend of Phenosafranin dye and titanium dioxide nanoparticles. The ratio of dye – nanoparticle blend of 1:4 shows lowest potential barrier and it is highest when Phenosafranin dye based organic device is made without any nanoparticle. The reduced potential barrier in the presence of higher concentration of nanoparticles can be ascribed to improved filling of traps. Lowered potential barrier at metal – organic contact will improve the charge flow resulting in better performance of the device.

Keywords: Metal – Organic Dye Interface; Norde Function; Potential Barrier; Phenosafranin Dye; Titanium dioxide Nanoparticles

1. Introduction

Certain features of organic devices such as cost effectiveness, high flexibility, easy processing, light weight and large area fabrication make them highly promising for many devices in recent years [1-3]. The performance of organic electronic devices is strongly

dependent on the charge flow at metal – organic (M/O) contact when dye is sandwiched in between two metal electrodes having different work functions. The main limitation of this device is the poor charge flow at M/O contact. There are many reasons behind the poor charge flow at the contact but in our work, we have ascribed high potential barrier at contact to be the main reason behind the low charge injection process. Earlier in our works, [4-7], we have tried to improve the flow of charge in terms of barrier lowering, trap concentration decreasing by modifying back electrode and also by incorporating different nanoparticles in different organic devices. In present work, variation of nanoparticles concentration has been done to observe its influence on potential barrier at the contact. We have taken Phenosafranin (PSF) dye as the organic material and this dye has been sandwiched in between Indium Tin Oxide (ITO) coated glass and Aluminium coated mylar (Al-M) sheet in absence of any nanoparticle. To observe influence of varying concentration of nanoparticles, we have chosen titanium dioxide (TiO_2) nanoparticle and have varied its concentration keeping the PSF dye concentration same. Titanium dioxide occurs in three crystalline polymorphs such as rutile, anatase,

and brookite and it has been extensively studied for its interesting electric, magnetic, catalytic, and electrochemical properties [8-9]. In one of our earlier works [10], we have shown the effect of titanium dioxide (TiO_2) nanoparticle on potential barrier and charge trapping of PSF dye based organic device without varying the concentration of nanoparticles but in this work, variation of concentration of titanium dioxide (TiO_2) nanoparticle on potential barrier of PSF organic dye based device will be studied in detail. In this work, titanium dioxide has been used in its anatase form. In some previous works, titanium dioxide has been introduced to improve the morphology of active layers in sandwiched structure organic device to increase the efficiency of the device and due to its chemical stability and biocompatibility, TiO_2 also finds its application in gas sensors, photocatalytic degradations of organic compounds and photovoltaic and photo electrochemical cells [11-13]. TiO_2 has a wide energy gap, a lower recombination rate of electron–hole pairs and high mobility along with controllable size which can be modified by addition of an organic molecule which in turn could change the interactions with other device components [14-15]. TiO_2 incorporation will also reduce the sensitivity of the organic semiconductor based device to oxygen and water vapour [16].

The current flow at the metal –organic contact can be either space charge limited current (SCLC) or injection limited current (ILC). From the theoretical calculations, it has been seen that for a potential barrier less than 0.3 eV, the current is space charge limited at room temperature [17] and when the interfacial barrier is greater than 0.3 eV, current is injection limited. In our work, as potential barrier at the contact has been found to be greater than 0.3 eV, we have considered the flow of the current as injection – limited.

We have estimated potential barrier at the metal - organic contact by using Richardson – Schottky (RS) model [18]. We have estimated potential barrier from I –V plot of this device without any nanoparticle and also for different concentrations of TiO_2

nanoparticles. We have also used Norde method to check the consistency of the obtained data from device's I-V plot.

2. Materials

Phenosafranin dye is a cationic dye whose structure is shown in Fig. 1 (a). This dye has been procured from Sigma Aldrich, Germany. Phenazinium dyes have extensive applications in semiconductors [19]. To observe the effect of nanoparticles in this organic dye based device, we have incorporated titanium dioxide nanoparticles (TiO_2) to the PSF cell. We have used TiO_2, which is in anatase form [20]. Its molecular weight is 79.90 g/mol. We have used 100 nm size TiO_2 nanoparticles. The TiO_2 nanoparticles have been brought from Sigma-Aldrich, Germany. Here the structure of the TiO_2 nanoparticles is depicted in Fig. 1 (b).

(a)   (b)
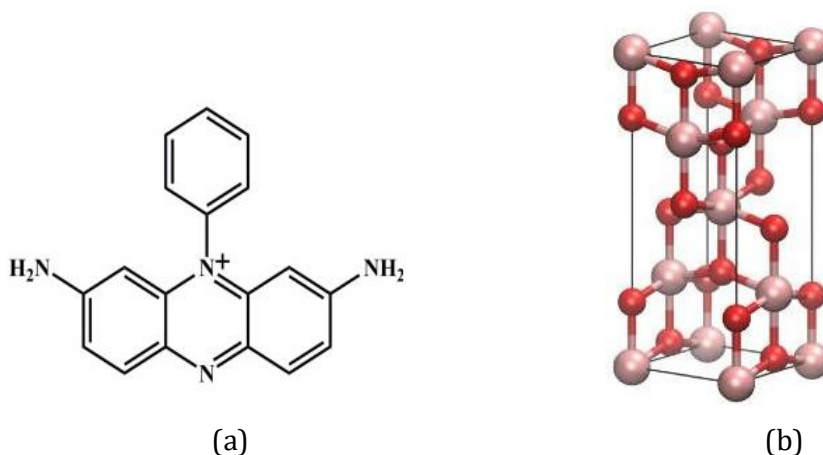
Fig 1 Structure of (a) Phenosafranin (PSF) dye and (b) Titanium dioxide (TiO_2) nanoparticles

3. Sample Preparation and Measurements

At first the PSF dye solution is prepared without any nanoparticle. In one of our earlier works [21], we have mentioned the PVA solution making technique. Now 2 mg of PSF is added in the solution and stirred for 10 minutes. One part of this solution is kept aside in a pre cleaned test tube. Then in the other portion of PSF dye solution, 2 mg TiO_2 nanoparticles is added and well stirred. A PSF: TiO_2 = 1:1 solution is kept separated. In this solution 2 mg of TiO_2 is added for preparing 1:2 solution. Similarly, the TiO_2 concentrations is increased to prepare 1: 3 and 1: 4 solutions of PSF : TiO_2. After preparing the solutions, PSF solution without any nanoparticle is spin coated at 1500 rpm speed and dried at 3500 rpm speed on a pre cleaned Indium Tin Oxide coated glass substrate. Similarly, the solution is deposited on the Aluminum (Al) coated mylar sheet and then ITO coated glass and Al-M are sandwiched together to form the cell. This cell and also other cells made of different solutions are vacuum dried for 12 hours.

Concentrations of PSF: TiO_2 in the other four cells are 1:1, 1:2, 1:3 and 1:4. Fig. 2 expresses schematic of Phenosafranin (PSF) dye based organic device. The thickness of each layer of the sandwiched structured device which are comprised of ITO electrode, PSF dye- nanoparticles composite and Al-M electrode are $1.3\mu m$, $4\mu m$ and $1.7\ \mu m$ respectively.
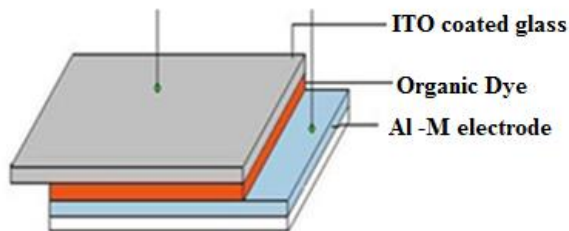
Fig. 2 Schematic diagram of the organic device

Figures 3 (a), 3 (b), 3 (c) and 3 (d) show the SEM images of four different concentrations of titanium dioxide nanoparticles in the four cells comprising of PSF: TiO_2 in the ratios of 1:1, 1:2, 1:3 and 1:4 respectively.
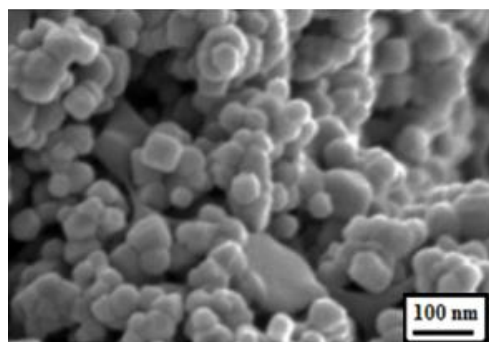
(a)
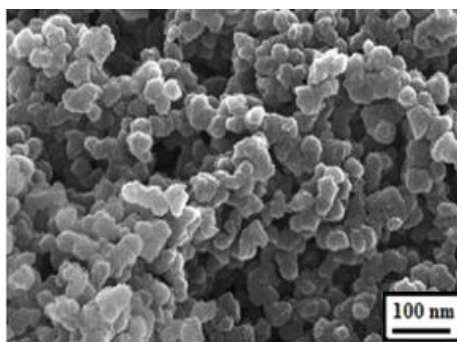
(b)
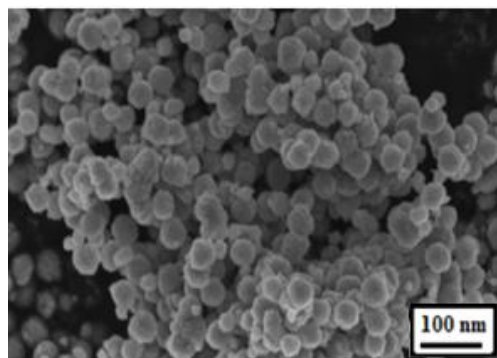
(c)
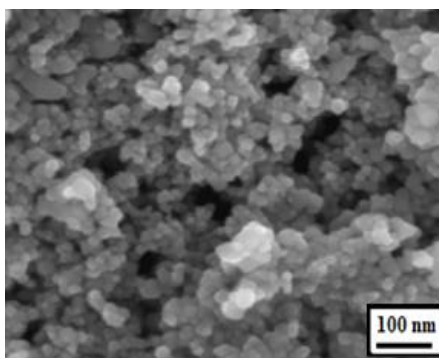
(d)

Fig. 3 SEM images of four different concentrations of TiO_2 nanoparticles in four different organic devices comprising of PSF: TiO_2 in the ratios of (a) 1:1, (b) 1:2, (c) 1:3 and (d) 1:4 respectively

In Fig. 3 (a) the SEM image reveals highly agglomeration of titanium dioxide nanoparticles. Agglomeration of nanoparticles affects the characteristics of nanoparticles and these agglomerates significantly decrease the number of nanoparticles in nanocomposites at a constant filler concentration [22]. The image in Fig. 3 (b) shows a slight decrease in agglomeration of titanium dioxide particles. Fig. 3 (c) shows SEM image which reveals clearly defined titanium dioxide nanoparticles. There are noticeable voids and pores on the surface. With increasing concentration of titanium dioxide nanoparticles, an alteration in the structure has been observed which is shown in Fig. 3 (d). It has been assumed that the observed big chunks are caused by higher supersaturation concentration of titanium dioxide nanoparticles since the atoms are readily available for random growth.

Keithley 2400 source measurement unit has been used for current – voltage measurement. In one of our earlier works, the detail of the current – voltage measurement technique is discussed [23]. The voltage range is kept in between 0 to 6 V in steps of 0.2 V with delay of 1000 ms. The room temperature was kept at 25^0C.

4. Results and Discussion

Steady – state current – voltage (I - V) plot of the PSF organic device without any nanoparticle and with different TiO_2 nanoparticles concentrations have been shown in Fig. 4. This figure shows that current improves with the increase TiO_2 nanoparticles concentration. When the concentration ratio of PSF and TiO_2 nanoparticles is 1:4, the current flow in the organic device is highest compared to other concentration ratios of PSF and TiO_2 nanoparticles which are 1:1, 1:2 and 1:3 respectively. The current flow is lowest when there is no nanoparticle present in the PSF dye based device. We can infer from these I-V plots that, charge injection process gets improved in presence of nanoparticles which can be related to the filling of traps. These traps are also act like recombination centres. By filling the traps, charge flow gets improved due to the presence of TiO_2 nanoparticles, which will also be resulting in potential barrier lowering at metal –organic contact.

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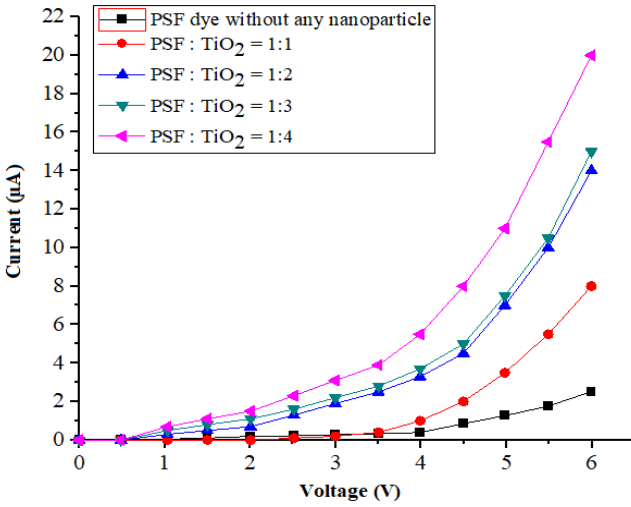
Fig. 4 Dark I-V plots of PSF dye without any nanoparticle and with different TiO_2 nanoparticles concentrations

Potential barrier is estimated from semi-logarithmic I – V plot of organic device without any nanoparticle and with different TiO_2 nanoparticles concentrations which has been shown in Fig. 5. This figure shows with introduction of TiO_2 nanoparticles, the potential barrier is lowered. Potential barrier is smallest when the concentration ratio of PSF dye and TiO_2 nanoparticles is 1:4 and it is highest for this device when no nanoparticle is present.
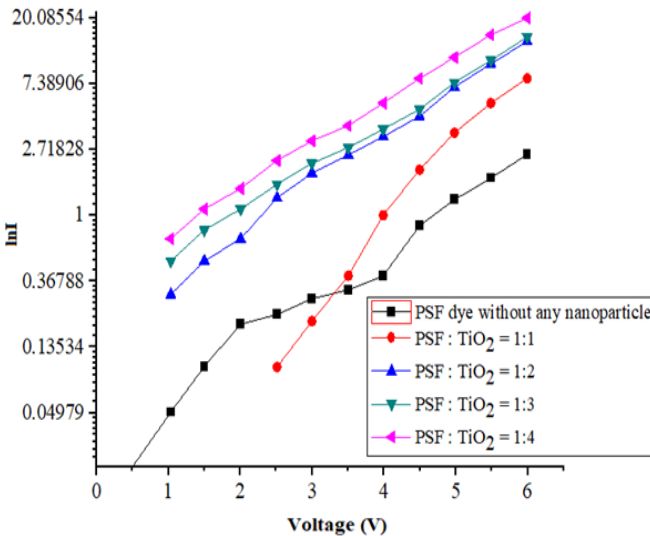
Fig. 5 Semi log I-V plots of PSF dye without any nanoparticle and with different TiO_2 nanoparticles concentrations

We have analyzed the current voltage characteristics of this PSF dye based device by using Richardson- Schottky (RS) model. Current is expressed as given by the following equation (1-2)

$$I = AA^*T^2 \exp(-\beta\phi_b)\left(\exp\left(\frac{qV}{nkT}\right)\text{-}1\right) \qquad (1)$$

$$I_0 = AA^*T^2 \exp(-\beta\phi_b) \qquad (2)$$

Where, $\beta = (q/kT)$ and q is the charge of electron, V is the voltage that is applied to the device, A is the device area, k is the Boltzmann's constant, T is absolute temperature, A^* is the effective Richardson constant, n is the ideality factor and ϕ_b is the potential barrier and I_0 is the saturation current [24-30]. The area of all the devices is of 1.5 cm^2.

Determination of saturation current is done by finding Y-axis intercept of ln (I) vs V curves and ϕ_b is obtained from I_0 extrapolation in the semi log forward bias I – V plot.

The potential barrier of prepared device can be estimated from equation (3) [31-32] which can be deduced from equation (2)

$$\phi_b = \frac{1}{\beta}\ln\left(\frac{AA^*T^2}{I_0}\right) \qquad (3)$$

We have also calculated potential barrier by Norde function. Norde function interrelates function F (V) and the current I (V). The expression has been shown in the equation given below (4) and I (V) is the current, measured from I-V characteristics of the device where all symbols carry their usual meaning [33].

$$F(V) = \left(\frac{V}{\gamma}\right) - \frac{1}{\beta}\ln\left(\frac{I(V)}{AA^*T^2}\right) \qquad (4)$$

where γ is the first integer greater than n.

In Fig. 6, the potential barrier is estimated without any nanoparticle and with different TiO_2 nanoparticles concentrations. The expression is shown in the following equation (5) [34-35] where F (V_{min}) = minimum value of Norde function.

$$\phi_b = F(V_{min}) + \frac{V_0}{\gamma} - \frac{1}{\beta} \qquad (5)$$

Fig. 6 shows that with presence of TiO_2 nanoparticles, potential barrier is lowered and the calculated values of this parameter remain consistent with the values obtained from device's I -V plot. The potential barrier estimated by Norde function also shows that ϕ_b is lowest when the concentration ratio of PSF dye and TiO_2 nanoparticles is 1:4 and it is highest when the device is fabricated without any nanoparticle.

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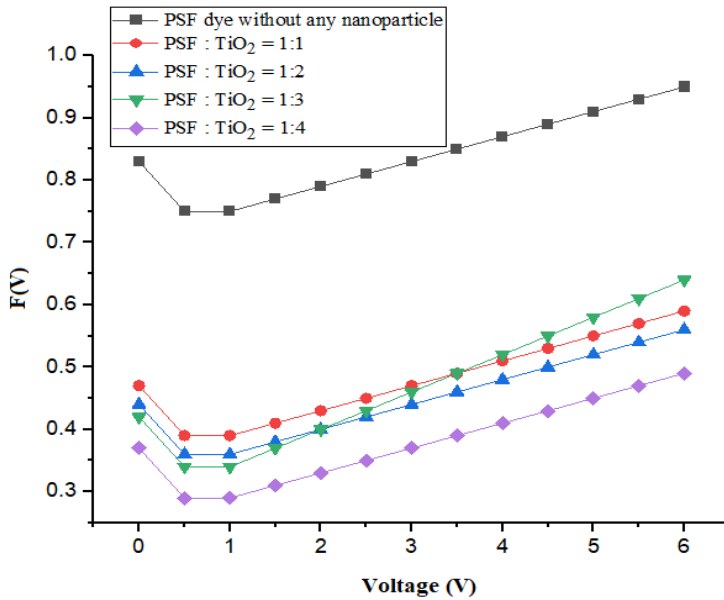
Fig. 6 Norde Function of PSF dye in absence of any nanoparticle and in presence of different concentrations of TiO_2 nanoparticles

The calculated values of potential barrier from I-V plots and by Norde function is shown in Table I given below

Table I Calculation of Potential Barrier of PSF Organic device without any nanoparticle and with different TiO_2 nanoparticles concentrations

Devices (PSF:TiO2)	Potential Barrier from I – V Plot (eV)	Potential Barrier from Norde Function (eV)
Without any nanoparticle	0.81 ± 0.05	0.83
1:1	0.44 ± 0.05	0.47
1:2	0.43 ± 0.05	0.44
1:3	0.40 ± 0.05	0.42
1:4	0.38 ± 0.05	0.37

From the above table it can be seen from analyzing steady state I-V plots that both the methods are in unison in showing that potential barrier is reduced maximum in the PSF: TiO_2 nanoparticles composition of 1:4.

5. Conclusions

In this work, we have estimated potential barrier at M/O contact of PSF organic device with different titanium dioxide (TiO_2) nanoparticles concentrations. The potential barrier has been estimated by using I-V plot of organic device. The values of potential

barrier obtained from I-V plot analysis remain consistent with values estimated by using Norde method. It has been found out that the potential barrier is lowest for the highest concentration of TiO_2 nanoparticles in the composite of PSF and TiO_2 nanoparticles. When the concentration ratio of PSF and TiO_2 nanoparticles is 1:4, it gives least potential barrier at the interface compared to other concentration ratios of PSF and TiO_2 nanoparticles which are 1:1, 1:2 and 1:3 respectively. The potential barrier is highest when the PSF organic device is formed without any nanoparticle. It can be inferred from these results that the presence of higher concentrations of TiO_2 nanoparticles improve flow of charge by potential barrier lowering at M/O contact which can also be ascribed to filling of traps. The device conductivity will also be ameliorated due to improved charge flow at M/O contact.

Acknowledgements

Conflicts of Interest

Both the authors declare that no conflict of interest is present regarding this present work.

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Low-Energy Quark Mass Test for *U* and *D* via Elastic Form Factors

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Abstract

The study was aimed at providing a device to estimate the range of values of the *u*- and *d*-quark masses through the elastic *ep*-scattering form factors at the low energy regime. ROOT generated *dcsep* data sets, from theoretical and experimental form factors, were compared to modified *dcseq* and their intersections were determined from the average of a total of 3000 events for each *dcs* at various scattering angles selected randomly from 0° to 180°. The proton mass was required as a parameter used in the relativistic recoil factor of *dcseq* to shift its distribution closer to *dcsep* thereby attaining the critical intersections. For quarks carrying effective masses, the extrapolated energy intersection of *dcsep* generated from the average of all form factors with the modified *dcseu* is $226.00013 MeV^2$ and this is lesser than that of the modified *dcsed* at $1093.00004 MeV^2$ with bin size of $1 MeV^2$ and their respective *dcs* intersections are 10.07049x10-4 and 0.36976x10-4, in barns. Summary of results are also given for quark masses derived from MS scheme and Lattice QCD. By considering all possible scattering angles at fixed transfer momentum, the relativistic recoil factor was treated as a constant that shifted the distribution and gave rise to a tool in estimating quark mass range.

Keywords: Quark Masses, Form Factors, *dcs*, Proton Mass, Relativistic Recoil Factor

Introduction

The up (*u*) and down (*d*) quarks are the lightest generation of quarks. As major constituents of matter, they form the proton (*uud*) and neutron (*udd*). Their respective

masses, m u=2.2+0,5- 0.4MeV and md=4.7+0,5-0.3MeV, are estimates in a Mass-independent Subtraction (MS) scheme [19]. They were first observed by experiments at the Stanford Linear Accelerator Center (SLAC) in 1968 [3,5] through deep inelastic scattering (DIS) experiments which indicated the protons to be made-up of three of these fundamental substructures [8]. Despite being common, the bare masses of u and d are not well determined. However, Lattice QCD calculations have a more precise value of 2.01±0.14MeV/c^2 and 4.79±0.16MeV/c^2, respectively [7].

Masses of quarks are fundamental parameters of the Standard Model. Quarks are confined inside the hadrons and are not observed as physical particles, therefore, quark masses cannot be measured directly but must be determined through their influence on hadronic properties.

Any quantitative statement about the value of a quark mass must refer to the particular theoretical framework that is used to define it. The quark masses for light quarks are often referred to as the current (bare) quark masses. Non-relativistic quark models use constituent (effective) quark masses, which are in the order of ~350MeV for the u and d quarks. Constituent quark masses model the effects of dynamical chiral symmetry breaking and are not directly related to the quark mass parameters of the QCD Lagrangian. Constituent masses are only defined in the context of a particular hadronic model. For mass measurements in lattice gauge theory one computes a convenient and appropriate set of physical quantities, frequently chosen to be a set of hadronic masses, for a variety of input values of the quark masses; precise measurements are determined by the lattice spacing a, that is the distance between neighboring points of the lattice and quark masses. The true physical values of the quark masses are those which correctly reproduce the set of physical quantities being used for the calibration. In the particle data listings, quark masses have been obtained by using a wide variety of methods. Each method involves its own set of approximations and uncertainties. In most cases, the errors are an estimate of the size of neglected higher-order corrections or other uncertainties. It is also important to note that the quark mass values can be significantly different for different schemes. At low energy Quantum Chromodynamics (QCD) where both perturbation theory and asymptotic freedom are not possible, the collective interactions between valence and sea quarks become significant. The effects of virtual quarks and gluons in the sea of quarks are assigned to some particular quarks, which get surrounded by the dense cloud of virtual quarks and gluons. This cloud is a high energy barrier concealing the current quark at the core. This system is called constituent quark with an effective mass. The bare masses of u and d are so light that they cannot be straightforwardly calculated because relativistic effects have to be taken into account.

Form factors used to generate differential cross section of elastic electron-proton scattering (*dcsep*) were measured through various methods. One of which is by Rosenbluth Extraction Method which obtains them from the plot of the reduced cross section versus the square of the transfer momentum at several angles by determining the plot's slope and intercept, and performing linear regression with it [14]. With the

world data [1,2,13,17,20], the form factor ratio is consistent to ~1.0 at very low energies. Another is by Polarization Transfer Method, wherein the form factor ratio is measured through polarization transfer where longitudinally polarized electron beam is scattered from an unpolarized proton target. For ep-scattering in the single-photon exchange, it was shown that the normal component of polarization vanishes and the transverse and longitudinal components satisfy certain conditions [15]. Without the need to measure the cross-sections, this gives the form factor ratio but which does not agree well Rosenbluth measurements. Form factor ratio from polarization transfer are well fit by 1-0.13($Q2$-0.04) [9]. The Super-Rosenbluth method of form factor extraction is associated with smaller angular-dependent corrections. And here, it is the protons that are scattered rather than electrons. Experimental data and results of elastic simulation from [14] used the Bosted global fit of previous Rosenbluth data from [4] due to the slight variation of Q^2 across the finite momentum and angle acceptance. P.E. Bosted ensured that form factors from the elastic simulation gave the closest corresponding final cross section. However, it is only valid at $0<Q^2<7 GeV^2$. Another fitting procedure was presented in [22] and explained with details in [16]. For the proton, simultaneous fitting on form factors to the data were performed and the fit is a bounded polynomial z-expansion [12]. This global data fitting procedure is valid up to $Q^2 \sim 30 GeV^2$.

Since the masses of u and d are not directly calculated, a device test can be formulated to estimate their masses via the measurement of the dcs generated from the form factors of elastic ep-scattering. The main objective of this study is to develop a technique in the mass estimation of u- and d-quarks with the proton mass as a parameter (and vice-versa) using the $dcsep$ generated from theory and experiments. The investigation was mainly to determine the energy and dcs intersections of $dcsep$, $dcseu$ and $dcsed$ where the quarks assume the minimum/ maximum bare and effective masses by modifying the relativistic recoil factor using the proton mass at the low energy regime.

Methods

The generated $dcsep$ data sets are compared to the modified $dcseq$, where q is either u and d, and their intersections were determined within the low energy regime. In the generation of $dcseq$, the quarks were assigned bare and effective (low energy) masses [10,18,19,21], separately. The relativistic recoil factor of $dcseq$ of the spin-averaged eq-scattering is modified by using the mass of the proton in order to shift the distribution of $dcseq$ closer to $dcsep$ and thereby putting a possibility of finding an energy intersection with it. This energy intersection actually means the square of momentum transfer at which the two dcs meet. This materializes the proton mass a parameter in the determination of the quark mass estimates. The dipole proton form factors (dff) [11] and form factors derived from the fitting of experimental data, such as polarization transfer fitting (ptf) [14], Bosted global fitting (bgf) [4] and global data fit (gdf) [22]; and the average of all form factors (aff) were used to generate the data for $dcsep$. Using these form factors, the $dcsep$, $dcseu$, and $dcsed$ were generated simultaneously in ROOT Data Analysis Framework [6]. The value for the anomalous magnetic moment of the proton

used is ^=2.793 and the mass of proton is set at m p = 0.938272081±0.000000023 GeV. A total of 3000 events each for $dcsep$, $dcseu$, and $dcsed$ were gathered at various scattering angles randomly selected within 0° to 180°. Then, they were averaged for each data point.

Analysis

The $dcsep$ and $dcseq$ are curves in the dcs versus Q^2 plot but there is no assurance of their intersection in at least one point unless alterations have to be implemented. So, the proton mass was required as a parameter in the quarks mass test. This can be done through modifying the relativistic recoil factor of $dcseq$ using the mass of proton, instead. For a fixed scattering angle or considering all angles, the relativistic recoil factor is just a constant at a particular transfer momentum. Doing so does not alter the distribution, however, it shifts the dcs vertically. Considering this modification could make the possible attainment of an energy intersection. With the proton mass in the recoil factor, the existence of an energy intersection at low-energy is highly probable. The proton mass parameter becomes the link between the two dcs curves. It should be noted that polarization transfer fitting (ptf) diverges at $Q^2 \sim 7.7 GeV^2$ and Bosted global fit (bgf) is valid only at $Q^2 \sim 7 GeV^2$. Hence, it is important that the intersections should be below these valid transfer momentum limit. To give a general applicability of the technique, the values of u- and d-quark bare masses (minimum and maximum) and the effective masses were used. Effective quark masses are important since they dominate at low energy. Table 1 summarizes the bare and effective masses used as inputs to determine the energy and cross section intersections.

Table 1. Mass range for u and d in MeV. _____ _____

Measurement schemes	$u$min	$u$max	$d$min	$d$max
MS scheme [19]	1.80	2.70	4.40	5.20
Lattice QCD [7]	1.87	2.15	4.63	4.95
Effective mass [10]	336		340	

Estimation of the masses of u- and d-quarks using the generated $dcsep$ from form factors coming from different fitting models has to establish the energy at which $dcsep$ and modified $dcseq$ intersect with the globally accepted proton mass as a parameter. Once the energy intersections and their corresponding form factors are determined and established, then the dcs can be generated and from it the range of masses will be obtained. Oppositely, with an established energy intersection, a range of values of u and d quark masses can be plugged-in to the modified $dcseq$ to obtain the accepted experimentally derived proton mass. Hence, a technique is developed for the mass estimation of u- and d-quarks using the generated dcsep from form factors derived from experiments. Different experiments give different dcs corresponding to different form factors, whichever come first at a given energy, vesting a range of values for the quark

masses as inputs to obtain the mass of the proton which is also determined in a multitude of ways.
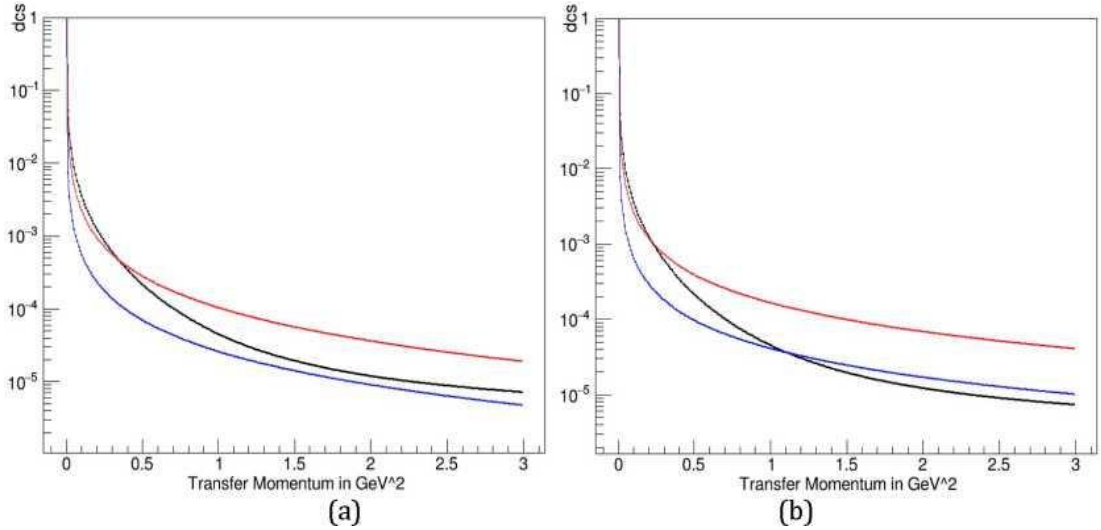
Figure 1. (a) The differential cross section (*dcs*) of the *eu*-scattering (red) and *ed*-scattering (blue) carrying effective masses are compared to that of *ep*-scattering (black) generated from the averaged form factors (aff). (b) The *dcseu* (red) and *dcsed* (blue) carrying effective masses are compared to *dcsep* (black) generated from aff with scattering angles ranging from 0°-180°. The intersections are pronounced here.

Results

The global data fit (gdf), one of the four form factor data fittings considered, does not agree well with the other three. This is due to the coefficient parameters of the curve. The limits of coefficient parameters are chosen only when actual data are available for analysis. For this study, it is assumed that the *dcs* data points generated from this fitting procedure are the deviants to the expected outcomes and they constitute 25% to the *dcs* generated from the average form factors (aff). The choice of coefficient parameters for gdf, to be within -0.214 to 0.214, is a compromised one and was based on the criteria that *dcsep* generated from gdf should produce an intersection with the modified *dcseq* not beyond $3 GeV$ for both the modified *dcseu* and *dcsed*. It should be noted that gdf has a validity of up to $\sim 30 GeV^2$, that is way beyond the limits of polarization transfer fitting (ptf) and Bosted global fit (bgf) which are valid only up to $\sim 7 GeV^2$.

Comparisons of the generated *dcsep* between *dcseu* and *dcsed*, where quarks assume the bare masses, have large disparities and no intersections were observed. However, in Figure 1(a) where quarks have effective masses, intersection can exist between the curves, see Tables 2 and 3, for the summary of energy and *dcs* intersections. The extrapolated average energy intersection of *dcsep* from aff with *dcseu* is $346.00008 MeV^2$.

It has no intersection with *dcsed* but they were closest at $\sim 1954.54339 MeV^2$. Their corresponding extrapolated *dcs* are 4.58726x10-4 and ~ 1.1597x10-5 in the units of barn, respectively.

Table 2. Accessible low energy intersections of *dcsep* and *dcseq* in MeV^2 with bin size of 1 MeV^2 and where the quarks assume effective masses. _____ _____

Quark mass	dff	pft	bgf	gdf	aff
^{u}effective	452.00004	485.00005	426.00001	2077.00001	346.00008
^{d}effective	1243.00018	1494.00005	1277.00001	281.00002	* ~ 1954.54339

*there is no intersection at this energy but the *dcs* are closest here.
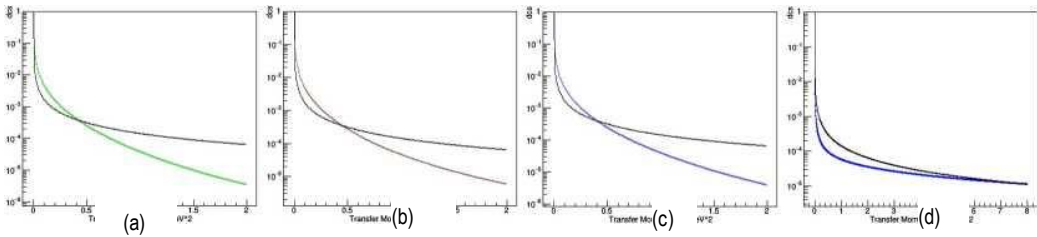
Table 3. Corresponding *dcs* (barns) intersections of *ep* and *eq*-scatterings in Table 2.

Quark mass	dff (x10-4)	pft (x10-4)	bgf (x10-4)	gdf (x10-4)	aff (x10-4)
^{u}effective	3.19285	2.89796	3.46249	0.34019	4.58726
^{d}effective	0.18923	0.14330	0.18169	1.52151	~ 0.11597

Figure 2. The *dcseu* (black) with minimum bare mass are compared to *dcsep* generated from (a) dff, (b) ptf, (c) bgf and (d) gdf form factor data sets.

Modifying the relativistic recoil factors caused the *dcseq* distributions to shift nearer to the *dcsep*, see Figure 1(b) for quarks carrying effective masses and Figure 2 for quarks carrying minimum bare masses. Due to the shift, intersections were observed. The energy intersections between *dcseu* and the generated *dcsep* from different form factor fitting were around the extrapolated value of $407 MeV^2$ to $450 MeV^2$ except for gdf which is beyond $7 GeV^2$. For *dcsed*, the energy intersections with *dcsep* occur beyond $1 GeV^2$ except for the ones generated by gdf which register around $183 MeV2$. In order to provide a range for the bare mass estimate of the quarks, their minimum and maximum values from MS scheme were used as inputs for this test.

Table 4. Low energy intersections of *dcsep* and *dcseq* in MeV^2 with bin size of 1 MeV^2.

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Quark mass	dff	pft	bgf	gdf	aff
u bare mass min (ms)	428.00033	450.00017	407.00002	> 8000.00000	349.00016
u bare mass max (ms)	428.00032	450.00016	407.00003	> 8000.00000	349.00015
d bare mass min (ms)	1037.00000	1171.00025	1051.00015	183.00000	1272.00005
d bare mass max (ms)	1037.00001	1171.00027	1051.00016	183.00000	1272.00004
u effective mass	324.00009	338.00005	297.00001	> 8000.00000	226.00013
d effective mass	953.00003	1075.00014	962.00015	534.00004	1093.00004
u bare mass min (lqcd)	428.00033	450.00017	407.00002	> 8000.00000	349.00016
u bare mass max (lqcd)	428.00033	450.00017	407.00002	> 8000.00000	349.00016
d bare mass min (lqcd)	1037.00001	1171.00026	1051.00016	183.00000	1272.00005
d bare mass max (lqcd)	1037.00001	1171.00026	1051.00016	183.00000	1272.00004

Table 5. Corresponding *dcs* (barns) intersections of *ep* and *eq*-scatterings in Table 4.

Quark mass	dff (x10⁻⁴)	pft (x10⁻⁴)	bgf (x10⁻⁴)	gdf (x10⁻⁴)	aff (x10⁻⁴)
u bare mass min (ms)	3.61778	3.42626	3.82414	< 0.10935	4.51368
u bare mass max (ms)	3.61775	3.42622	3.82410	< 0.10935	4.51363
d bare mass min (ms)	0.33880	0.29505	0.33375	2.24898	0.26820
d bare mass max (ms)	0.33880	0.29504	0.33375	2.24889	0.26820
u effective mass	6.56931	6.24876	7.29239	< 0.10959	10.07049

^{d}effective mass	0.43926	0.37751	0.43419	0.89979	0.36976
^{u}bare mass min (lqcd)	3.61778	3.42625	3.82413	< 0.10935	4.51367
^{u}bare mass max (lqcd)	3.61777	3.42624	3.82412	< 0.10935	4.51366
^{d}bare mass min (lqcd)	0.33880	0.29505	0.33375	2.24895	0.26820
^{d}bare mass max (lqcd)	0.33880	0.29504	0.33375	2.24892	0.26820

The extrapolated energy intersection of *dcsep* generated from aff with the modified *dcseu* carrying the minimum bare mass is $349.00016 MeV^2$ and this is greater than that of the modified *dcseu* carrying the maximum bare mass at $349.00015 MeV^2$; their respective extrapolated *dcs* intersections were at 4.51368×10^{-4} and 4.51363×10^{-4}. The extrapolated energy intersection of *dcsep* generated from aff with the modified *dcsed* carrying the minimum bare mass is $1272.00005 MeV^2$ and this is greater than that of the modified *dcsed* carrying the maximum bare mass at $1272.00004 MeV^2$; their respective extrapolated *dcs* intersections were both at 0.26820×10^{-4}. For quarks carrying effective masses, the extrapolated energy intersection of *dcsep* generated from aff with the modified *dcseu* is $226.00013 MeV^2$ and this is less than that of the modified *dcsed* at $1093.00004 MeV^2$ with respective *dcs* intersections at 9.83012×10^{-4} and 0.36743×10^{-4}. For quark masses calculated from Lattice QCD, the extrapolated energy intersection of *dcsep* generated from aff with the modified *dcseu* carrying the minimum and maximum bare masses were both at $349.00016 MeV^2$; their respective extrapolated *dcs* intersections were at 4.51367×10^{-4} and 4.51366×10^{-4}. The extrapolated energy intersection of *dcsep* generated from aff with the modified *dcsed* carrying the minimum bare mass is $1272.00005 MeV^2$ and this is greater than that of the modified *dcsed* carrying the maximum bare mass at $1272.00004 MeV^2$; their respective extrapolated *dcs* intersections were both at 0.26820×10^{-4}. All intersections are summarized in Tables 4 and 5.

Conclusions and Recommendations

Indeed, a device to estimate the range of quark masses for *u* and *d* via the elastic *ep*-scattering at low momentum transfer can be possible by generating *dcsep* data sets from form factors and comparing them to the modified *dcseq*, where *q* is either *u* and *d*, wherein the proton mass is a parameter. The theoretical dipole form factor and some form factor fitting models used in experiments such as the polarization transfer fitting, Bosted global fitting, global data fit and their average were used to generate the *dcsep*. The *dcsep*, *dcseu* and *dcsed* would have been independent of each other without the modification of the relativistic recoil factor since they do not possess a critical

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intersection that could be exploited. By using the mass of the proton into the relativistic recoil factor of the spin-averaged *eq*-scattering, the *dcseq* distribution was shifted closer *dcsep* and thereby increasing the possibility of intersection. Materializing the proton mass as a parameter, intersections were observed within the low energy regime by using the experimental quark masses as inputs. These intersections were summarized in Tables 2 through 5. Once established, these intersections can be used on experimental elastic *ep*-scattering data in order to estimate the masses of *u* and *d*, as well. Using most, if not all, data from actual experiments, a global range of *u* and *d* can be estimated. For the estimation of effective quark masses, both the intersections of the raw and modified *dcseq* have to be used simultaneously. One of the things to be done in making the intersections formidable would be incorporating additional form factor fitting models and to integrate the results of the actual experiments as they come. Generating the *dcs* with much smaller bin sizes is recommended to give a more precise measurement of the intersections. Also, choosing the optimum coefficient parameters for gdf could lead to a better result. Although the protons are measured in a multitude of ways, but more precise mass ranges of *u* and *d* are led by the precise measurement of its mass being the parameter of the test. The accuracy of the results can also be improved by generating even more events and considering more scattering angles. All of these recommendations, however, would entail much more computing power.

Acknowledgment

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Interior Materials and Colors for Study Room Comfort

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Abstract

The article studies the properties of interior color schemes and finishing materials in order to find optimal combination for improving indoor conditions in higher education study room and to contribute to better educational process. Optical, physical, physiological and emotional properties of colors and materials are compared to living and study requirements in the context of their complexity. Recommendations for appropriate combinations of finishing materials and colors are given.

Keywords: higher education, interior color, interior material, study room, living comfort

Introduction

Higher education study is a complex process. Existing facilities rarely meet the contemporary comfort requirements and are not designed toward providing conditions supporting properly the multiple tasks of study process. Prospects for using the research results are creating color-material combinations for high education study room in order to improve study process for both students and lectors.

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The goal of this research is to define optimal combinations of interior covering materials and color schemes to provide alternative solution to interior comfort requirements regarding study process in higher educational facility in Sofia, Bulgaria. In the article study room exploration period and color design are analyzed. Optical, physical, physiological and emotional properties of colors and materials are studied regarding the way they alter human perception about the space and its elements.

Researches on color in architecture date from the very early written sources up to nowadays [16]. Studies on color impact upon temperature perception date back from 60-ies of 20-th century [8]. Studies of interior materials imoact upon inhabitants date back to the 90-ies of 20-th century [19]. Studies about contemporary education specifics and new kind of space organization it requires, including comfort levels. Researches about finishing materials study the way they improve interior thermal, light and acoustic comfort, regardless of color scheme.

Color studies can be categorized by their duration, by the way they are held, by the studied subject, by selected target group, by studied activities and by the results.

There are few studies of the role of study room color-material combination as a means to solve the complex task improving indoor comfort and study and creativity process as well.

1. Study room analysis

1.1. Higher educational process changes

Higher education system is undergoing qualitative changes affect the students and the process of studying [1]. Results of the process are to be specialists technically and emotionally intelligent [3]. Though technologies development raises a discussion about necessity of physical space for studying process, there are solid arguments in favor of physical presence [4]. However great part of higher education facilities is built in earlier periods and organized for different educational system and processes. Meeting the new study process requirements raises the need for new kinds of spaces and organization. Based upon the trend for sustainable development outlining resource and economical shortages new buildings are not always possible solution [6]. Revitalization and modernization of existing ones becomes a priority [7].

Two main groups of contemporary requirements can be identified. Building constructions are expected to meet contemporary requirements for energy efficiency, environmental-friendly materials and technology-supporting qualities.

Study environment is expected to provide the necessary conditions for the ongoing processes including thermal comfort, air quality, light comfort, acoustic comfort, learning and information assimilation, problem solving, recreating and socializing.

In addition to conventional approaches, alternative developments are also considered. Such is the application of colors and materials according to their optical, physical, physiological and emotional properties.

1.2.   Higher education study room analysis

Permanent inhabitants are students (20 + persons) average aged about 22 years.

Temporary residents re lecturers and assistants, time of stay and age vary.

Activities vary from lecturing, practical exercises, self training to socializing and recreating.

The combination of various activities and occupants requires combined approach towards improved working and study environment [5] and meeting inhabitants' preferences [6]. Significant amount of objective and subjective factors are to be taken into account in order to create optimal comfort.

Period of active use is 2-8 hours per day, average 5 days in a week, from September to June. No or seldom incident use in July and August.

Fig.1 displays that periods of active visiting of study room coincides with weather periods of lower temperatures and predominant cloudy.
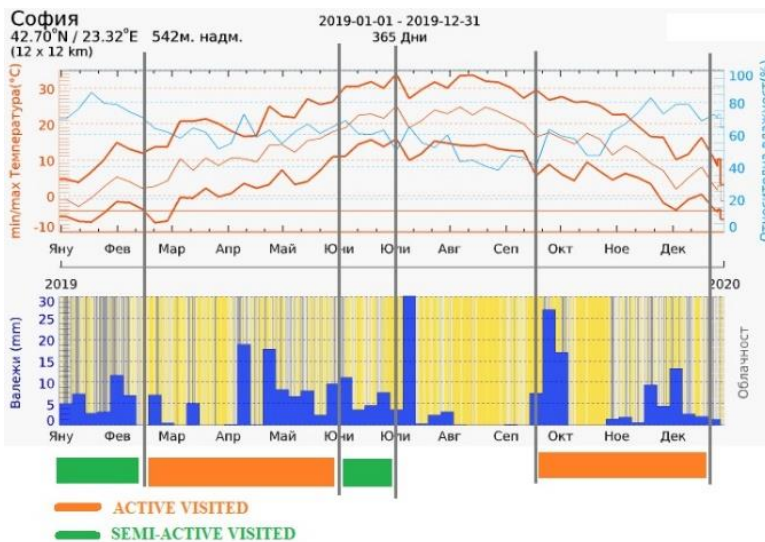
Fig.1 Monthly visiting activity compared to weather data for a year period (data source: https://www.meteoblue.com/bg/времето/historyclimate/weatherarchive/София_re publika-bulgariya_727011)

83% of the inhabitants reveals admit that study rooms "feel" cold and dark more than half of the time. Conclusion is that priority should be given to improving heat and light comfort.

Since the building is insulated with 10 cm XPS, colors and materials should be considered as a means to alternate heat and light comfort perception of the inhabitants.

1.3. Higher education study room color design analysis

The comparison illustrated in table 1 reveals that the application of colors according to those properties that contribute to increasing the comfort of the occupants does not appear in the traditional color scheme of a study room.

Table 1. Comparison of traditional study room colour design with modern requirements

Modern requirements	Traditional colour design
information about surrounding objects, functional zones marking	information about surrounding objects, functional zones marking
aesthetic value	aesthetic value
symbolic meaning	-
according to the perceptions and preferences of inhabitants	-
visual supplementation and adjustment of living environment characteristics	-
light distribution and heat storage	-
physiological and psychological impact on the inhabitants	-
new technologies in covering materials	-

1.4. Choosing higher education study room color scheme

Colors influence light comfort perception through their physical properties to reflect or absorbed light. Centripetal and centrifugal color properties alternate the way space and its elements are perceived [13] (tab.2).

Table 2. Optical properties of colours

color	% reflected visible light	Elements' perciving			
		Zooms in	Zooms out	sharpens	smoothes
white	90			x	
yellow	50-70	x		x	
orange, red, brown	20-40	x		x	
green, blue, purple	15-25		x		x
black	10	x			x

Physiological effects of colors include the stimulation of certain processes in human body [8], [10]. Emotional impact on colors is related to a subjective comfort criteria trough variety of associations color tones and shades induce [15].

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Table 3. Psychological aspects of colour design in study rooms

Colour	Thermal perceiving		Light perceiving		Acoustic perceiving		Space perceiving		Study activities		Mood	
	warm	cold	light	dark	good	bad	broadly	narrow	focus	distract	good	bad
white		x	x				x					
yellow	x		x		x		x		x		x	
orange	x		x		x		x			x	x	
red	x			x				x		x		x
pink	x		x							x	x	
brown	x			x		x		x		x		x
green		x				x		x	x		x	
blue		x	x			x		x	x		x	
violet		x	x			x		x	x			x
black				x		x		x		x		x

1.5. Choosing higher education study room finishing materials

Studies reveal that according to the way they have been processed, materials can lead to lowered blood pressure (wood) [17], can affect air quality perception (wood, cotton, corian) [18], can moderate air humidity and therefore impact air temperature due to exchange of latent heat and also have antibacterial effect, improves acoustic, has positive emotional and tactical effect (wood) [19].

2. Conclusions

When creating material-color design of study room the complexity of activities and inhabitants should be considered. The space should be zoned trough color and material signatures to several functional zones.

Colors to alternate thermal and light comfort perception are light shades of red, orange and yellow.

Colors to activate study process are yellow and purple.

Colors to support problem solving and creativity are red, orange and purple.

Colors to improve student-lector communication process and socialization are yellow and orange.

Materials to improve air and acoustic comfort perception are natural-based materials with minimum procession as wood, cotton and corian. Wood also improves physiological and emotional comfort.

Optimal combinations would be wooden-based covering elements with saturated shades of red, orange, yellow and purple.

Acknowledgments

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An Evaluation of Urban Open Spaces in Larisa, Greece

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Abstract

A great deal of researchers elaborated on the importance of the urban spaces and human life. Urban spaces are necessary types of spaces for a city and they have a timeless value. This research is focused on people's perception about urban spaces in Larisa, Greece, a medium-sized city selected as case study. An electronic questionnaire survey was conducted and conclusions are drawn on how adequate are the urban spaces in Larisa. Moreover, people are asked to propose ideas on how other spaces, function more as urban gaps, can be integrated on the urban grid. In that way, it is easy to study what people believe about the city's life and how the existing urban spaces function. Some conclusions derived from this research can be also useful in succeeding a combined traffic and urban planning in other Greek, in the context of the implementation of a Sustainable Urban Mobility Plan (SUMP).

Keywords: urban spaces, urban gaps, evaluation, questionnaire survey, Larisa.

Introduction

Urban spaces, from ancient times (Rubenstein, 1992) up to the present day, are a key element of cities. Their role has always been important since it was multidimensional as it served a sequence of functions. These functions, according to some researchers (Stefanou and Stefanou, 1999; Ghel, 2006; Kyriakidis and Siolas, 2014) are the result of the morphology of urban spaces while according to others are the parameters that organize and configure these spaces (Moughtin, 2003; Merleau-Ponty, 1962).

Regardless of the point of view, the study of the function of urban spaces is necessary due to the fact that the public spaces of cities, which are the majority of urban areas, have

been described as decadent (Loukaitou-Sideris and Banerjee, 1998; Sarigiannis, 1999). The meaning of the function of urban spaces can arise through research at various scales, such as: (a) microscopically: recording static activities that occur in public spaces and recording the number of pedestrians passing through them in order to identify the activities that are being developed in public spaces, recording the frequency of their repetition and investigating the relationship between physical characteristics of the site and the actualization of the respective activities, (b) macroscopically: recording the frequency of use of specific urban areas and identifying the time frame for visiting these sites, studying -at a city level- the satisfaction of residents from urban areas of the city and exploring urban gaps and the desirable way of deploying them, based on citizens' opinion.

The issues that are listed above, make it possible to understand the fact that for a proper study of social life in urban spaces and to comprehend the degree of satisfaction of the public by these spaces and their degree of success, it is necessary to use a series of methodological tools, such as observation and interviews (Lynch, 1960; Whyte , 1980, Mehta, 2009, Kyriakidis, 2016), flaneuring, photography (Kyriakidis, 2016) or short videos (Whyte, 1980) and questionnaire survey.

The combination of the above methods is partly based on the idea of methodological triangulation, which is a practice that is being implemented in the sciences that are related to the study of human behavior (Teddie and Tashakkori, 2011). However, in case of studying the issue that is being described above, due to the range of the subject, the use of various methods approaches to greater degree the view of Yeasmin and Rahman (2012) which defines that it takes place in order to understand the different dimensions of a phenomenon, since the subject of research is interdisciplinary.

Based on the above mentioned, this research paper focuses on recording the degree of satisfaction of residents from the existing urban areas in Larisa, a greek medium-sized city, used as a case study.
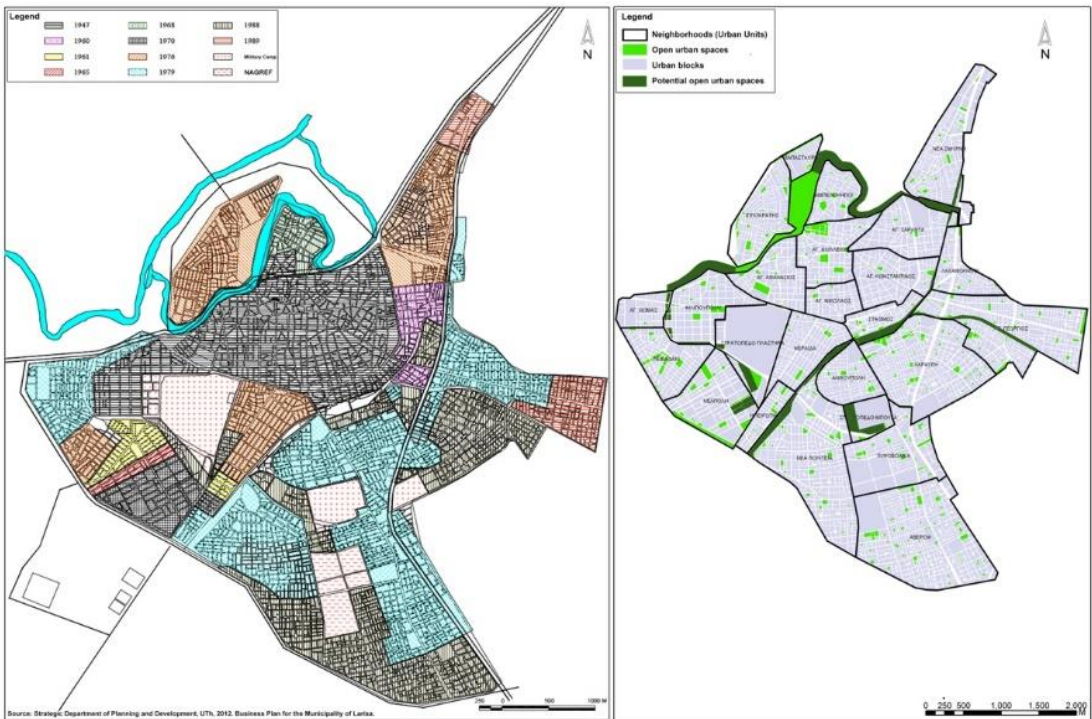
Figure 1. a. Larisa expansion over the years. B. Existing and potential urban open spaces in Larisa. Source: a. Strategic Business Plan for the Municipality of Larisa. (2012). b. Barberis, A. (2007).

Methodology

This research paper is related to Larisa, a medium-sized Greek city (143,848 residents / 2011), which is a typical example of a city with intense urban life, for most of the 24 hours a day (Kyriakides, 2016). The survey was based on a questionnaire survey, conducted electronically from May 2018 to June 2018. The questionnaire contained 15 closed-ended questions or rating scale quetions. Social media have been also used in order to inform the public. Overall, 83 residents of Larisa participated in the survey, men (54.2%) and women, 26 to 35 years of age in the majority (50.6%). Most of them are graduates either from Technological Educational Institutes or from Higher Education Institutions with an area of study in engineering (25.6%) and human sciences (23.2%).

It is worth mentioning that the questionnaire design was based on the results from recording of urban areas of the city and their quality, through a field research that was preceded. In addition, data that generated by press clipping concerning the problems of different urban areas and the intentions of local authorities relating to them have also been used.

The findings of the survey about the degree of satisfaction that urban areas offer are specifically related to Larisa and cannot be generalized in other cities. However, through the survey, suggestions are made for the use of potential urban areas, a fact that can be generalized in similar cases, as with this way it: (a) identifies the reasons that make some areas potentially urban, (b) formulates ideas for the uses that these areas could have and (c) expresses the importance of space management and by whom. These issues are important and relevant to the planning that is being implemented in all Greek cities.

Figure 2. Potential (In terms of design) open urban spaces in Larisa. Figure 2o is the only exiting one. Source: Google Street View.

Discussion with citizens

Larisa is a medium-sized town located approximately in the geographical center of Greece. Since prehistoric times, its center is the Fortress Hill, and a large part of the central area consists of urban spaces. There is also a large number of urban spaces in the other central areas and neighborhoods of the city, since Larisa had been expanded considerably in the twentieth century (Figure 1a). Squares, green spaces, parks and roads, large or small in width, are among the urban areas of the city.

How adequate are the urban spaces in Larisa?
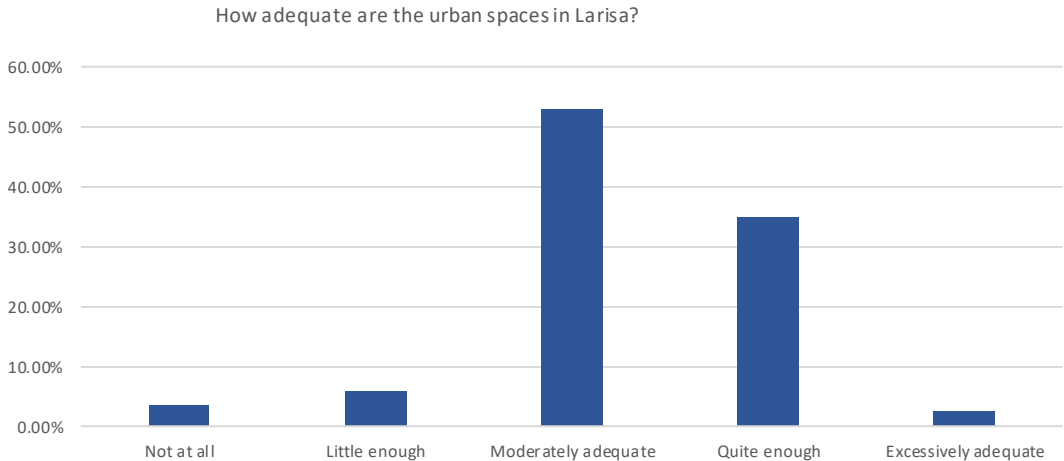
Figure 1b illustrates the urban open spaces and green spaces in Larisa, which are emphasized in the context of this survey. Emphasis is also placed on some other areas that have been criticized as dysfunctional or urban gaps (Figure 1b). As can be clearly seen from Figure 1b, urban areas of Larisa are almost evenly distributed in the city, with most of the urban open spaces being situated in the northern and western parts of it. This means that the residents of Larisa are expected to be satisfied due to the adequacy of the existing urban areas of the city. However, in the questionnaire survey, 53% of respondents hold a neutral stance, with only 37.3% of the respondents considering the existing sites as satisfactory in terms of their configuration and adequate in number (Diagram 1). Although in Larissa, there are four large green areas (riparian area in the city center, Alcázar Park, Hatzi-chalaar Park and the Aesthetic Park); however, the majority of respondents believe that green is the missing element of urban areas of the city (72.1%). Actually, the absence of green, may be a cause that 36.1% does not use as much as they would like the urban areas of the city (Diagram 2). This interpretation may also be related to the fact that most of the residents choose the urban areas of the city center (60.2%) and not the ones of neighborhoods (39.8%), although the neighborhood squares are the main public spaces of neighborhoods.

How often do you visit open spaces in Larisa?
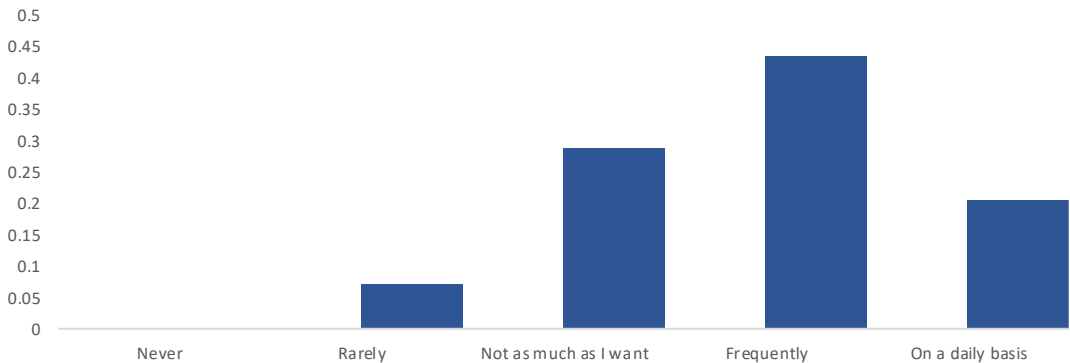
Diagram 1. How adequate are the urban spaces in Larisa? 53% of respondents hold a neutral stance, with only 37.3% of the respondents considering the existing sites as satisfactory in terms of their configuration and adequate in number. Source: Own elaboration.

Diagram 1. People in Larisa prefer to visit open spaces, quite often. However, the absence of green, may be a cause that 36.1% does not use as much as they would like the urban areas of the city. Source: Own elaboration.

In the framework of the same survey, respondents were asked to give their opinion on a number of sites, such as (Figure 2):

- the riparian zone outside the city center, which is not part of the urban fabric. This certain area is unformulated but lies within the urban area, in the northern and eastern parts of the city and today it acts as a boundary between two districts (Agioi Saranda and Nea Smyrni). It is worth mentioning that the General Development Plan for the Municipality of Larissa (2009) predicts the configuration of this area as green spaces and sports facilities.

- the railway line in the south-eastern part of the city, according to Kevin Lynch's (1960) theoretical approach, acts as a functional boundary between the northern and southern parts of the city, as well as the western and the central with the eastern. Actually, the area that covers in the southern part of the city is important, given the presence of a depot and several rail lines. Along the urban section of the railway lines many fatal incidents have occurred. A typical case was the incident with victim a child 10 years old in November 2017 that triggered social reactions (Iefimerida, 2017), and was the reason for discussions in the Hellenic Parliament about the undergrounding of the railway line (Mavroyiannis, 2017) a suggestion that had been proposed by Larisa Strategic Business Plan (2012).

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- the military camps, which have occasionally been attempted by the municipality of Larissa for the concession of army land for the purpose of creating urban spaces and the construction of public land. In this context, spaces of the 1st Army were granted for the opening of a road and the construction of a primary school. In September 2017, there was also the question of granting important land within the city for exploitation by the municipality (Kakaras, 2017). Like the issue of underground railway lines, the removal of the camps was also proposed by Larisa Strategic Business Plan (2012). According to the General Development Plan for the Municipality of Larissa (2009), planning for the relocation of a camp from the area within the project is required to meet the green needs.

- the Hatzi-chalaar Moat –located close to the Bazaar area that is used only a few days within the year-, for which integration into the city was declared an architectural competition in 2008. Although a part of the planned regeneration was implemented resulting in the construction of a park, a large part of the area was left untapped and today it is a vacant area most of the time, is an informal parking area.

Are there any open spaces that should be integrated in the urban grid?
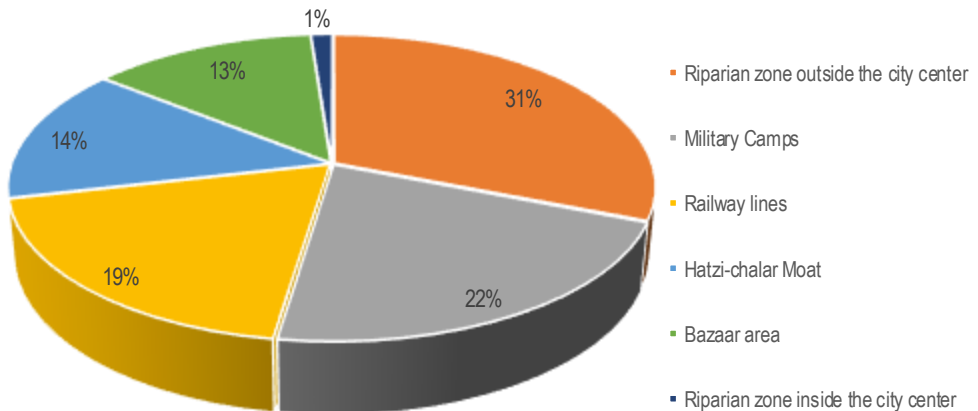
Diagram 3. The most important open space that should be integrated in the urban grid is the riparian zone, outside the city center. Source: Own elaboration.

Of the above sites, the riparian zone outside the center was assessed as the most important untapped area (31%) (Diagram 3), because they consider it to be an area of natural beauty, but due to the fact that it has not been shaped (41%), it also cannot be exploited. However, there were many respondents who evaluated as significant the use of some military areas (21.4%) and the surface of the railways in the city (19%) (Diagram 3). The above answers were motivated by the fact that the aforementioned

sites create problems in the neighborhood communication (25.3%). In order to make better use of the above areas, in the majority of cases (50%), respondents asked for green spaces to be created. The paradox is that although the number of cafes in Larisa is big (1,674 cafes, 2014) (Iefimerida, 2014), 19% of respondents suggested the development of new recreation areas (Diagram 4). The proposal for the creation of urban vegetable gardens was proposed by only 8.3% of respondents, obviously, for the integration of the undeveloped riparian zone (Diagram 4).

What do you think better in order for the open space to be integrated in the urban grid?
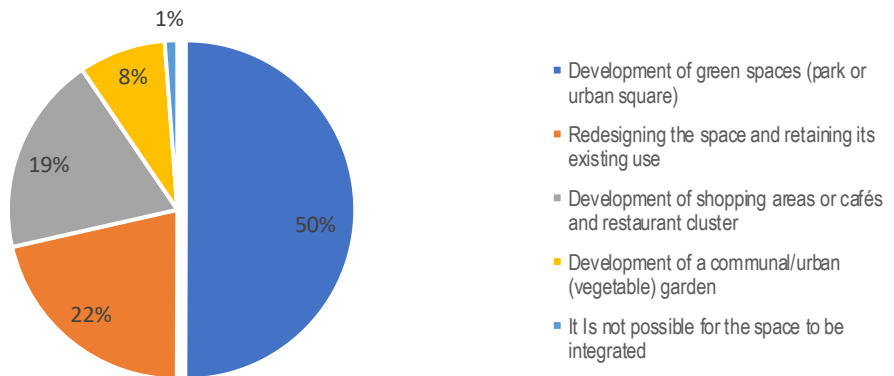
- Development of green spaces (park or urban square)
- Redesigning the space and retaining its existing use
- Development of shopping areas or cafés and restaurant cluster
- Development of a communal/urban (vegetable) garden
- It is not possible for the space to be integrated

Diagram 3. The most important open space that should be integrated in the urban grid is the riparian zone, outside the city center. Source: Own elaboration.

80.9% of respondents believe that the development of a new urban park would greatly encourage the use of the aforementioned sites, with a primary positive impact on citizens being the improvement of the quality of life (63.4%). 24.4% of respondents believe that through such an intervention, the urban landscape of the city will improve, which will help to attract investment, a fact that is theoretically supported (Gospodini, 2002; Gospodini, 2006; Kyriakidis and Siolas, 2013; Athanasopoulou and Giannakopoulos, 2018).

Finally, it was considered appropriate to identify the attitude of the inhabitants to the management of a new urban park. This issue has been studied in the international bibliography (Martin, 2013; Kyriakidis and Siolas, 2014; Han, Hawken and Williams, 2015; Khairi, et.al., 2017) and has become relevant in the context of an effort to upgrade such several sites, such as Pedion Areos and Tritsi Park in Athens. The questionnaire survey revealed that 63.1% of respondents are positive in setting up a management body to ensure the high quality maintenance of the site. In fact, 54.5% of them agree with the management of the space by a private individual, although the sites in question are expected to be common. In this way, it is noted that the public character of the urban

space does not need to be based on property or management issues, but it should be more closely related to how it operates and the people who can use it.

Summarizing the above, we can conclude that although the existing urban areas in Larisa partially satisfy their inhabitants, there is room for further exploitation of areas where urban green can play a dominant role. The general change in the lifestyle of the past few years, to outdoor recreation and sports, degrading entertainment in cafes and restaurants, is also obvious in the case of Larisa, as shown by this questionnaire survey. In this context, the development of open public urban spaces tends to be one-way street for the best satisfaction of the modern needs of its inhabitants.

Conclusions

Although the use of open public urban spaces has been the focus of criticism for several times, since these spaces have been considered as decadent, for different reasons in different areas, their role is nevertheless considered to be indisputable, especially in European cities, which have been historically developed around such areas and until nowadays are their hearts. In this context, this paper explores the extent to which the residents of Larisa are satisfied with the existing urban spaces. As it emerged, although the existing urban areas in Larisa partly satisfy its inhabitants, there is room for: (a) aesthetic improvement of existing sites; and (b) creation of new urban spaces. The implementation of the Sustainable Urban Mobility Plan (SUMP) of Larisa as well as the urban regeneration projects funded by the NSRF in the framework of the Integrated Spatial Investment of ISI-SUD, at this time, is expected to contribute significantly to the improvement of the image of urban areas and mostly of the existing urban areas. However, these circumstances can be used to extend the city's recreation networks, while creating green paths.

In this sense, the above questionnaire survey revealed that in Larissa, nowadays, there are spaces that by being unformulated or by restricting the access of the public to them, they act as limits for the communication between neighborhoods of Larisa and prevent their further exploitation and viewing of the city. Such linear spaces are the riparian zone outside the city center, which can act as a backbone for the development of green path networks. The combination of a corresponding green route along the railway lines can achieve the development of a green ring around the center, thus giving all residents equal access to high-quality green areas for mild recreation and sports. Such interventions can be examples of planning in other Greek cities as well. Actually, the integration of such interventions in the context of the SUMP projects implemented in Greek cities can contribute to the achievement of unified planning in the context of policies for a solid and sustainable city.

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Interactive Multimedia Services Research, Used in the Systems Engineering Career of the Technological Institute of Mexicali

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Abstract

This quantitative research, has the objective of measuring the impact on the users of Interactive multimedia services, in the systems engineering career of the Instituto Tecnológico de Mexicali. The method is a survey applied to a sample of students of the Systems Engineering degree at the Instituto Tecnológico de Mexicali. The results of a survey applied about Interactive multimedia services is Interactive multimedia services, is a new tool of the Acrobat DC professional suite, which allows the user to generate PDF documents which contain various multimedia elements, such as MP3 audios, Videos, Photos, which are intended to be a valuable tool in the student teaching process and is used successful for the 402 students enrolled in systems engineering career of the Instituto Tecnológico de Mexicali. Based on the results obtained from this research, it can be seen that the students of the systems engineering career of the Technological Institute of Mexicali, consider themselves to be enthusiastic about information and communication technologies, such as interactive multimedia services, and they wish to use these technologies, as an area of opportunity we discovered that this technology is not currently used in the systems engineering career of the Technological Institute of Mexicali, nor in other academic departments, the students surveyed show that they know these technologies and that they would recommend them as a means to improve the learning, besides that they consider these technologies reliable.

Keywords: Interactive Multimedia Services, PDF Multimedia, Systems Engineering

1. Introduction

Interactive multimedia services, is a new tool of the Acrobat DC professional suite, which allows the user to generate PDF documents which contain various multimedia elements, such as MP3, Videos, Photos, which are intended to be a tool valuable in the teaching learning process of students, this quantitative research has the objective of measuring the impact on users of the systems engineering career of the Technological Institute of Mexicali, which has 402 students enrolled and make a diagnosis, based on the results of a survey applied to a sample of students from the systems engineering career of the Technological Institute of Mexicali.

2. Instrument Used

1. The Interactive Multimedia Services that are used in the subjects of the Computer Systems Engineering career at the Technological Institute of Mexicali, are known by the students.

2. The Interactive Multimedia Services that are used in the subjects of the Computer Systems Engineering career at the Technological Institute of Mexicali, are useful for the student.

3. The Interactive Multimedia Services that are used in the subjects of the Computer Systems Engineering career at the Technological Institute of Mexicali, are used regularly in classes.

4. The Interactive Multimedia Services that are used in the subjects of the Computer Systems Engineering career at the Technological Institute of Mexicali, would recommend them to other students.

5. The Interactive Multimedia Services that are used in the subjects of the Computer Systems Engineering career at the Technological Institute of Mexicali, you consider them necessary for a better learning.

6. The Interactive Multimedia Services that are used in the subjects of the Computer Systems Engineering career at the Technological Institute of Mexicali. Apart from the use in class, you have seen them used in some other department of the ITM.

7. The Interactive Multimedia Services that are used in the subjects of the Computer Systems Engineering career at the Technological Institute of Mexicali. In the last 12 months you have used them in the ITM.

8. The Interactive Multimedia Services that are used in the subjects of the Computer Systems Engineering career at the Technological Institute of Mexicali. If you had the opportunity to use this technology, you would use it.

9. The Interactive Multimedia Services that are used in the subjects of the Computer Systems Engineering career at the Technological Institute of Mexicali,

you consider them reliable for use in the classroom.

10. As a student of the subjects of the Computer Systems Engineering career at the Technological Institute of Mexicali, you consider yourself an enthusiast of information technologies.

With the following multiple choice answers:

a. Totally disagree

b. Disagree

c. A little disagree

d. A little bit of agreement

e. Agree

f. Totally agree
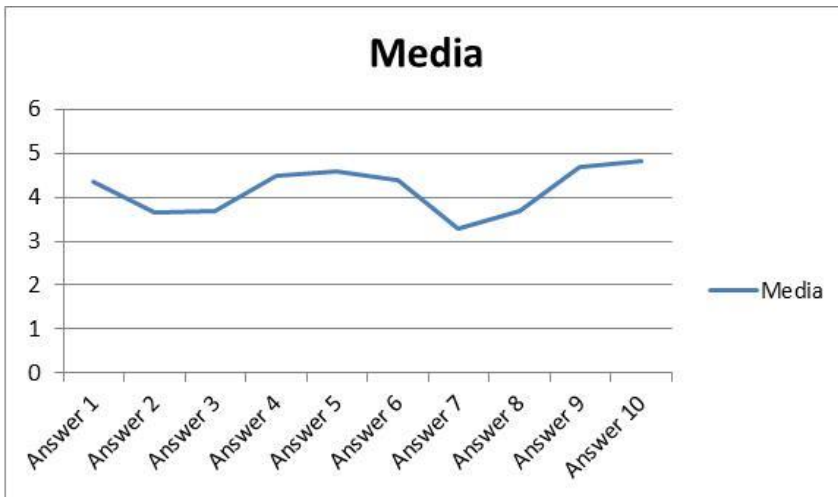
Fig. 1. Graph of results.

Conclusions

Based on the results obtained from this research, it can be seen that the students of the systems engineering career of the Technological Institute of Mexicali, consider themselves to be enthusiastic about information and communication technologies, such as interactive multimedia services, and they wish to use these technologies, as an area of opportunity we discovered that this technology is not currently used in the systems engineering career of the Technological Institute of Mexicali, nor in other academic departments, the students surveyed show that they know these technologies and that they would recommend them as a means to improve the learning, besides that they consider these technologies reliable.

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Study of Driving Behavior in Ilioupolis, Athens According to the Environmental Affordances Theory

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Abstract

The urban space is characterized by specific qualities that may contribute to, or mitigate the social life. These qualities were described by James Gibson as "environmental affordances". But beyond social life, such environmental affordances can affect other human behaviors, such as driving behavior. Such an approach can be particularly useful, since the objective in most European cities is to regain the social character of roads and streets and thus to reduce the speeds on the roads and the number of cars. Through this research, conclusions can be drawn related to road elements that contribute to the development of high traffic speeds to prevent their use during urban planning while encouraging the use of other qualities that will support the maintenance of low speeds of cars. In the light of the above, the specific research focuses on a neighborhood of the southern suburbs of Athens, Ilioupolsi. Through observations and an electronic survey, conclusions are drawn on the behavior of drivers in Ilioupolis. Finally, an attempt is made to generalize the effects of the specific physical characteristics in order to optimize the design of cities where the roads will be social spaces in addition to vehicle traffic channels.

Keywords: environmental affordances, road design, driving behaviour, Ilioupolis, Athens.

Introduction

Roads are an important part of open public urban spaces in cities (Jacobs, 1961; Dumbaugh, 2005; Ghahramanpouri, et.al., 2012; Lamit, et.al., 2013; Mehta, 2013; Mahdzar, et.al., 2015; Shao, et.al., 2016), worldwide. According to Vlastos and Tsorou

(2006), the streets are the most important places where pedestrians operate and are thus more perceived as social sites than as building and functional elements of cities. Jacobs (1961) and Malone (2002) agree to that view and argue that streets are the social settings where human personality and society are reflected. It is no coincidence that a series of studies (Jacobs, 1961; Carmona, et.al., 2003; Mehta, 2009; Mehta, 2013; Ghel, 2010; Ghahramanpouri, et.al., 2012) support the multidimensional role of roads (political, cultural, religious, psychological and symbolic), in the context of social life. For this reason, an understanding of the parameters that influence human behavior has also been the subject of research for space designers and environmental psychologists. The latter, in fact, have formulated a set of theories that justify the emergence of specific behaviors.

In this work, the use of such a theoretical approach is used not for the study of social behavior, but for the understanding of driving behavior. Earlier studies conducted at the Sustainable Mobility Unit, NTUA, found a relative incompatibility between understanding a road as a social site and its function as a motorized traffic channel. The speeds developed seem to be a parameter that negatively affects the sense of safe pedestrian traffic while making communication between them difficult. Thus, the following questions arise: What parameters affect the movement of vehicles at high speeds within cities? Are these parameters detrimental to the movement and concentration of pedestrians on the streets?

The above queries are attempted to be answered through this research. The issue is examined in the light of the environmental affordances theory in a particular neighborhood of Athens located in the southern suburbs called Ilioupolis. Two methodological tools, observation and questionnaire survey, are used in order for the issues studied to be explored and a holistic approach of environmental affordances is presented. Finally, the resulting conclusions are generalizations regarding the possible correlation between driving behavior and the shape of the road space. These conclusions can be useful in case studies of road section regeneration, in order to motivate citizens to make more use of roads as concentration and social gathering areas, enhancing the sense of community.

Theory of Environmental Afordances

This research lies within the scientific area of environmental psychology that, from the 2nd half of the 20th century (Clayton and Saunders, 2012; Cassidy, 1997), studies the relationship of the environment and human behaviour (Scholz, 2011). Thus, over the last decades, a number of studies have turned its interest in understanding people's behavior, utilizing different theoretical approaches. According to Moser and Uzzell (2003), the major theories are grouped into three groups of theoretical thinking: determinism, interactionism and transactionism. The approach of environmental affordances falls within the transactionistic theories.

Under this theory, any human behaviour is related to the possibilities offered by the space on every user, each time (Warren, 1984; Greeno, 1994). According to Mehta (2013), environmental affordances are not treated as elements that are characterized by "obligatory" to the users of the space qualities but as elements of the environment that make it capable of developing some experience as well as experiencing some aesthetic experience. Althouth, the various features of the site can support or constrain behaviours, this does not mean that these behaviors will definitely take place (Gibson, 1979). Indeed, environmental affordances are a "*real chance*" for the event of an action (Tillas, et.al., 2017). Characteristic is the example that is demonstrated by Gaver (1996), who expects that the number of moving individuals on space located at a higher altitude level from another is less because of the height difference.

Although several groupings of environmental affordances have been formulated (Fallah and Fallah, 2015), the most frequent categorization is that based on the "benefit of the user" criterion and distinguishes the affordances into positive and negative affordances. Other categorizations can be made based on "actor's involvement" (potential or actualized affordances) or "perceiving acting agent" criteria (individual or shared affordances). These types of categorization were used in this specific research paper, which uses the affordances as a mean of understanding driving behavior.

Methodology

To answer the research questions, a particular area was selected as a case study. According to Jennings (2001), case study research is a kind of a primary research since it offers new information both qualitative and quantitative, in order to draw conclusions that will be useful in design projects of similar research theme (Kyriakidis, 2016; Bakogiannis, et.al., 2017). The characteristic that makes them a useful and reliable tool of research is that they are empirical studies of the phenomenon under the scope of real life, as Yin (1984) notes.

Ilioupolis was selected because it: (a) is characterized by an average degree of compactness (Kyriakidis and Iliadis, 2018), consisting a typical city case, (b) constitutes an autonomous non-center neighborhood within the metropolitan area of Athens, which is important since most researches on how a place can become socially more active concern the central districts rather than the neighborhoods (Mahmoudi Farahani, et.al., 2015), (c) is located on the perimeter of the metropolitan area of Athens and is crossed by major motorways that operate as an extension of the regional ring (Attiki Odos) (d) is an area developed after urban planning and not in an anarchic way, as several areas in Greece, (e) has a wide variety in the characteristics of the roads, as there are many highways where high traffic loads are recorded, as well as local roads, (f) is among the municipalities that will develop the Sustainable Urban Mobility Plan (SUMP) and will therefore design and implement interventions that will affect mobility at municipal level.

Concerning the understanding of driving behavior in Ilioupolis, two methods were chosen: (a) Drive-by and walk-by observation; and (b) Questionnaire survey. The first

method aimed at the recording of basic driver mobility choices, such as the approximate calculation of average speed, giving priority to pedestrians when they use zebra-crossings for crossing the roads, the maintenance of priority in the nodes, parking in areas where parking is prohibited, the use of traffic lights, etc. The second method aimed at understanding the perception of drivers about how they are moving to Ilioupolis. Through the questionnaire survey, it is checked whether drivers understand the behavior they express; for example, understanding of the speeds they reach when they drive, understanding of the cases when they violate a signal, etc., as well as the attempt to understand the motivation for the expression of specific behavior. The survey was conducted between 8-22 June 2018, electronically. 91 people participated in the survey. They were informed via social media. In that way the random character of sample selection among residents or visitors of the city who have an account on a social media platform was ensured. Regarding the profile of the survey participants, the majority of participants are men (53.3%), aged 25-35 (66.7%), university graduates (52.2%) driving a car or motorcycle (91, 1%). 56.7% of the respondents declare residents of Ilioupolis, while the others visit the study area on a daily basis (45.7%) or 3-5 times a week (30.4%). It is worth noting that the majority of questions were closed-ended, since in open-ended research the open questions do not find the appropriate response from the respondents (De Bruijne and Wijnant, 2014; Zhou, et.al., 2017).

The results obtained from the field research were evaluated in the light of the literature on environmental affordances. A table was accrued, showing the affordances found in Ilioupolis and are classified according to the "benefit of the user" and perceiving acting agent" criteria.

Case Study: The Municipality of Ilioupolis, Athens

Ilioupolis is located in the southern part of the metropolitan area of Athens. Its population is 78,153 inhabitants and the population density is estimated at 13,175.8 inhabitants/km². Indeed, it is characteristic that it consists a relatively compact municipality in its urban section (Kyriakidis and Iliadis, 2018), assessing a number of parameters, such as public transport coverage, the height of buildings and the surface of public and green spaces.

Although the balance of public spaces versus private ones is positive for public spaces, however, most of them are not attributed to the use of pedestrians but to the movement of motor vehicles. The city is crossed by highways and roads of large width with high traffic loads. On most of these roads, the speeds developed are above the permissible limit within urban areas. Indeed, 69% of the respondents said that the average speed of their vehicles in Ilioupolis is 40-60 km/h when the permissible limit is 50 km/h. 4.6% of the participants even underlined that their average speed in Ilioupolis is more than 60 km/h. As the main cause of high speed development, the large width of the roadway was considered the most important parameter (52.9%), while the number of lanes and the existence of a separating island were two other features that favored this. As

respondents are also pedestrians, when they were asked they think that cars are moving at high speeds on the main streets of the city, 78.9% of respondents responded affirmatively. However, it is paradoxical that even from those who recognize that they have exceeded the speed limit (76%), only the 46% believe that they exceed the boundary within an urban area.

These features are evident on roads such as Marinou Antypa Ave., Andrea Papandreou Ave. and Heroon Polytechniou Ave., which after Eleftheriou Venizelou Ave., an extension of Attiki Odos, are roads identified as roads where drivers develop high speeds. In fact, some intersections on the above roads were characterized by the participants in the questionnaire survey as dysfunctional. However, this parameter does not seem to affect the land values in the Municipality of Ilioupali, as the property rating index tend to be increased form the southeast to the northwest side of the municipality. It seems that wide-width roads and avenues –in which heavy traffic loads are recorded (General Study for Traffic Control and Parking Management in the Municipality of Ilioupolis, 2017) - are being evaluated in a positive way due to the fact that act like connecting axes with the center of Athens and the northern suburbs of the Athens metropolitan area. The question of the movement of the drivers at the junctions focused on the roundabouts that are numerous in Ilioupolis. The majority of survey respondents consider that they are largely served by the city's roundabouts (40.5%). The same positive was their attitude towards the regulation of traffic with traffic lights, since most (70.6%) do not consider that there are delays in the rotation of the movements and therefore do not feel that such a delay causes them to violate the red signal.

The survey also looked at the attitude of drivers towards pedestrians crossing the streets. Although the majority (35.8%) of respondents uses the crossings during their crossing on the main streets of Ilioupolis when they move as pedestrians, only about 30% of the total assess the crossing of the central streets of Ilioupolis as comfortable. This may be due to the fact that crossings are also located and where there is no traffic light, resulting in a large number of drivers not stopping. Indeed, 50% of the respondents do not stop at the crossings when there is no traffic light.

The on-street parking was another phenomenon that was largely observed in Ilioupolis, as in many Greek cities (Vlastos and Chronopoulos, 2007; Kyriakidis and Bakogiannis, 2018). On both central and local roads, parking along the road and sometimes even on the sidewalk seemed to make it harder for pedestrians to move. However, only 25.2% of respondents consider parking to be one of the reasons that make it very difficult or too difficult for them to be pedestrians. This view is perhaps related to the satisfactory assessment of the pavements in terms of their width (39.7%). This view relates, in particular, to the sidewalks of the main roads where the sidewalks are of sufficient width and the existence of additional pavement patch (area between the street line and the building one), that in several places is not delimited, creates the sense of even larger pavements. A similar situation prevails on some roads that have been restored and function as mild traffic roads. However, it has been found that there are many points in

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the city where the width of the sidewalks is too small, so it is not enough even for the safe movement of healthy people.

Regarding the issue of the protection of pedestrian traffic on the sidewalks, the attitude of residents and visitors was investigated for the use of equipment, such as the pillars, to restrict parking. 41.7% of respondents are taking such measures positively to make pedestrian movement easier and safer. This point of view is important because, recently, railings have been placed in order to release the pavements from parked cars. In addition to the portable obstacles, horizontal marking can also act as a deterrent to parking. Indeed, lining and using pictograms prevents drivers from parking at specific points. It is typical that 94% of respondents in the survey have never parked on a bicycle lane marked by road markings.

	Big Formation width of a road	Big Carriageway width (sealed road)	Big pavement width	Islet	More than 1 traffic lanes	Big Lane width	On-street parking	Great number of private parking-areas	Roundabouts	Traffic lights on nodes	Simple intersections	Zebra-crossings not integrated with traffic lights	Road signs	Horizontal Signals/Markings	Plastic protective barriers	Green spaces and trees	Inclined ground	Horizontal Marking
Car-user	P	P	P*	P	P	P	N*	N	P	P	N	N	P	N*	N*	P*	N	N
Pedestrians	P*	N	P	N*	N	N	N	N	N*	P	N*	P	P*	P	P	P	N	P*

P*/N*: potentially possitive or negative affordances.
It should be noted that some estimations are made by taking into account the functional or social character of each affordance.

Table 1. Main environmental affordances in Ilioupolis, Athens, categorized according specific criteria. Source: Own Elaboration.

The above points were evaluated in the light of the literature for environmental affordances. Once identified, they are tabulated and presented in Table 1. It should be noted that the affordances presented in this table are an indicative list of the most important affordances for the whole municipality. A corresponding, more detailed

record on a smaller scale (i.e. street or neighborhood scale) may bring to light other affordances not listed in Table 1.

The sum of the recorded affordances (17) were evaluated on the basis of the "benefit of the user" criterion for two categories of users (drivers and pedestrians) and categorized into positive and negative. However, some affordances are characterized as potentially positive or negative depending on the benefits to the user most likely to have. As depicted in Table 1, motor vehicle drivers tend to have more benefits from the existing planning in the municipality of Ilioupolis. 44.4% of the affordances were positive for the comfortable movement of vehicles, while 11.2% were potentially positive. For pedestrians, 33.3% of the affordances were positively evaluated and 16.6% potentially positive. Respectively, as negative affordances for vehicle traffic were evaluated the large number of private parking areas, simple intersections, zebra-crossings not integrated with traffic light and the inclined ground. The affordances in terms of pedestrian traffic characterized as negative were more.

The above confirm the fact that Ilioupolis is a neighborhood of Athens that is designed with an orientation that serves the most motor vehicles rather than the pedestrians, as most Greek cities (Vlastos and Perperidou, 2007). It is no coincidence that 50% of respondents to the questionnaire survey do not express a clear position on the question: "How safe do you feel as a pedestrian in Ilioupolis?" The recent regeneration of some road sections seems to be moving towards pedestrian protection. However, a single united planning is required to promote sustainable mobility throughout the municipality, through integrated strategies, ensuring both pedestrian safety and the limitation of the circulation of motor vehicles. The affordances presented in Table 1 can serve as indicators for progress in the area of sustainable mobility. Thus, the design goal should be to increase positive environmental affordances for pedestrians, even if this means limiting the comfort of vehicle traffic, at least on local roads.

Finally, it is worth noting that the increase of positive affordances for pedestrians is expected to have a positive impact on cyclists as well, since the physical characteristics of an area influencing the presence of pedestrians affect in a similar way, in the majority, the presence of cyclists as well. These characteristics include the width of the pavement, as there is no autonomous bicycle space, the degree of shading of the pavements, the urban green, the ease of crossing the roads, etc.

Conclusions

Streets are fundamental parts of cities and people's everyday life. Nevertheless, over the decades, large surfaces of them have been conceded to the use of cars. As a result, they function more as traffic channels than spaces of social interaction. This situation tends to be reversed through the implementation of SUMPs, based on the European Union's guidelines, to make roads safer for pedestrians and to regain their importance as social sites. To do this, a number of street interventions aim to modify some of their physical

characteristics, assuming that they affect the choice of the means of moving by people as well as their behavior as drivers, cyclists or pedestrians.

These physical characteristics are called environmental affordances and were described in the context of homonymous theory, which falls within the field of environmental psychology. The affordances recorded in an area can be categorized in a number of ways: positive, negative, actualized or potential, affordances perceived by drivers or pedestrians.

The above theoretical approach has been applied in the case study examined in this research paper concerning the Municipality of Ilioupolis. Ilioupolis is a neighborhood in the southern part of the metropolitan area of Athens with large public areas. Although the degree of urban compactness for its urban segment is relatively high, however, a large part of its public spaces are the streets, thus limiting the sociability in its public spaces. The ratio between roads and public spaces for pedestrians has been the motivation for exploring driving behavior in Ilioupolis and the way it is influenced by the physical design of the area.

To investigate the issue, a questionnaire and walk-by and drive-by observation research was conducted to capture behaviors and investigate the cause of their expression. The research has shown that physical characteristics are related to driving behavior as well as pedestrian behavior. The conclusions that have emerged for Ilioupolis can, under certain conditions, be generalized for other Greek cities, as well, with corresponding characteristics. In summary, the key findings can be described as follows:

The large sealed road width contributes to the development of higher speeds than the permissible speed limit. Other parameters that affect high speed development are the number of lanes per direction and the existence of a separating islet between the traffic flows. In any case, the existence of an islet is legitimate, since its geometrical characteristics are such that do not discourage pedestrian movement and the safe crossing of the roads, since they consist urban areas. Regarding the width of the sealed road, it is legitimate to keep it in small widths within urban network to prevent high speeds. An alternative would be to use different asphalt material.

Roundabouts are rated more positively than negative. Negative evaluation of roundabouts occurs to a greater extent by pedestrians who do not have access to the central island area, even if there is a design that predicts their presence in it. In any case, the operation of roundabouts in Greek cities could be more efficient as long as there was a better education of drivers in terms of priority and the combination of different means such as roundabouts, traffic lights and vertical marking was prevented.

The adjustment of traffic into nodes with traffic lights against typical nodes (priority settings) is more efficient and safer. However, switching of traffic light signals should be tactical so as not to encourage drivers to violate light signals.

On-street parking is a parameter that prevents pedestrian movement. However, its effects are smaller, as long as there are wide widths of sidewalks. Potentially negative may be the effects of the parking garage and for drivers since they have difficulty in parking and traffic on the road. Negative impacts on drivers also arise from the existence of a large number of private car parking areas, as they have difficulty in finding a car park.

Obstacle use can be a satisfactory method of limiting on-street parking and parking on the sidewalks. A large portion of the audience agrees with their use. An alternative could be to pinpoint and use pictograms for easy and cost-effective interventions, at least in a stage of public opinion adaptation for future permanent footpaths or regeneration of streets.

The above points summarize the findings of research on the psychology of drivers who move to an area with specific physical characteristics. It was found that there was a correlation between driving behavior and the existence of specific features, which, in theory, was more established for pedestrian behavior. Research may further specify the relationship between driving behavior and pedestrian traffic in the study area as well as focus more on the parameters that affect the use of the bicycle as a means of transport. Through such an integrated approach, important conclusions could be drawn that shape a set of policies that need to be taken into consideration when designing roads, which has been increasingly observed in Greek cities over the last few years due to the increased demand for SUMPs. Thus, because through such a behavioral research the psychology of behavior is being examined, it can be said with relative certainty that designs based on such policies are expected to have positive effects on the safety of citizens, the enhancement of the publicity of public spaces and the development of a strong community sense.

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Determining the Probability of Cyberattacks

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Abstract

The use of information is inextricably linked with its security. The presence of vulnerabilities enables a third party to breach the security of information. Threat modeling helps to identify those infrastructures, which would be most likely exposed to cyberattacks. In some cases, however, threat modeling can not be classified as sufficient method of protection. This paper entitled "Determining the probability of cyberattacks" presents an analysis of different techniques with an attempt to identify the most informative parameters and cyberattack prediction markers, which would lay the foundation for the development of cyberattack probability functions. Next, it would be relevant to design such cyberattack probability functions, which would be used upon the initial identification of a cyberattack. The findings of this research could be applied during the future assessment of risk levels of information systems to ensure more effective information security management.

Keywords: Probability of cyberattacks, information security, cyber security, risk management, risk prediction.

1. Introduction

1.1. Motivation

The information systems are currently monitored by various systems. Such checks (audits) help to obtain various system characteristics within the perimeter of the information system security. On the basis of such verification or data monitoring it is possible to assess a risk level of cyberattack within the protected perimeter (infrastructure, system). The risk assessment is limited to the calculation of its level of risk at a certain time point, such as a freeze frame in a movie. The full risk analysis encompasses several stages. The implementation of each stage takes time. One or several indicators might be radically modified in the process of calculation of values in the end of one or more stages of a risk level analysis. Hypothetically, the risk indicator can be altered significantly as a result of this process and it may even exceed the maximum allowed level. This deviation can not be promptly tracked, while the analysis takes much time. For example, the conduct of risk assessment with MEHARI (MEthod for

Harmonized Analysis of RIsk) Expert tool [18] may take more than six months [12]. From this it follows that in the context of such a risk assessment model, there are periods that remain uncontrolled.

The system threat modelling allows to obtain a probabilistic image of a cyberattack plan. At the same time, we can not predict the period of a cyberattack initiation. The periodic scanning of information system for known vulnerabilities helps to identify a list of the system vulnerabilities. However, this list can not ensure an accurate risk assessment in case of all these established vulnerabilities. Thus, for SIEM (Security Information and Event Management), it is important to ensure an obtainment of such a list arranged according to the importance of primary actions and reactions. Additionally, it is important to ensure proper classification of primary responses based on the analysis of the data from this list. First, it would be necessary to use the results of vulnerability assessment covering the most important assets in order to ensure their protection against identified critical vulnerabilities.

To date, there are training developments for Artificial Intelligence (AI) that are formed through the analysis of traffic logs to identify outliers. With this approach, it is possible to identify a cyberattack with a certain probability in a real time. The difference between Intrusion Detection System (IDS) and AI is that the AI learns without analyzing deeply the cyberattack signature.

This research aims at developing a cyberattack prediction system based on various system parameters. Today it is impossible to determine precisely the time point at which the planned cyberattack will be committed and which vector will be chosen. This confirms the relevance of "prediction of cyberattacks" to be able to identify the levels prone to risks at every moment. Thus, it is proposed to extend risk prediction to all the existing data (risk indicators history).

1.2. Our Contributions

Identification of probability of an attack on information system S between t and t+Δt;

Development of attack forecasting function entitled "Oracle".

For example, the system configuration change, system modification allocation of funds for the system protection or creation of a working schedule.

Prior to applying X-parameters, it is suggested to check:

External threats:

Threats in social networks messages or sent emails;

Text in backlinks;

Text in backlinks to the attack target.

Trapping:

Fail2ban[1], IPS, etc.;

Pages of nonexistent administrators (as reconnaissance component);

One has also to consider the creation of markers that can influence the attack probability.

Experience, knowledge, tactics of the attacker side.

2. Literature review

A number of systems, such as Intrusion Detection System, can detect attacks [3] in real time. The detection of attacks is based on the application of rules (attack signatures) and work statistics under normal conditions (without attacks). The attack detection platforms applying machine learning methodology are based on the following three components:

Statistical analysis;

Attack signature analysis, covering the existing or new signatures created by an information security analyst and based on various sources. This analysis enables the identification of known behaviors or known attacks;

Machine learning to identify outliers.

The PatternEX (Threat Prediction Platform) [19] is an example of a system based on the automatic learning method [4]. The artificial Intelligence combines analysts' intuition with machine learning to mimic a security analyst to predict real-time and large-scale threats. To ensure an application of Artifiial Intelligence in InfoSec, PatternEx has developed a patent-pending technology entitled Active Contextual Modeling[2], or ACM. This technology continually identifies new and evolving (active) threats with the help of (contextual) analyst, and, once identified, synthesizes new models (modeling) that can distinguish between malicious and benign models. Another way to recognize threats is heuristic scanning[3], which is a method used by antivirus software to detect new viruses, as well as new variants of the already known viruses. Heuristic analysis is a method based on the supposed behavior of a program to determine whether the program is a virus or not. This method differs from statistical analysis, which is based on comparisons of the program with known viruses referenced in an anti-virus software library. The heuristic method can be used to detect DDoS attacks [11], Predictive Blacklisting, Phishing Attacks [9] and Malicious Web Pages [10]. As can be seen from the examination of attack prediction systems, this direction of research is a new one, and as it usually happens with new systems, it should be improved and refined to ensure good results.

3. Formal consideration

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[1] http://bit.ly/2XbITyu

[2] http://bit.ly/2P6JOwd

[3] http://bit.ly/2X9nJ2U

3.1. Problem

This research is an attempt to propose a risk level forecasting method. The Formula for establishing a risk value is

$$R = P \cdot I$$

(1)

where R is the risk value, P is the probability of an attack event and I is the impact (a likely consequence) of an attack event.

To determine the risk, we can predict only the probability P, while the impact I is considered by us as a constant value. However, the valuation of assets also plays a significant role in determining the future impact, due to changes in asset prices.

Given:

parameters of information system S:

set of business processes;

set of assets;

set of protection techniques applied to ensure the safety of assets;

security policy;

set of of this system log files;

risk assessment methodology;

attack forecasting time frame (t;t+Δt).

Find:

probability that an attack take place on information system S between t and t+Δt;

future risk level allowing to assess and identify the budget required to maintain an acceptable risk level.

The idea of the research aimed at the development of this field could be summarized as follows:

Development of attack forecasting function entitled "Oracle". Determination of parameters for attack forecasting function 2 "Oracle":

$$Oracle: X \rightarrow [0,1]$$

(2)

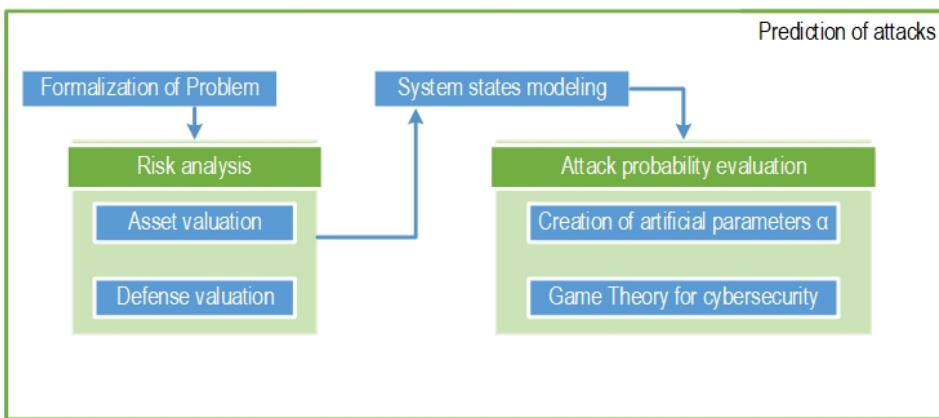Let us consider the research project's general scheme in Figure 1.

Figure 1: General scheme of the research project.

3.2. Formalization

The following should be noted for proper consideration of this formalization:

Calligraphic letter stands for a domain, for example A;

Capital letter - denotes a subset, for example A;

Small letter stands for - a subset element, for example a.

Based on the above system input parameters, we can represent the initial state of the system S=(A,D). In the output stage we get the modified system state S'=(A,D'), which satisfies the following requirements:

RM(A,D') represents acceptable risk level for our system.

$D' = \min\limits_{x \varepsilon D} Cost(D, Conf, x)$ stands for the selection of a configuration of a minimum cost that meets the requirements for an acceptable risk level.

Based on the input data, we are proceeding to formalizing an attack forecasting function in "Oracle" 3.

$$Oracle: BP, A, D, LOG, SP_r, RM, (t; t + \Delta t) \to [0,1]$$

(3)

Where

Attack - denotes an actual occurrence of an adverse event.

[0,1] is the probability value of the event (attack).

BP: represents a set of business processes. The sequence of $bp_0, bp_1, \dots$ comprises a set of meta-variables applied by us through the entire BP. Each business process encompasses a lot of assets. For example, content management (bp_0) using assets A

comprises a set of assets: Application data (data bases) (a_0), Electronic mail (E-mail) (a_1), Local Area Network services (LAN services) (a_{10}), Web editing Service (a_{27}): $bp_0 = \{a_0, a_1, a_{10}, a_{27}\}$.

A: represents a set of assets. The sequence of $a_0, a_1, ...$ describes a set of meta-variables used by us, which are ultimately comprising A. The examples of assets include the Application data (data bases), Electronic mail (E-mail), Local Area Network services (LAN services), Web editing Service, Digital accounting control, etc.

D: describes the defense techniques applied to ensure the safety of assets A. The sequence of $d_0, d_1, ...$ describes meta-variables applied through the range D. In our example, the following techniques were used to ensure protection of the operating computer: a firewall, an antivirus and logging. Each security measure could be classified based on its configuration ($Conf$) - the configuration affecting the system system functioning and performance.

LOG is classified as a sequence of lines, where each line represents an event with unique information.

SP: stands for the security policy. The security policy comprises a set of instructions (the sequence of $sp_0, sp_1, ...$ describes meta-variables used by us through the range SP) for implementing business processes. The security policy can be accepted and formalized "on paper" as a set of safety rules. However, there are times when the actual security policy is different from what is on paper. Therefore, we will consider two types of security policies, Real (SP_r) and Theoretical (SP_t). For example, the proper use of security measures D to ensure the safety of an acceptable level for collection of assets A. or setting minimum requirements for the configuration of the protection system. The security policy describes which ports should be open to the firewall, antivirus updates frequency, timeframes for the system antivirus scan, logging detailing and the determination of location of the undertaken security measures (firewall at the entrance, antivirus and logging inside the system).

The adopted risk assessment methodology (MEHARI, CobiT, etc.) RM is represented as a function of $RM: A \times D \times SP \rightarrow R$, that returns the level of risk R of loss of assets A when using protection components D and, consequently, disruption of business processes BP.

($t; t + \Delta t$) time frame for attack forecasting.

To clarify this formalization we propose to refer to the following article: *Formalization of attack prediction problem* [13].

4. Risk analysis

In order to ensure an adequate protection level, each time we need to identify what should be protected and from whom. For this, it is necessary to identify the assets and obtain the information about them. The above mentioned statement could be illustrated by the following example:

Analysis of business activities or processes:

Determining the ownership of an asset in a business process.

Asset analysis (assessing the degree of importance, the level of loss when the asset is lost, of each value).

Given: List of business activities.

Find: Intrinsic Impact table.

Audit of the protection techniques applied to ensure the safety of assets:

Defense system analysis.

Risk analysis.

Given: List of protection techniques applied to ensure the safety of assetss.

Find: Attack scenarios, risk per asset type, risk per event type.

4.1. Analysis of business activities or processes

Proceeding from the above-mentioned, it is possible to conclude that the obtainment of information about them plays a crucial role. Asset valuation is a very important step in ensuring a proper system security. Thus, we need to know which assets should be protected to maintain their confidentiality, integrity and availability. *MEHARI Expert* [17] uses the following classification of the data, classification of services and classification of compliance with laws and regulations relating.

Sometimes, it is difficult to assign monetary value to assets. This is why each of these classification elements evaluates the classification level in terms of the maximum damage.

There are different methods of risk analysis. Each approach uses its own technique for the interpretation of asset values. It is necessary to represent the valuation of assets to be able to connect and use the results of asset analysis obtained applying different methodology. For that, we could quantify the categories. This will allow us to treat them as generalized attributes.

For example, MEHARI makes assessments based on 4 points scale (from 1 (Weak) to 4 (Unbearable)). As initial approach for this research project we could apply MEHARI only. In this case, the classification level must be determined before initiating risk analysis by MEHARI Expert. This should correspond to the maximum negative consequences of malfunctioning affecting this criterion of the asset evaluation process. It's really easier to determine the assets value in the event of their loss assessing each of the following security principles: availability, integrity, confidentiality. These are three principles for evaluating the Impact of loss asset.

We can represent the Formula 1 for establishing the risk value as follows:

$$R = \sum_{i=0}^{m} (P_{availability}(asset_i) \cdot I_{availability}(asset_i) +$$

$$+P_{integrity}(asset_i) \cdot I_{integrity}(asset_i) +$$

$$+P_{confidentiality}(asset_i) \cdot I_{confidentiality}(asset_i)) \qquad (4)$$

where R stands for the risk value, $P_{availability}(a_i)$ is the probability of loss availability of asset a_i due to an attack event and $I_{availability}(a_i)$ stands for the impact (a likely consequence) of an attack event due to loss availability of asset a_i, and m stands for the amount of assets. the same for integrity and confidentiality for all the asset. The same relates to the integrity and confidentiality of all assets.

To determine a risk, we can predict only the probability P, while the impact I is considered by us a constant value for the time window $(t; t + \Delta t)$.

The probability of losing an asset is the probability of attacks on a given asset. Similarly, for security purposes, the likelihood of loss of availability / integrity / confidentiality for an asset P_{asset} corresponds to the likelihood of attacks $P(A)$ on the availability / integrity / confidentiality of the asset : $P_{asset} = P(A)$

In Section 5.1. "Cyberattack probability evaluation in each of the states", we take a closer look at the decomposition of the Formula for the probability of an asset attack.

The principle of reasonable sufficiency [8] states that it is fundamentally impossible [7] to create an absolutely insurmountable security system. It is important to choose the appropriate protection level for which the costs, risks and possible damages would be acceptable. Each of these steps takes time. The intervals between modifications can reach several months.

Formula 1 is still applied in MEHARI [17]. It allows to verify an average risk, but does not reflect the risk level in real time. There is a need to know the level of a probabilistic risk to track the risk levels over the specific time period.

The risk level can be calculated separately for each of the assets. The security context (security system) is created for each asset separately. Each security system consists of many components. In this way, we can design a chain of all security components (security barriers) for each asset separately. Each asset in the information system is valued differently in the event of total loss. We can rely on the indicator I (impact) which remains constant throughout time.

The elements of this table need to be expanded to take into account the different levels of probabilities of attacks and impacts. Lets assume that the average risk level for the whole company is ranked as 2 in compliance with MEHARI. This is a "Tolerated" level. However, another department of this company can be assigned an "Unbearable" risk level (4 of 4). Reasoning with the average value does not make it possible to spend the security budget properly. Thus, we want to have a dynamic system that adapts all the time, which can cost on average 25k$ per year, even if the forecast for next month is only

around 500\$. This can significantly change the value of a risk indicator and even allow to get out of the maximum allowed level (by MEHARI it is level 3 "Unacceptable"). This difference can not anticipated within very strict deadlines, while the analysis takes time. By doing this, as part of this risk assessment model, we will explore the so-called unchecked periods. An example of such case is shown in Figure 2. In this graph, the red line represents the limit of acceptable risk. The blue bars represent the true value of the risk and the black dots stand for the calculated risk values (calculations are carried out every four time units).
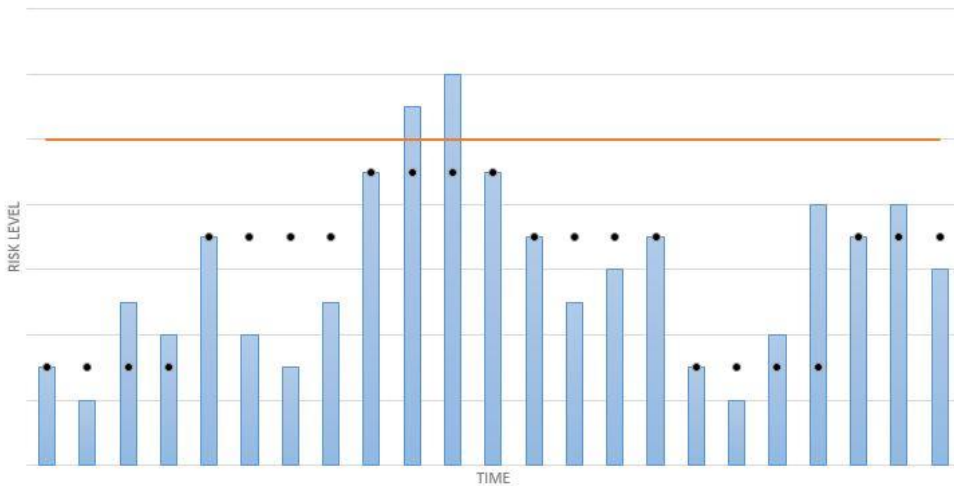
Figure 2: Graphical representation of the periods when risks take the passed calculated value.

In order to be able to represent the risk level at any time, it is suggested to analyze the already existing data sets and associated risks. For that we need to have an estimate of the appropriate level as a function of time, that is, a probability.

4.2. Audit of the protection techniques applied to ensure the assets safety

The system safety assessment approach through a security system audit is structured as questionnaire (yes / no) designed to analyze each security category (according to MEHARI Expert).

It is worth to undertake an analysis of protection measures D for assets A involved in business processes BP for the initial configuration of the system $Conf_h$, where $h = 0$ stands for the initial configuration.

$$D = (Conf, v), \tag{5}$$

where v - vulnerabilities and exposures.

The following Formula 6 is used by us to determine the level of risk for business processes:

$$RM: BP \times A \times D \to [1..4]$$

(6)

MEHARI uses charts containing audit results collected after the provision of "yes" or "no" answers to the questions used to collect the information enabling an analysis of the existing security systems. This analysis takes place within the time interval Δt. The risk level assessment in the time period $t_0 + \Delta t$ takes place with an application of the chosen risk assessment methodology RM. This analysis assesses the existing measures to protect the assets entering the business processes. After completing all the charts relating to the organisation's audit, the MEHARI risk analysis methodology forms a panorama of risks for each asset type (information, services, management processes). The asset protection system needs to be improved to change the risk level. It could be strengthened after the system configuration change i. e. $Conf_{(h-1)} \to Conf_h$ (where $Conf_h$ stands for the system configuration ensuring lesser risk for business processes). Each of $h \in R^+$ configurations has its own price by function $Cost: (d_{firewall}, Conf_{firewall}) \to p$, where $p \in R^+$. The task of the defense side is to minimize the risk level R to an acceptable level, with minimal costs $Cost(D, Conf_d)$.

$$\begin{cases} RM(BP \times A \times D') \to \text{acceptable level of risk} \\ D' = \min_{x \varepsilon D} Cost(D, Conf, x) \end{cases}$$

(7)

It is suggested to use a cycle consisting of 1) analysis, 2) modeling, 3) selection and 4) application of the configuration in case of the system configuration change. The cycle is presented in Figure 3.
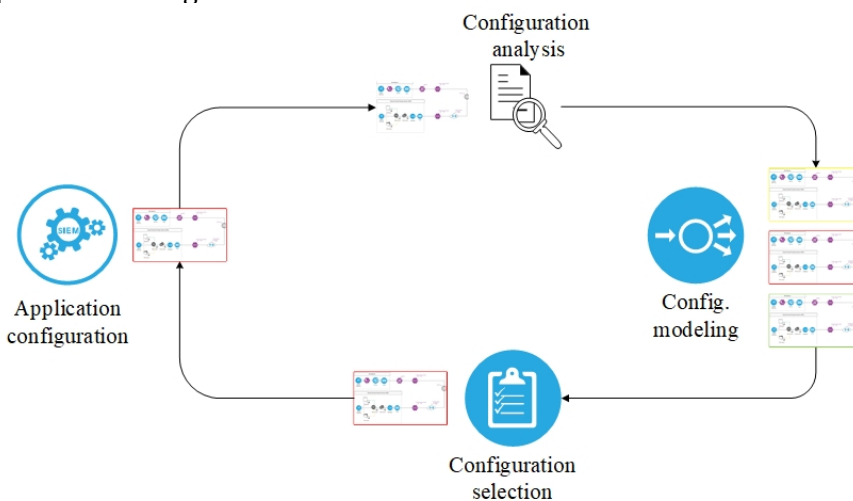

Figure 3: System configuration change cycle.

5. System states modeling

It is necessary to determine and model states of the system applying a formal method, meaning that we should decompose the system into simple components or variables (host, port, service, service version, availability, etc.). Each variable should be determined for the initial time instant. Later, system will affect the change of variables, i.e. removal and addition of variables describing the state of the system at each time point.

The system state change takes place upon the change of its configuration, switching or connection of any component aimed at ensuring its protection.

security configuration change $D[Conf_h/Conf_{h+1}]$;

disabling the system protection component D^-;

connecting system security component D^+.

The system is modelled by a probabilistic attack graph G, which is tuple,

$G = (S; \tau; \pi; L)$ consisting of

initial or start state $s_0 \in S$;

all of the states S;

transition relationship $\tau \subseteq S \times S$;

probabilistic transition $\pi: S \to S$;

labelling of states $L: S \times S$.

The function π specifies probabilities of transitions from probabilistic states, that applies to all transitions, meaning $s_1 \to s_2 \in \tau$ such that $s_1 \in S$, thus we have $P(s_1 \to s_2) = \pi(s_1)(s_2) > 0$. In that context $\pi(s)$ can be viewed as probability distribution on next states. Intuitively, when the system is in a deterministic state s_0, we have information about the relative probabilistic state s_1. Next it will choose the next state according to probability distribution $\pi(s)$.

In the context of this work it was suggested to apply MEHARI methodology. Consequently, we have four risk levels (identified by different colors, higher intensity corresponds to the maximum risk level). An approximate draft of the system is displayed below in Figure 4.
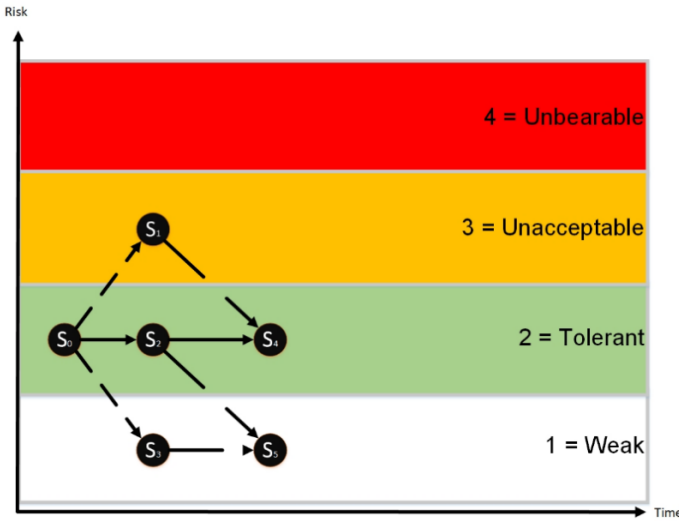
Figure 4: Graphical representation of states and risk levels.

5.1. Cyberattack probability evaluation in each of the states

We introduced Formula 1 for establishing the risk value of an asset. Let us rewrite this Formula considering the probability of losing an asset as a result of possible attack on one of the assets:

$$R_{asset}(Attacks) = \sum_{i=0}^{k} (P_{availability}(attack_i) \cdot I_{availability}(attack_i) + \\ + P_{integrity}(attack_i) \cdot I_{integrity}(attack_i) + \\ + P_{confidentiality}(attack_i) \cdot \\ I_{confidentiality}(attack_i)) \qquad (8)$$

where $R_{asset}(Attacks)$ is a risk value due to attack events, $P_{availability}(attack_i)$ is the probability of loss availability of asset $attack_i$ due to attack events and $I_{availability}(attack_i)$ is the impact (a likely consequence) of an attack event of loss availability of asset $attack_i$, and the same for integrity and confidentiality for the asset due to attack events. The number of attacks is expressed by k.

Each attack is based on exploiting the existing vulnerability using an attack vector. Attack vector [1] - is a path or route used by the intruder to gain access to the target (asset). Vulnerability [5] - is a weakness in design, implementation, operation or internal control of a process that could expose the system to adverse threats at the time of threat events.
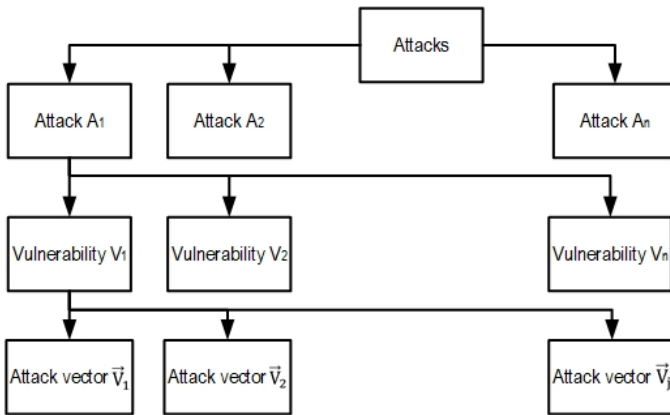
Figure 5: Attack consists of exploiting an existing vulnerability using an attack vector.

We can rewrite the likelihood of an attack (a_i) of all the attacks A on one of asset for each of security principle (availability, integrity or confidentiality) as follows: $P_{availability|integrity|confidentiality}(a_i) = P_{(c,[t;t+\Delta t])}(a_i|s)$.

Where

c - situation context within the time window $[t; t + \Delta t]$;

s - system state in the time window $[t; t + \Delta t]$.

Visual representation[4] of an attack on an asset is displayed in Figure 6.

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[4] Full size picture of decomposition of an attack on an asset http://bit.ly/2PnSl8l

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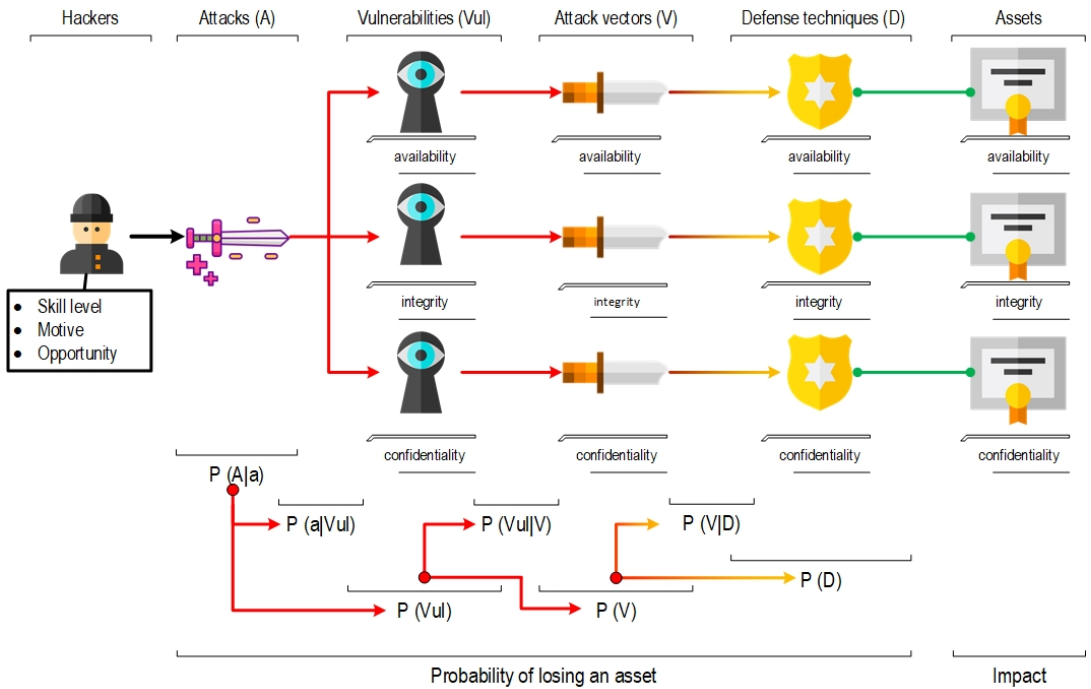
Figure 6: Visualized decomposition of an attack on an asset.

Since we cannot rely on average risk values, it is necessary to establish the probability of an attack a_i within the time window $[t; t + \Delta t]$ inside the context c (system parameters and LOGs), denoted by $P_{(c,[t;t+\Delta t])}(a_i|s)$:

$$P_{(c,[t;t+\Delta t])}(a_i|s) \qquad = \sum_{i=0}^{k} \left(P_{(c,[t;t+\Delta t])}(A|a_i) \cdot P_{(c,[t;t+\Delta t])}(a_i) \right)$$
(9)

Where

k - stands for a number of all system states S;

$(P_{(c,[t;t+\Delta t])}(A|a_i)$ - denotes probability of attack a_i from various attacks (frequency of using this attack a_i), statistical data;

$P_{(c,[t;t+\Delta t])}(a_i)$ - stands for probability of occurrence of an attack a_i. This event is predetermined by total probability of exploiting all vulnerabilities $|Vul|$ during the time interval $[t; t + \Delta t]$. Let us consider this decomposition in more detail in the Formula 10.

$$P_{(c,[t;t+\Delta t])}(a_i) = \sum_{j=0}^{|Vul|} P_{(c,[t;t+\Delta t])}(a_i|vul_j) \cdot P_{(c,[t;t+\Delta t])}(vul_j)$$
(10)

Where

$|Vul|$ - number of vulnerabilities enabling commitment of an attack a_i;

$P_{(c,[t;t+\Delta t])}(a_i|vul_j)$ - probability that precisely this vulnerability vul_j among among others vulnerabilities of attack a_i (frequency of using this vulnerabilities vul_j), statistical data.

The probability of occurrence of a vulnerability vul_j event depends on total probability of exploitation of attacks vector $\overleftarrow{V}$ during the time interval $[t; t + \Delta t]$ presented in Formula 11.

$$P_{(c,[t;t+\Delta t])}(vul_j) = \sum_{i=0}^{|\overleftarrow{V}|} P_{(c,[t;t+\Delta t])}(vul_j|\overleftarrow{v_i}) \cdot P_{(c,[t;t+\Delta t])}(\overleftarrow{v_i})$$
(11)

Where

$|\overleftarrow{V}|$ - identifies the number of vulnerability attack vul_j;

$P_{(c,[t;t+\Delta t])}(vul_j|\overleftarrow{v_i})$ - probability of using attack vector $\overleftarrow{v_i}$ from among various attacks vectors for the vulnerability vul_j (frequency of using this attack vector $\overleftarrow{v_i}$), statistical data.

More detailed representation of the attack vector probability can be tracked by analyzing Formula 12.

$$P_{(c,[t;t+\Delta t])}(\overleftarrow{v_i}) = \sum_{j=0}^{|D|} P_{(c,[t;t+\Delta t])}(\overleftarrow{v_i}|d_j) \cdot P_{(c,[t;t+\Delta t])}(d_j)$$
(12)

Where

$|D|$ - number of protective measures against the attack vector v_i;

$P_{(c,[t;t+\Delta t])}(\overleftarrow{v_i}|d_j)$ - harm caused by an attack vector $\overleftarrow{v_i}$ with a valid protection measures d_j (return value of quality of defense against attack vector), statistical data;

$P_{(c,[t;t+\Delta t])}(d_j)$ - probability of using this protection measure (yes or no).

When calculating values in one or more stages of the risk level analysis, some parameters of P (Formula 13) might be changed. Each attack vector has different parameters α_1 (information flow on the computer network), α_2 (number of backlinks), $\dots, \alpha_n$, which affect the probability of an attack.

The detection of anomalies for parameter α_i serves as one of the ways to determine the intrusion through IDS. For example, IDS / IPS analyze the data to detect the following intrusions:

Anomaly detection;

Signatures and Heuristic Detections.

For each probability $P_{(c,[t;t+\Delta t])}(\overleftarrow{v_i}|d_j)$ of attack within context c, attack vector $\overleftarrow{v_i}$ and protection measure d_j we can define the function $f(\alpha_1, \dots, \alpha_n)$:

$$P_{(c,[t;t+\Delta t])}(\overleftarrow{v_i}|d_j) = f(\alpha_1, \dots, \alpha_n)$$

(13)

The improved prediction of probability of attacks could be achieved through the creation of artificial parameters. Consider such countermeasures to increase the prediction chances. Some countermeasures assume the application of parameters α that increase the predicting probability. The examples of attacks and countermeasures are presented below:

Copy a site using HTTrack software or similar programs [16]. In this case, it would be necessary to perform a real-time speed analysis and check the order of web pages asking. Consider an option of script-markers adding upon finding a complete copy of the website (JavaScript for the website's pages). The downloaded pages will automatically contain these built-in scripts. This will allow to determine whether these pages were opened from a different address or not. When opened, the address of the opened page will not match the original (canonical) address. The script for these markers sends information to the attack prediction system with the note "view the saved pages of the site" ($\alpha_{view-saved-pages-site}$) in case you view the downloaded pages on your website. In this case, it is desirable to send the maximum complete information from the computer which was used to open the registered copy of a website. This will help to obtain the information about the potential attacker, which will change the system risk level.

Create false or incorrect metadata for txt, docx, xlcx, pptx, etc. In this case, it is necessary to consider the creation of fake characters (first and last name). The search is done in the search engines that provide erroneous information to the potential attacker. Relying on this collection of information, it is necessary to transmit to the attacker the fake web page where it is necessary to obtain the most complete information on the potential attacks during the transmission and, consequently, a notification is sent to the attack forecasting system with a note "display false pages with the transmission of the search system" ($\alpha_{display-false-pages}$).

Fill in the robots.txt file with additional false information and try to confuse the attacker who is interested in this file. Add links to this file, which would provoke the attacker's interest, such as links that include words like "admin", "login", etc. Establish link tracking transitions in the same way as in step 2. All calls to the robots.txt file by agents that are not search engine robots must be logged to inform the system prediction attacks through the note "display of the robots.txt file is from intruder" ($\alpha_{display-robots.txt-by-intruder}$).

In the html code of the page, it is necessary to provide comments where fake addresses of system administrators and/or developers are found. Applying scanning programs,

like The Harvester [15], the attacker will get "an interesting target for an attack" that will be an excellent marker for predicting attack system ($\alpha_{display-target-for-an-attack}$).

In case of our example, shown in Figure 7, it is possible to embed script-markers for the attack prediction system on Cloud VPS. With built-in scripts-markers, the $S_{scripts-markers}$ system parameter $\alpha_{scripts-markers}$ will be added to the list of indirect parameters affecting the probability of attack.

It is possible to add false metadata, including a fake author of some files (docx, pdf, etc.). One has to create a page with contacts of this fake author who created these files (docx, pdf, etc.) on the website. Relying on the site's viewing statistics, we can track visits to the pages of the fake author's files. Viewing this page is a consequence of studying method documents for the purpose of *footprinting and reconnaissance*. It means that someone is interested in the created fake pages, then the probability of the parameter $\alpha_{metadata-fake-search}$ will change the state of the system to the state $S_{metadata-faike-search}$.

For a variety of attack vectors one must identify parameters $\alpha_1, \dots, \alpha_n$ to produce the probability function of various attacks. These parameters, indicating a certain type of attack, must be "sieved" using the BigData method. It is necessary to eliminate noise from the results of the study. Following the BigData methodology, the most informative parameters will be highlighted.

To estimate the probabilistic law of our reference parameters $\alpha_1, \dots, \alpha_n$ we should choose different learning techniques, for example, the artificial neural network. This could help us find the exact function of $f(\alpha_1, \dots, \alpha_n)$ for each probability $P_{c_{[t;t+\Delta t]}}(a_i)$ of attack.

6. Example of simplified website administration on a cloud dedicated server

In this section we will attempt to clarify the application of our approach by referring to a simplified example. Figure 7 illustrates an example of simplified website administration on a cloud dedicated server (system S).
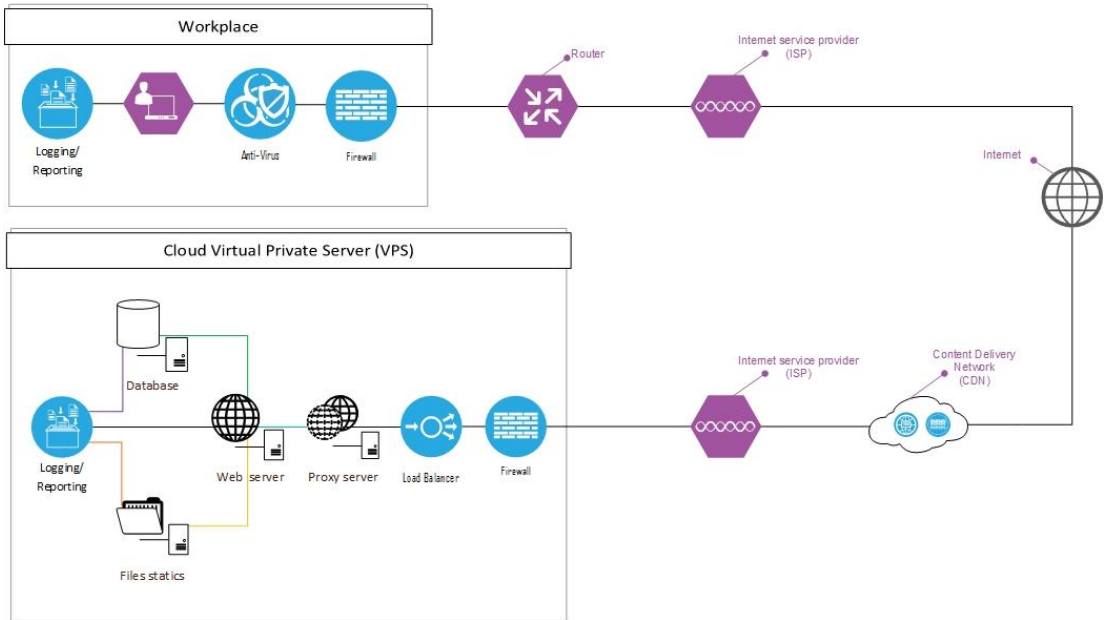
Figure 7: Website administration on a cloud dedicated server.

The list below contains a general set of website administration components on a dedicated server:

Workplace:

Firewall;

Anti-virus;

Logging/reporting by operating system (OS) and by anti-virus.

Router (for connection to the Internet Service Provider (ISP));

Content Delivery Network (CDN);

Cloud Virtual Private Server (VPS):

Firewall;

Load balancer (e.g. Gobetween, Nginx, etc.);

Proxy server (e.g. Squid, Varnish, etc.);

Web server (e.g. Apache, IIS, etc.);

Statics files (e.g. images, CSS, JS, etc.);

Database (e.g. MySQL, MSSQL, etc.);

Logging/reporting by OS.

The administrator has root access via SSH to the server through one-step authentication via a Certificate for Authentication, while a hacker wants to obtain a database dump. This is a simplified model consisting of two sides: administrator and hacker. We will refer to this example later to clarify different steps within the framework of our approach.

6.1. Example of assets analysis

Let us analyze the system description in more detail. The initial stage encompasses the consideration of assets. They are falling under definition of business processes that use assets (application data, data bases, personal office data, local area network services, common services, working environment, digital accounting control, etc.) $A: a_0 \dots a_n$, where $n \in N$.

Each asset class comprises the following components avl - Availability, int - Integrity, cnf - Confidentiality:

$$a = (Asset_0, avl, int, cnf)$$

(14)

An estimate is made of their value $(Val_{avl}, Val_{int}, Val_{cnf})$. This evaluation occurs by assigning each asset a certain criticality level when the asset is completely lost. Thus, the damage is taken into account after the asset's complete loss. The asset valuation is carried out in compliance with the selected methodology (MEHARI, CobiT, etc.). The system S performs an analysis in compliance with the chosen risk assessment methodology RM. This means that the value of the used assets is determined in case of each business process.

A: represents a set of assets. The sequence of $a_0, a_1, \dots$ describes a set of meta-variables used by us, which are ultimately comprising A. For this example of assets: $a_0 =$ Application data (data bases).

A^N: describes a set of attribute names of A. Availability (avl), Integrity (int), Confidentiality (cnf), Efficiency (eff) are attribute names applied by us to specify a security class of an asset a. For example, efficiency of the management process in order to comply to the legal, regulatory or contractual requirements, domain laws and regulations.

A^V: represents a set of attribute values of N_{att}. We are proposing to use 4 point scale (1 = Low, 2 = Acceptable, 3 = Inadmissible, 4 = Intolerable) for any asset's attribute name (avl, int, cnf, eff) while assessing the degree of importance (the level of loss when the asset is lost) of each value.

Val: represents a function 15 of assets valuation.

$$Val: A \times A^N \to A^V$$

(15)

In the example, provided by us, it is defined as $Val_{a_0} = (3,3,4)$ (Application data) and established for the following three attribute's components (Availability $a_0[0] = 3$, Integrity $a_0[1] = 3$, Confidentiality $a_0[2] = 4$).

For a_0 = Application data (data bases)

$Val_{a_0[0]} = 3$ (Availability = Intolerable);

$Val_{a_0[1]} = 3$ (Integrity = Inadmissible);

$Val_{a_0[2]} = 4$ (Confidentiality = Inadmissible);

6.2. Example of protection measures analysis

It is worth to undertake an analysis of protection measures D for assets A involved in business processes BP for the initial configuration of the system $Conf_h$, where $h = 0$ stands for the initial configuration.

$$D = (Conf, v), \qquad (16)$$

where v stands for vulnerabilities and exposures.

The following protection measures are ensured in case of our system:

Cloud Virtual Private Server (VPS);

Firewall;

Logging/reporting by OS.

The following Formula 17 is used by us to determine the risk for business processes:

$$RM: BP \times A \times D \rightarrow 2"\text{Tolerant}"$$

$$\qquad (17)$$

The risk level is assessed for the applied system configuration $Conf_i$, and it corresponds to the undertaken security measures. The network audit is carried out applying the chosen risk assessment methodology RM. At configuration modeling stage, the system configuration variants are created to match the acceptable risk levels.

6.3. Example of system states modeling

Consider the example of a network shown in Figure 7. In our example, a hacker would undertake an attempt to download the entire database dump. Here we are speaking about SQL injection[5]. In that context we would need to use the following Formula 18 as a first step:

$$R_{database}(\text{SQLinjection}) = \sum_{i=0}^{1} (P_{availability}(\text{SQLinj.}) \cdot 3 + P_{integrity}(\text{SQLinj.}) \cdot$$

$3 +$

---

[5] OWASP SQL Injection http://bit.ly/2vmHNTD

$$+P_{confidentiality}(\text{SQLinj.}) \cdot 4) \qquad (18)$$

Relying on OWASP it is possible to conclude that $P_{confidentiality}$ is one of the most widespread types of attack[6].

$$P_{(c,[\text{month}])}(\text{SQLinj.}|s) = \sum_{i=0}^{1} (1 \cdot P_{(c,[\text{month}])}(\text{SQLinj.}))$$
(19)

For illustrative purposes let us consider only the following vulnerability CVE-2019-8429 [14] applying Formula 10:

$$P_{(c,[\text{month}])}(\text{SQLinj.}) = \sum_{j=0}^{1} P_{(c,[\text{month}])}(\text{SQLinj.}|\text{CVE}-2019-8429) \cdot$$

$$\cdot P_{(c,[\text{month}])}(\text{CVE}-2019-8429)$$
(20)

Only one attack vector (Network) is identified for this vulnerability, therefore, Formula 11 will look as follows:

$$P_{(c,[\text{month}])}(\text{CVE}-2019-8429) = \sum_{i=0}^{1} 1 \cdot P_{(c,[\text{month}])}(\overleftarrow{v_i})$$
(21)

Taking into account the applied protection measures (firewall and logging), we may represent Formula 12 as follows:

$$P_{(c,[\text{month}])}(\overleftarrow{v}) = \sum_{i=0}^{1} (P_{(c,[\text{month}])}(\overleftarrow{v}|\text{firewall}) \cdot 1)$$
(22)

In our case, the firewall does not protect against SQL-injection. The success rate of this attack corresponds to 1. Accordingly, the level of risk remains "Unacceptable" in one month : $S_0 \rightarrow S_1$ (Figure 4). To maintain the level of risk, it is necessary to reconfigure the system $S_0 \rightarrow S_2$ (Figure 4). For possible attack scenarios, it is necessary to select such α parameters (markers) that will indicate a planned attack. In our case, a log analysis can show how often hackers are attempting to identify vulnerabilities. For our example, the period of one month is based on the logs analysis. Thus, we can predict the level of risk for the future. This will allow us to prepare for an attack in advance.

7. Future Work

One of the possible directions of the scientific work is the Theory of Games. This theory enables the prediction of behavior patterns of attacking and defending sides. Let us briefly consider this option.

Today, it is possible to draw an analogy between an Intruder (or a group of cybercriminals) and an information security specialist (a group of information security experts). Both could be compared with two gamers (teams) playing against each other

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[6] Top 10-2017 A1-Injection http://bit.ly/2VVAopZ

in real time. This game environment creates a realistic situation when both teams must take rapid decions, which might have serious consequences.

The teams are lacking time and have rather limited amount of information while making such decisions. In such a game, the defending party may incur maximum financial losses, while the attacking party can be prosecuted. The stakes in such a game are raised much higher, in the case the attacking party is represented by a special governmental department acting nationwide.

The mechanism of this game is shown in Figure 8.
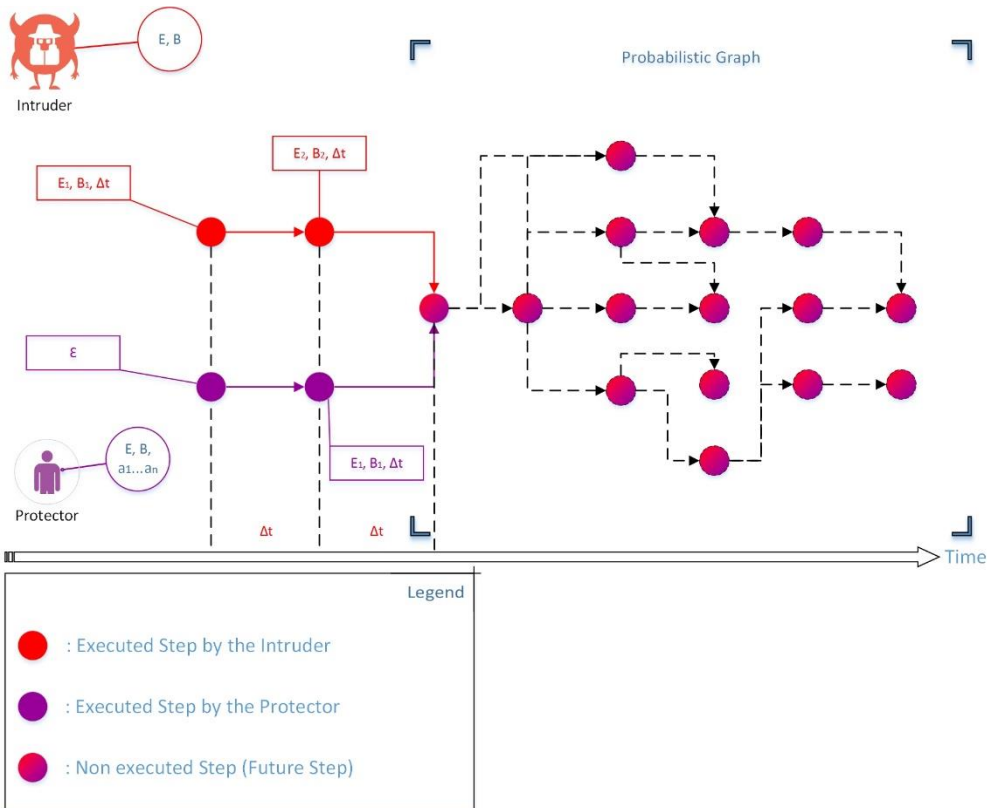
Figure 8: The mechanism of game for cybersecurity.

Consider a formal example of such a game. The attacker - Intruder (I) starts his game by identifying the vulnerabilities in the information security system of the defending party - Protector (P). Protector makes an action plan $a_1 \dots a_n$ to improve the protection of your system in real time. Intruder, in turn, analyses the presence of the vulnerabilities $v_1 \dots v_n$. Afterwords, he/she compiles an attack strategy. Each side has its own characteristics in this case, which include the level of experience E, the budget B, the time limit for the accomplishment of certain actions Δt. Bayesian games could be viewed as another

representation of the characteristics describing the game theory. In Bayesian games, the challenge is to identify how a player can assign appropriate initial beliefs to its opponents. Furthermore, it is sometimes interesting to consider a dynamic update of the players' beliefs. The formal definition of the repeated Bayesian game can be expressed applying   a
7-tuplet [6]:

$$G = (N, \Theta_k, A_k, H(t_q), \Sigma_k, \mu_k, U_k)$$

(23)

where:

N is the set of game players (M stands for a number of players);

Θ_k is the set of possible player types $k \in N$;

A_k is the set of available action types $k \in N$;

$H(t_q)$ is the set of possible $date - t_q$ game histories;

Σ_k is the set of the player's behavior strategies $k \in N$;

μ_k is the player's posterior belief k defined as a conditional probability that its opponents' types are θ_{-k}, given history $h(t_q) \varepsilon H(t_q)$ and type $\theta_k \in \Theta_k$;

U_k is the utility function of a player $k \in N$ until time $t_q, q \geq 0$, given the history $h(t_q)$.

Let us consider as a basis the shortest time for the execution of an attack or countermeasures taken during Δt. Each side has its own budget B and experience corresponding to level E. Anyway, a certain level of experience is required to perform one action, which also results in time expenditures expresses as $n \cdot \Delta t$. In this case, the empty action is taken ε. Upon the accomplishment of several actions, each system state would affect the opponent's subsequent steps. The system states modeling is enabled through the resort to probability graphs.

Conclusion

This research work has practical applications in information security systems. The findings of this work will contribute to the development of prediction of cyberattacks. Thus, it will be possible not only to simulate a threat, but to determine the level of its risk, depending on different configurations of security systems. This will enable more effective information security management. This work will serve as a basis for further research in the area of distribution of funds for the investment in information security [2]. This research work is also an attempt to prove that in the context of system security it will be possible to predict the level of risk of the weakest points based on the analysis of statistical data and hackers' behaviour in different contexts.

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Engineering Students' Perceptions when Working with Narratives in a Humanities Course

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Abstract

This research reveals the change that occurs in a university course when using narratives, which allows facing monumentalism in the classrooms, considering that, in most of them, classes are still being held in a traditional way without taking into account what the students think about the topics covered in the courses. The research is within the qualitative method. The results obtained allow to establish the influence of the course on the learning strategies used by the students, as stable learning indicators, two networks are presented: one corresponding to the use of narratives, and the second, incorporation of the question. Students are motivated to work collaboratively and have a favorable opinion of implementation.

Keywords: narratives, engineer training, humanities education, collaborative work, qualitative research.

Introduction

The importance of complementary training in engineering studies has been recognized in most of the world's universities, and traditionally, it has been covered by requiring one, two or three subjects that deal with specific topics of humanism (Belandría, 2011. p.17)

Likewise, some students state that they lack interest or vocation for these subjects. Obviously, the consequence of this situation is apathy, a reluctance for humanism and a deep immersion of the students in the realm of mathematics, physics, chemistry and engineering techniques. (Belandría, 2011. p.18)

Likewise, the field of action of the engineer is not related only to the scientific and technological, but is immersed in a complex reality that he must understand and know in its entirety to optimize the exercise of his profession based on the integral well-being of society and the natural environment where he develops. This requires knowing the

society and the environment that it transforms, understanding its cultural and natural diversity, being aware of the needs of the human being and for this he needs to be sensitive and aware of his social function as a person, as an engineer and as an agent of progress, change and development (Belandría, 2011. p.18)

According to the Organization for Economic Cooperation and Development (OECD), a large number of Chileans (53% of adults, but 84% of the country) do not understand what they read, thus they become functionally illiterate, moving away from the understanding of their social, cultural and historical environment. This is not new or local, on the contrary, it has been happening in different countries for at least thirty years. Today, prominent economists, such as the Spanish Joan Antoni Melé, propose concepts such as "ethical banking" or Edmund S. Phelps, Nobel Prize in Economics, quoted by Nuccio Ordine (2018) says:

(…) Today economies lack the spirit of innovation. Not only do labor markets need more technical skills, they require an increasing number of soft skills, such as the ability to think imaginatively, to come up with creative solutions to complex challenges, and to adapt to changing circumstances and new constraints. (…) A necessary first step is to reintroduce humanistic subjects in schools and in university curricula. The study of literature, philosophy and history will inspire young people to seek a fulfilling life, a life that includes making creative and innovative contributions to society. (p. 23)

Certainly, knowledge of history will make people better understand how society has arrived at the present moment. Experiencing the feelings and teachings of literature and the arts will make citizens more aware and sensitive to reflect on the decisions to be made, as opposed to the excessive use of reason, which can lead to misleading the correct direction of that society. Possessing knowledge of philosophy will make society develop fundamental critical thinking that will help choose the path to the destiny of the country.

In The Utility of the Useless, Nuccio Ordine speaks of the marginalization of the humanities in this technological age, highlights the importance of the humanities in the training of citizens and criticizes the commercial use that has been made of education. These areas (literature, philosophy, history) have a value in themselves and are decisive in our human and civic education, or in the development of our critical and at the same time compassionate thinking, capable of keeping that humanity in mind, and that it implies being the same and different. In many universities, from different countries, the idea that these, only, should work with mercantilist principles and should be oriented with the postulates of profitability, effectiveness, efficiency and competitiveness typical of the market economy has been installed. Ordine expresses concern that students are considered clients, and since the client is always right, the quality of teaching suffers in favor of the speed with which a degree is sought. On the other hand, according to Terry Eagleton (2017):

Academic institutions, in the past areas of critical reflection, are being increasingly reduced to market bodies (…). For the most part, they are in the hands of technocrats

(…). The work of the new intellectual proletariat of academics is evaluated according to whether their lectures on Plato or Copernicus help to stimulate the economy. (p. 169)

Nothing could be more wrong, according to Nuccio Ordine (2018), when he talks about humanistic knowledge or those that do not produce an immediate economic benefit. "These are an end in themselves since they can play a fundamental role in the cultivation of the spirit and in the civil and cultural development of humanity." (p. 9)

Theoretical framework

Why the humanities serve today more than ever, with regard to technology today and in Heidegger, is because the latter is the representation of society. This society that bases its development on technique, this same technique that is part of consumption to sustain the economy. The conjunction of technique and economics lead to solidify a way of distracting attention from how important it is to be aware of the reality and the immediate social environment of people. The humanities help to understand the above to form a solid foundation for critical thinking.

According to Martha Nussbaum, cited by Adriana Valdés (2017), "treating people as manipulable objects if they have never learned another way of looking at them" is the basis of the inequality of a society like ours. A society in democracy is difficult to be thought of if citizens are not "capable of thinking for themselves, criticizing tradition, and understanding the meaning of other people's sufferings and achievements." Likewise, "(…) generations of utility machines will begin to be produced, instead of comprehensive citizens" (Valdés, 2017). The same could be thought of the educational reforms of secondary education where the government tried to eliminate philosophy, history and the arts, at some point in Chile. When there is little or no critical or reflective thinking, as Adriana Valdés puts it, the sense of what the country wants to achieve is lost, part of the citizenry begins to feel exploited and excluded. In this way, people become useful in the manner of Heidegger (Acevedo, 2016). The utensil, the human being in this case, remained unthemed by deception, or fear, thus remaining at the hand of the system for decades, both at the beginning of the republic and throughout the twentieth century. In the same way, the person is "provoked" and transformed into a resource even though it is not, but it becomes quantifiable. Without going any further, companies still maintain their Human Resources departments today. Some recently began to call their workers collaborators, thus forming a respectional totality. When all the above happens, without realizing it, Byung Chul-Han's statement, "Now you exploit yourself and believe you are realizing yourself," makes perfect sense. For these reasons it is that humanistic knowledge is for life and not instrumental, temporary, as are some skills that have been learned and then discarded due to their obsolescence over time, an example of the above is the learning of computational languages that a user had to have to operate a computer, before the appearance of the Windows operating system. According to Ordine (2018), knowledge, humanistic for our interest, is the only form of "wealth" that does not diminish or lose when it is given and, on the contrary, it does enrich the recipient for life.

The fact that people always experience crises is a fundamental reason to study the humanities. We exemplify this, in general, with engineers who throughout their lives make decisions based on the quantitative; However, when all the goals are fulfilled as family, home, car and midlife approaches, some begin to wonder what the meaning of all this has been, feeling enslaved to work and the responsibilities of life. It is when the midlife crisis can appear. The humanities are the way that leads to the answers and that solves such uncertainties and questions by finding in them those answers that are not quantitative, but qualitative. Literature gives some examples that transpose time such as Hamlet and his vital doubt of taking revenge, or not on her mother and uncle for the death of her father, the king of Denmark or Faust selling his soul to the devil for the success that did not arrive. How useful it is to read these texts to realize that literature contains this knowledge that has no immediate economic value, but that helps people understand vital issues in times of crisis.

Other types of crises, such as social ones, have been present throughout the history of humanity. Some of them recent, in Chile, such as the social issue of the nitrate companies at the beginning of the last century, with all that it meant between abuses and deaths of men, women and children. Then Luis Emilio Recabarren (2010), in his speech "The Rich and the Poor Through a Century of Republican Life", in Rengo on September 3, 1910, diagnoses the situation of Chilean workers when celebrating the centenary of the republic and where he says that the workers, one hundred years after the republic, have nothing to celebrate. That is why, for him, it was so important that workers know how to read:

To promote instruction, in all its degrees and in all its forms, is the duty of every person who considers himself civilized. Encouraging education, as has been said, is to weaken the foundations of unpredictability and vice; it is to initiate his disappearance ... Let us encourage him to read, to think, to analyze. Doing this, (…) is leading the people to improve their living conditions. The most educated people will be the most powerful people. (p. 55)

In an interview, Howard Gardner (2016) says:

(…) And it is one of the reasons for the crisis of maturity, when they realize that there are no (…) humanistic studies: Philosophy, Literature, History of Thought (…). You can live without philosophy, but worse. In an experiment with MIT engineers, we discovered that those who had not studied humanities, when they reached their 40s and 50s, were more likely to suffer crises and depressions (…). Because engineering and technological studies end up giving you a feeling of control over your life, in the end, unreal: you only focus on what has a solution and on the questions with answers. And for years you find them. But, when with maturity you discover that it is impossible to control everything, you become disoriented (…) due to lack of humanistic studies.

Training in the humanities allows promoting reflection in people, producing an internal change in them. This also allows a personal reflection to make a generational comparison

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between the present generation and their parents or grandparents. Likewise, with the evolution of society, allowing a reflection on it and how they will develop in their work environment, for example, to help improve society. This reflection gives all people the opportunity to share and realize that they have common ideas. Morin (1999), raises the need:

(...) for the education of the future, of a great relationship of the knowledge resulting from the natural sciences in order to locate the human condition in the world, of those resulting from the human sciences to clarify the multidimensionalities and human complexities and the need to integrate the invaluable contribution of the humanities, not only of philosophy and history, but also of literature, poetry, the arts (...). (p. 22).

Adela Cortina (2018) adds an ethical factor to humanities training when she points out:

The question is not, then, in schools and universities to train only well-specialized technicians who can compete and meet the demands of the markets, whatever they may be, but to educate good citizens and good professionals, who know how to use the techniques to implement them at the service of good ends, who take responsibility for the means and the consequences of their actions in order to achieve the best ends. (pp. 134-135)

In some relation to this, the only thing we are clear about going forward is that society as a whole will change, be it in technology, education, jobs or historical processes, therefore the last thing that education should do is deliver more information to students, they already have a lot (Harari, 2018). What they will need is the ability to decide between what is more or less important, it is in these circumstances where the professional person of the future will need a solid humanistic training that allows them to have the tools that enable them to make better decisions, both in terms of personal as well as professional. Harari himself states that:

The decisions we make in the coming decades will shape the future of life itself, and we can make these decisions only from our current world view. If this generation lacks a complete conception about it, the future of life will be decided at random. (pp 287-288)

Methodology

A qualitative research was carried out, which is guided by significant areas or research topics. Ander-Egg (2011) defines the concept of research as "a reflective, systematic, controlled and critical procedure that aims to discover or interpret the facts and phenomena, relationships and laws of a certain area of reality" (p.18). Within which questionnaires and narrative diaries were used, through the latter, the data of this research were taken, so that the students could express their appreciations of their state before and after taking humanities subjects from the curriculum of their career.

Narratives were used to collect data which sought to gather information about the course, which aspect was the most relevant for students when learning humanities, for

example. The narratives of the students delivered throughout the semester were analyzed. Data analysis was carried out with the qualitative software Atlas.Ti 7.0.

Narratives in education are used as a didactic resource, in this way the conception of an education that is limited to the memorization of information and its retention is combined, where the student is motivated to learn new knowledge in a different way (Tapia, 2019).

The notion that mediates the narrative perspective is that of listening to the voice of the subjects, understood as that which is the bearer of life history (Arévalo, Fernández, Hidalgo, Lepe, Miranda, Nuñez and Reyez, 2016. p. 225)

Results

To begin with the narratives, a coding was carried out and then organized and grouped into categories according to the main topic of the research, which allowed to develop an interpretation and synthesis of the information found in the narratives. The categories were raised once the narratives were applied to the participants of the experience.
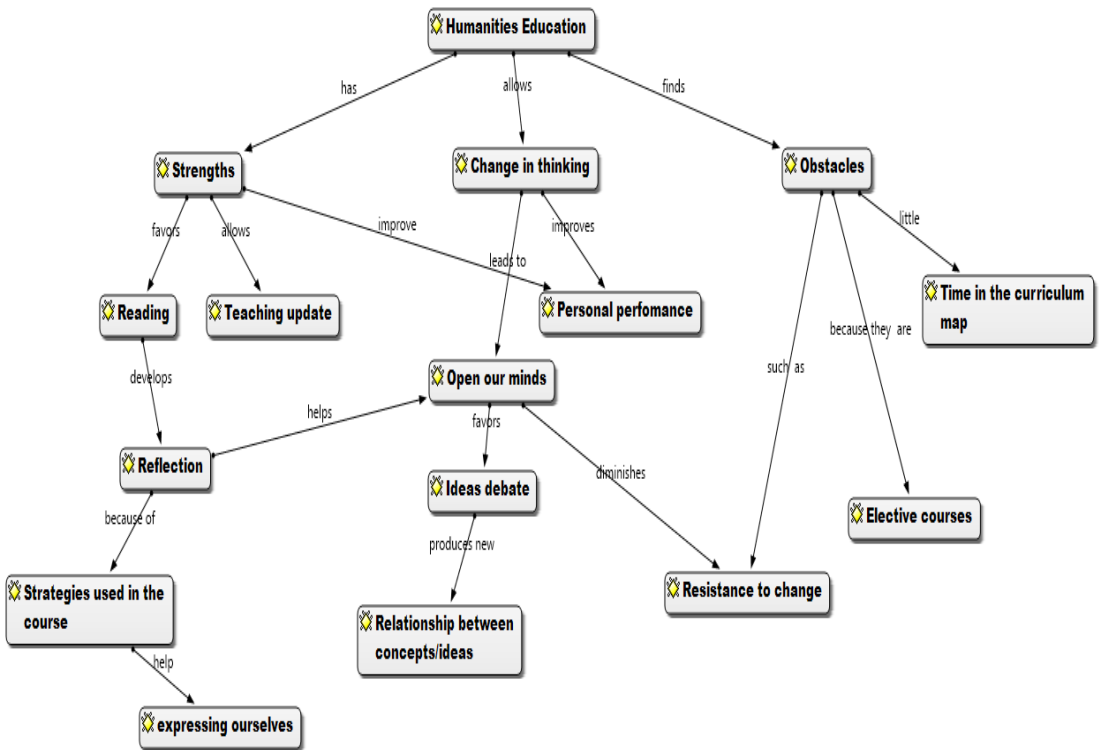

Figure 1. Humanities Education semantic network

Figure 1 shows the semantic network called Education in Humanities in which three subcategories can be seen, the first called Strengths, it is observed that humanities

training favors reading in students, allows them to reflect on his practice, to be able to express himself. In addition, the strategies used in the course facilitate teaching and it is given in a more contextualized way.

It is observed, in the second subcategory called Way of Thinking, how students are able to open their minds to other topics proposed in class, discuss ideas and relate concepts. There is also the third subcategory called Obstacles, where, due to the information provided by the students, one of the drawbacks is that the humanities are very little valued in the training of engineers, there are no compulsory humanities courses, the Humanities courses are very little valued by students too, they prefer to take other subjects.
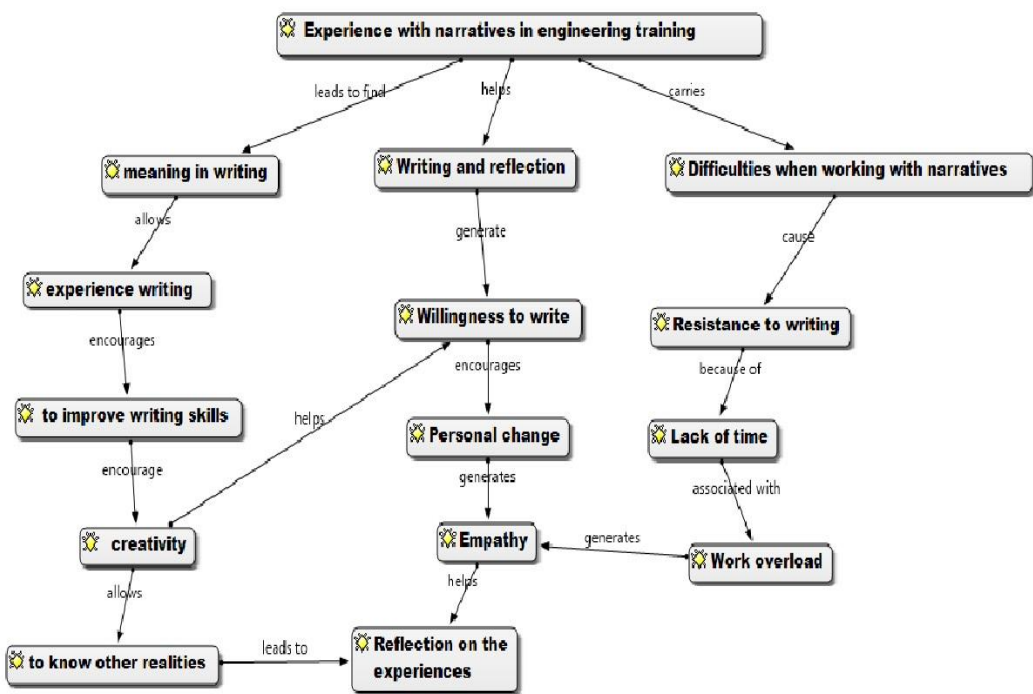

Figure 2. Semantic network Experience with narratives in engineering training.

Figure 2 shows the semantic network corresponding to experiences with narratives in the training of engineers, it is composed of three subcategories. The first subcategory is called Meaning of Writing, here we find how writing influences students and the benefits that it brings them in their training, increasing their creativity, allowing them to know other realities.

The second subcategory is called Writing and Reflection, here we obtain how students present a willingness to write and realize that this is a tool that allows them to achieve

changes in society, since they can put themselves in the place of the other and better understand reality, leading them to reflect on the situations they have experienced.

The third subcategory is called Difficulties when working with narratives, where we find the resistance of students towards writing, since they insist that they have very little time to carry out this activity, in addition to an overload of work.

Conclusions

It can be observed, through the interviews applied to the course participants, that working with narratives is a learning experience that allows to modify the work in the classroom and that favors knowing other ways of delivering the contents. This helped to increase communication within the work groups, foster responsibility among students, with a greater bonding of students, as a result of the knowledge generated between them, they also recognized the ability to incorporate changes during the development of classes, being able to respond to emerging situations.

This research will continue in the future with a quantitative component, where a questionnaire will be built, to expand it to a mixed research.

Finally, everything that makes them more human and that will contribute to the different capacities of the future professional person. Likewise, the teaching of the humanities, at the university level, would allow students to relate different aspects that influence decision-making in the various areas of their lives. The above to have, in the end, not only a specialist who makes better decisions, but an integral person, aware of his/her social, historical, cultural environment and with instrumental knowledge for life, at the same time.

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