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Comparison of the Experimental and Theoretical Critical Buckling Force at the Rod of a Defined Shape

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Abstract

The paper compares the critical buckling force values obtained by different computation ways with experimental measurements performed at the rod of a defined shape. Nowadays there are many theoretical ways for critical buckling load computation because of the stability loss which appears at sufficiently slender rods. Accurate computation ways do not exist for all kinds of rod geometry. Due to this, the experimental measurements were performed. Values from these measurements can be significantly different from computed values. This paper deals with the deflections at critical buckling force computation by means of different computation ways from experimental measurements at the rod with flattened ends.

Key words: stability loss, flattening, critical buckling force

1. Introduction

Nowadays, economizing of materials and development of devices is very important in constructional practice. In order to meet this requirement, the material of the components has to be utilized efficiently. According to some authors, despite its long tradition, steel is utilized neither in half of its material properties [1]. Recently, the emphasis on decreasing construction mass has grown with the aim of decreasing material consumption in the manufacturing. At constructions, we use the members or components of a low mass simultaneously of a high strength. According to these requirements, the best profile is a circular tube which has a higher carrying capacity in a buckling load, higher stiffness in torsion, low wind resistance and lower mass compared to the other profiles [2, 3].

The connection of tubes is more complicated than at other profiles because we do not have any

flat surface that is so important for rivets or belts placement, which makes the construction demountable. In order to use the smallest number of components, the easiest solution is to flat the tube on its ends and clamp it on gusset joint plates by bolts [4]. Many rods in constructions are loaded by an axial force, whether it is tension or pressure, which can cause the stability loss. The stability loss which appears mainly at sufficiently slender rods is the most dangerous phenomenon. This paper compares values of the critical buckling force at the rod with flattened ends computed according to different ways with the experimental measurements.

2. Material and methods

For theoretical computation of critical buckling force we will use the following ways:

- computation by the Euler equation without the consideration of flattening and with pinned fitting on the rod ends,
- computation by the Euler equation without the consideration of flattening and with pinned fitting on the rod holes,
- computation by the Energy method with pinned fitting on the rod holes.

The critical buckling force without consideration of flattening was computed by Euler equation [5]

$$F_{crit} = \frac{\pi^2 \cdot E \cdot J_{min}}{(\beta \cdot l)^2} \quad (\text{N}) \dots\dots\dots (1)$$

where:

- E – Young modulus of elasticity (Pa),
- J_{min} – minimal cross-section moment of inertia (m^4),
- β – buckling coefficient (-),
- l – rod length (m),

The critical buckling force with the consideration of flattening was computed by the energy method. Approximate equation for the critical buckling force computation can be assumed as follows:

$$F_{crit} = \frac{\int_0^l w_{(x)}'^2 \cdot dx}{\int_0^l \frac{w_{(x)}^2 \cdot dx}{E \cdot J_{(x)}}} \quad (\text{N}) \dots \dots \dots (2)$$

where the deflection line function $w_{(x)}$ can be written in form:

$$w_{(x)} = w_0 \cdot \sin \frac{\pi \cdot x}{l} \quad (\text{m}) \dots \dots \dots (3)$$

where the value of maximum rod deflection w_0 does not have to be known.

Function of cross-section moment of inertia was written by a hollow rectangle shape in the position of flattening; by a hollow ellipse shape in the position of flattening and circle transitional area, and by an annulus shape in the position of the circle part of a tube. Equations for the individual functions of minimal cross-section moment of inertia which were being changed according to x axis, have forms:

$$J_{(x)\text{min rec}} = \frac{B_r \cdot H_r^3 - b_r \cdot h_r^3}{12} \quad (\text{m}^4) \dots \dots \dots (4)$$

$$J_{(x)\text{min ell}} = \frac{\pi}{64} \cdot (B_e \cdot H_e^3 - b_e \cdot h_e^3) \quad (\text{m}^4) \dots \dots \dots (5)$$

$$J_{(x)\text{min cir}} = \frac{\pi}{64} \cdot (D^4 - d^4) \quad (\text{m}^4) \dots \dots \dots (6)$$

where $B_r, H_r, b_r, h_r, B_e, H_e, b_e, h_e, D$ and d are characteristic dimensions which are shown in Figure 1.

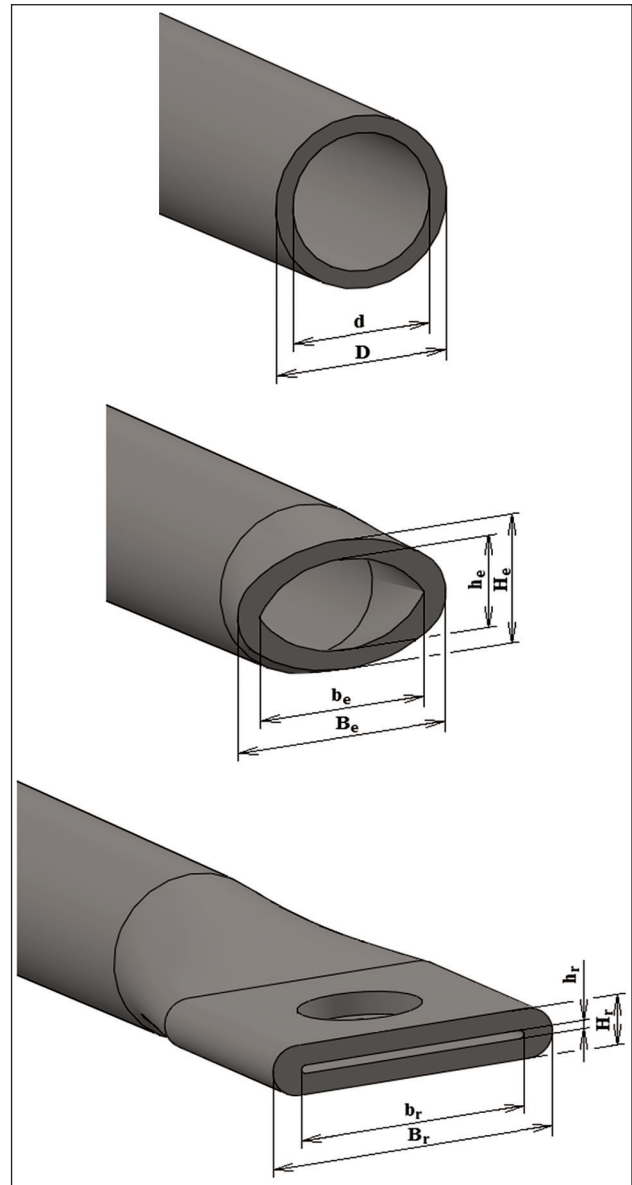


Figure 1. Characteristic dimensions of a tube

Then the numerical evaluating of the integral in denominator of equation (2) can be written [6] as follows:

$$\int_0^l \frac{w_{(x)}^2 \cdot dx}{E \cdot J_{(x)}} \doteq \frac{l}{3 \cdot n \cdot E} \cdot \left(\frac{w_{(x_0)}^2}{J_{(x_0)}} + 4 \cdot \frac{w_{(x_1)}^2}{J_{(x_1)}} + 2 \cdot \frac{w_{(x_2)}^2}{J_{(x_2)}} + 4 \cdot \frac{w_{(x_3)}^2}{J_{(x_3)}} + \dots + 2 \cdot \frac{w_{(x_{n-2})}^2}{J_{(x_{n-2})}} + \dots \right) \dots \dots (7)$$

$$+ 4 \cdot \frac{w_{(x_{n-1})}^2}{J_{(x_{n-1})}} + \frac{w_{(x_n)}^2}{J_{(x_n)}} \Bigg)$$

where:
 n – interval distribution (it was done with the step of 1 mm).

The specimens with an outside diameter of 10 mm and thickness of 1 mm were used for the experimental investigation of the tube critical buckling force. Construction steel S 235 was used as a tube material. The measurements were performed with four length variants of specimens, concretely 500, 640, 800, and 830 mm. The ends of tubes were modified by flattening on the length of 15 mm with a hole diameter of 7 mm in the distance of 6 mm from the tube edge because of the clamping to a fixture according to Figure 2. The measurements were done with a statistically significant number of specimens.



Figure 2. A tube flattening

The values of the critical buckling force were obtained by the universal machine Testometric M500–100 CT which provided the data about a dependence of axial force and displacement (Figure 3).

The fixtures in fact simulating the real gusset joint plates were made for clamping rods. These fixtures were installed on the machine and the tubes were clamped by bolts (Figure 4).



Figure 3. Testometric M500-100 CT

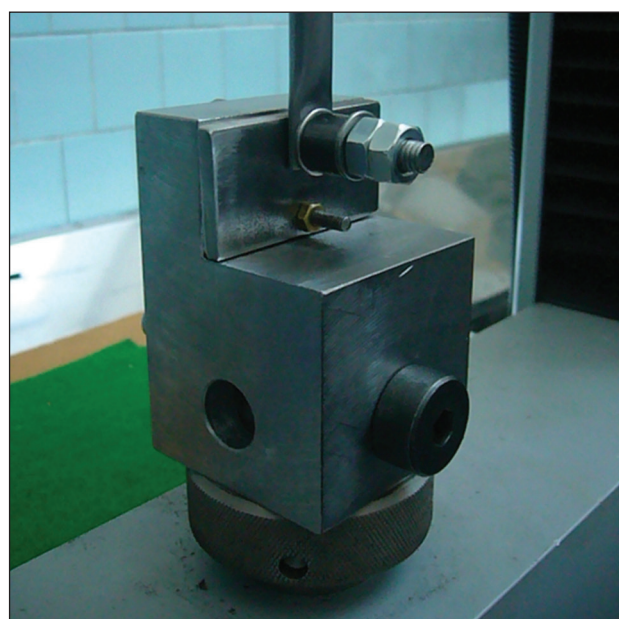


Figure 4. Fixture

Also the critical buckling force value was obtained by the CREO Simulate software. The model was designed following the energy method computing, concretely by pulling of the individual rectangular, elliptic and circular cross-sections.

3. Results

From the measured values of the critical buckling force, the average critical buckling force value was computed for each length dimension and, of course, the standard deviation which is important for a significance of differences was computed too. The critical buckling force values obtained by theoretical and experimental ways are shown in Table 1. *Table 1. The overview of the critical buckling force values*

Rod length (m)	0.5	0.64	0.8	0.83
Experimental measurement				
Average buckling force (N)	3063	1897	1234	910
Standard deviation	387	109	92	236
Theoretical computing				
Euler (axis – axis) (N)	2522	1523	967	898
Euler (whole tube) (N)	2403	1466	939	872
Energy (axis – axis) (N)	2504	1515	963	894
CREO Simulate (N)	2540	1532	972	902

For obtaining the knowledge of a significance of value differences, the Student t-test was done between the measured values and the highest theoretically computed values. T-test values for individual tubes lengths are shown in Table 2.

Table 2. Student t – test values

Rod length (m)	0.5	0.64	0.8	0.83
Student t - value	2.214	10.195	7.875	0.038

4. Discussion

As we can see in Table 1, the highest theoretical value of critical buckling force is obtained from CREO Simulate software at all investigated rod lengths. This value changes in dependence on used computational ways. The lowest value is obtained by the Euler formula with pinned fitting at the rod holes without the consideration of flattening. The relative error of theoretical values of critical buckling force from simulated situation ranges from 3.33% to 5.41% in dependence on the rod length.

When a pin support is moved on the rod ends, there appears changing of the relative error value and it will be shown by its decrease in a range from 0.47% to 0.71% and using of the energy method from 0.85% to 1.41% in dependence on an investigated length. Considering the allowed relative error up to 5% value, we can consider this computing process as accurate sufficiently.

In Table 2, we can see, the relative error decreases with an increase in a rod length in all investigated computing ways. From this, we can conclude that with rod slenderness decrease the computed values will have a higher mutual variance. Experimental measurements have shown that all theoretically computed values of critical buckling force, except the length of 0.83 m, are statistically significantly different from experimental values.

These deviations could be created by interaction of different imperfections. The imperfections include non-homogeneity of material, uneven increase in fibres temperature, eccentricity of clamping holes, flattening plane rotation to each other, their non-parallelism with rod axis, faults of the fixture manufacturing and non-ideal alignment of the machine hubs. When looking for the causes of differences between theory and the experiment, we have two possibilities to choose. Either we will look for the cases why the theoretical equations are correct only at one length, or why the measured data do not correspond with the theoretical equations. We will look for the causes of higher measured values. If this force is higher, it is needed to look for some effect which can cause this state. In our opinion it is caused by imperfections such as the mutual rotation of flat planes around the rod axis and a subsequent hole jam and seizure in a primary deformation direction.

At the mutual rotation of flat planes, we have had a limitation in a form of simple rod rotation around the pins. The axial force causes the jam of one of hole, possible seizure and rod rotation difficulties, which results in increase in force.

5. Conclusion

The aim of this paper is to compare values of critical buckling force obtained by different computing ways with experimental measurements investigated on a rod with defined geometry. Experimental investigation of critical buckling values was done on universal machine TESTOMETRIC M500-100 CT. Tubes with flattened ends at four length variants were used as specimens. Tube diameter, thickness and flattening geometry were the same at all specimens.

From each variant, repeated measurements were done for the average value of critical buck-

ling force and standard deviation determination. For each variant, theoretical values of critical buckling force according to Euler and the energy method were computed. The situation was also simulated in CREO Simulate software.

As we can see in Table 1, theoretical values of critical buckling force are different from each other in 5% tolerance, which means we can use the random method without making a significance error. Experimental measurements show that the experimental values are significantly different from the computed values and this fact is verified in Table 2, where the statistic significance is confirmed. In the part Discussion, the possible causes are described.

Almost all described imperfections have an effect of decreasing critical buckling force at the specimens. Due to the imperfections, a deformation appears earlier than it is described in the theory. The mutual rotation of flattened planes is an exemption because in this case the deformation does not appear in the same direction from both the directions of view. As a result, it should have an increase in the critical buckling force value. Correctness of this hypothesis will be verified in future. In the case of its correctness, achievement of this type of imperfection can increase stiffness of construction components.

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Effects of Permanent Magnets on Torque and Power Density of Spherical Motors

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Abstract

The paper deals with electromagnetic analysis of a spherical electric motor in which different magnet types are used in rotor construction. The flux densities, torque, power density and physical dimensions for the designed motor have been obtained in the study. It has been seen that high torque and high power density at spherical motors are related to magnet types. Using NdFeB and SmCO permanent magnets in rotor structure of the spherical motor has increased the torque and power density values.

Key words: Spherical motor, power density, permanent magnet, maximum torque

1. Introduction

In electric machines; soft magnetic materials, conductors, insulators and permanent magnets are used. [1], [2]. It is expected that soft magnetic materials must have high permeability, high saturation and less core loss, and for these reasons the soft magnetic materials create magnetic circuit of machine. In addition to this, in order to decrease magnetic circuit's reluctance, this magnetic material used in machine needs to have high magnetic permeability. Apart from this, saturated flux density must be high for decreasing iron volume and weight.

Permanent magnets are used for creating exciting field in electrical machine. When they are run in normal limits, magnets keep energy over them for an infinite time. If an electromagnet is used instead of a permanent magnet and a magnetic field is created energy of the excited field is still kept, nevertheless only a few ohmic energy losses are come up with conductor's resistance. Permanent magnet materials are categorized as AlNiCo, ceramic (ferrite) and rare earth magnets according to their chemical compositions. In most applications which need a small volume and low weight, rare

earth magnets are used. When AlNiCo alloyed magnets, Barium Strontium and Ferrite magnets are developed; it has been seen that designs of electric motors and generators with magnets have more frequently emerged.

Ma and et. al. have compared the performance of NdFeB powders and the fundamental characteristics of polymers for bonded magnets [3]. Gay and Ehsani have experienced and analyzed a permanent magnet eddy current brake [4]. Gürdal and Öner have made magneto-static analysis of a spherical actuator and performed its application. This motor has got a spherical rotor made by NdFeB permanent magnet strips and a stator has a soft iron and a basic coil winding [5]. Yıldırım and Aydemir have developed an axial flux, permanent magnet generator with coreless stator, twin rotors to use in wind turbine [6]. Aydın has developed a design method for AC and DC permanent magnet motors, demonstrated designing steps of permanent magnet motor on a disc motor sample [7]. Ezenekwe have pioneered to researches of high pulling force between ferromagnetic cores and permanent magnet rotors [8]. Göngör and Çetin have optimized air gap, slot geometry and crossing angle parameters of a generator which produces electricity from wind by finite elements method [9]. Vrtič has presented the variations of permanent magnets dimensions in axial flux permanent magnet synchronous machine [10].

Huang and et. al. have outlined a detailed approach to size axial flux machines by means of general purpose sizing and power density equations [11], [12]. Guo and et. al. have compared two types of 3D flux electrical machines with soft magnetic cores, claw-pole and transverse-flux machines [13]. Nerg and et.al. have presented a lumped-parameter-based thermal analysis applicable to radial-flux electrical machines with a high power density [14]. Tarimer has designed and pro-

duced a permanent magnet axial flux structured generator for wind turbines [15].

In this study, a spherical motor’s rotor which is constructed by a permanent magnet core has been developed. In order to achieve this construction, several rotor prototypes have been seized, and then their possible torque outputs and magnetic flux densities have been obtained. Torque curves of the seized rotors have been extracted for different magnet types.

2. Structure of permanent magnetic materials

Cobalt is used in AlNiCo and rare earth–cobalt magnets. Ferrites are electrical and thermal insulators. AlNiCo’s have high permanence and low coercivity. In the design of electrical machines, it’s expected that using less material must provide more power. At the same time, machine’s volume must be less too. Gay and Ehsani have stated that permanent magnet machines would give high torque at less weight comparing with asynchronous and switched reluctance machines [4].

Permanent magnets are harsh magnetic materials. Their B–H curves are big; permanent magnetism and magnetizing coercivity forces are high [16]. Magnetic and thermal features of the magnets commercially available are given in Table 1. From Table 1, the magnet which have the best performance permanent magnets with 290 kJ/m³ maximum energy multiply are made by Neodymium-Ferrite-Boron without Cobalt material.

When temperature increases, some magnetic features change as feedback and some changes without feedback. The changes with feedback are determined with temperature constants (α and β per

Kelvin). These values give function of temperature, magnet running point and field density[1]. Even though magnets made from ceramic are cheap; NdFeB magnets are used instead of ceramic magnets in applications needed low volume and low weight. Small volume magnets could be used since that NdFeB materials have high energy multiply. This makes other sizes such as iron apparatus and windings of the machine to become small.

3. Using different permanent magnets in spherical motor’s rotor design

The meshed structure of the rotor and cross sectional area of the designed motor in the study has been given as shown in Figure 1 (a, b). This simulation has been obtained by Maxwell 3D program [17].

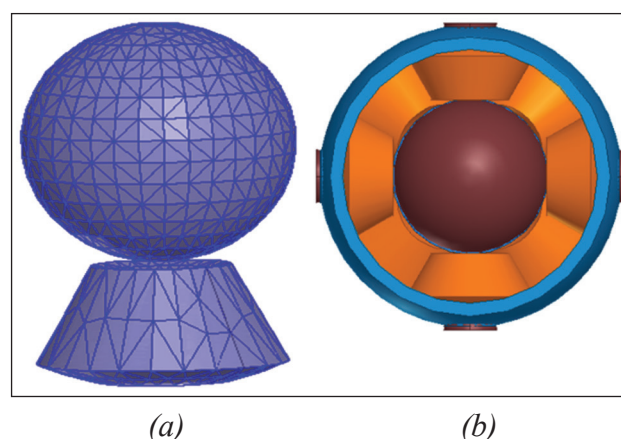


Figure 1. (a) Meshed structure, (b) cross sectional view of the spherical rotor

The volume of winding to be placed in the stator of the spherical motor in the study has been calculated as 73.4796120162 mm³ by Maxwell 3D software. When making simulations, eight dif-

Table 1. Magnetic and thermal features of commercial magnets

Features		Magnet Types			
		NdFeB	SmCo5	AlNiCo	Ceramics
B–H _{max}	(kJ/m ³)	200–290	130–190	70–85	27–35
Br	(T)	1.20	0.97	1.1	0.4
Hc	(kA/m)	870	750	130	240
Curie temperature (C°)		310	720	830	450
α	(% K)	-0.13	-0.045	-0.02	0.2
β	(% K)	-0.6	-0.25	0.01	0.4
Maximum working temperature (C°)		140	250	500	300

ferent permanent magnet types have been used to take this winding volume. In order to use each magnet type in rotor structure, magneto-static and time-varying (parametric) analyses of the system have been made. For using each of magnet types in the motor, several simulations have been done regarding to these cases; flux linkage and torque simulation results parallel to rotor production materials have been obtained. The dimensions and sizing parameters of the designed spherical motor have been given in Table 2.

Table 2. Dimensions of the designed motor

Dimensions	Values	Units
Rotor diameter	8	mm
Number of poles	2	--
Stator outside diameter	15.6	mm
Stator inner diameter	14.4	mm
Stator core material	M19_24G	--
Winding core material	M19_24G	--
Number of windings	8	--
Outer diameter of the winding core	4	mm

The designed motor's physical values can be seen from Table 2. The views of the designed spherical motor and its meshed structure have been shown in Figure 2 (a, b).

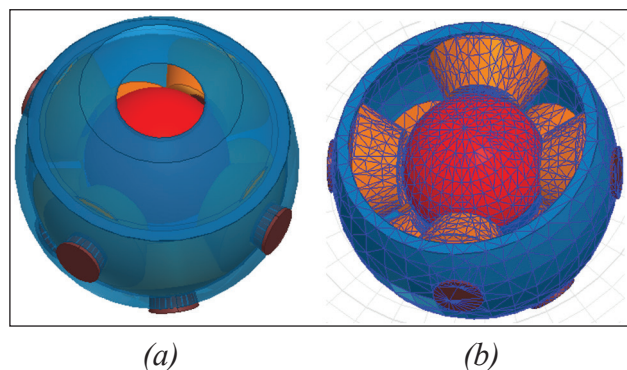


Figure 2. (a) - (b) Two perspective views of the designed spherical motor

From Figure 2, it is needed to have an extensive mesh between winding and magnet to obtain a more accurate solution [1]. The simulation results which show flux density and torque values are given in Figure 3 and Figure 4 respectively. Figure 5, 6 and 7 show the curves of torque versus angle. The error rate has been selected 1% in the analysis.

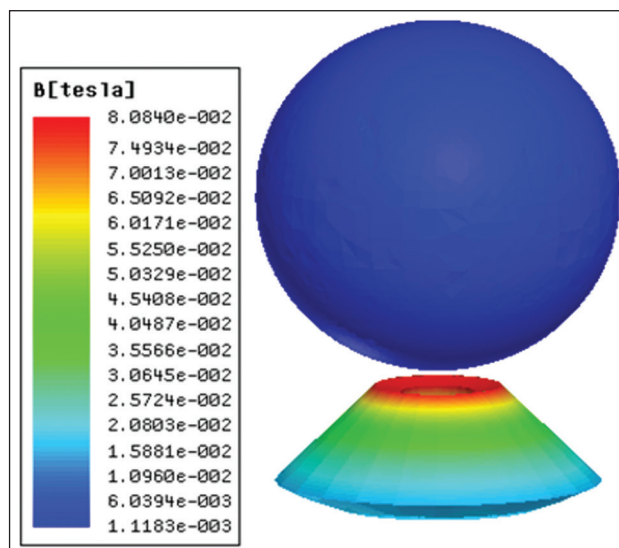


Figure 3. Magnetic flux density of SmCo28 permanent magnet material rotors

From Figure 3, the spherical rotor made from SmCo28 permanent magnet material produces magnetic flux density as .

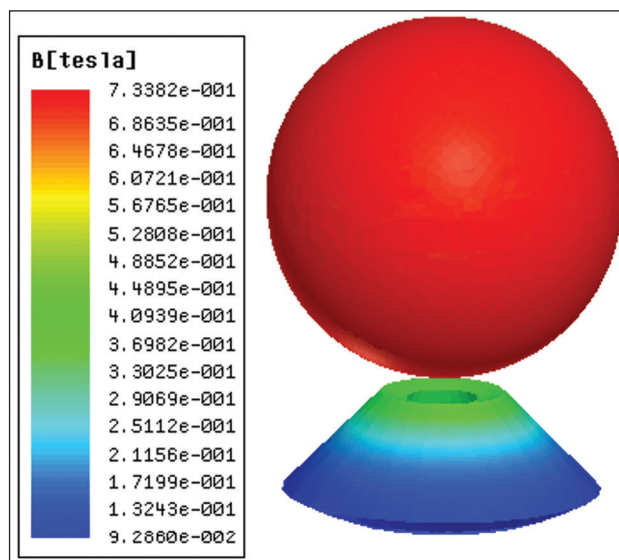


Figure 4. Magnetic flux density of NdFeB35 permanent magnet material rotors

From Figure 4 the spherical rotor made from NdFeB35 permanent magnet material produces magnetic flux density as $7,34 \times 10^{-1}$ T.

The energy density is associated with static electric and magnetic fields. This is also valid for time-varying fields. The power density experienced by the charged particle is given by [18]:

$$P = q(\vec{E} + \vec{u} \times \vec{B}) \cdot \vec{u} = q\vec{u} \cdot \vec{E} \dots\dots\dots (1)$$

where; q is a charged particle, u is velocity of the charged particle, P is power, E and B are the time-varying electric field intensity and magnetic flux density, respectively.

Eq. (1) proves that the time-varying magnetic field does not supply any energy to the charged particle. Only the electric field intensity supplies power to the charged particle. In terms of the power density, power equation can be written as

$$P = \frac{dP}{dv} = \vec{j} \cdot \vec{E} \dots\dots\dots (2)$$

where; J is current density vector of winding at volume V .

Eq. (2) can be used to derive relationships for the energy stored in a time-varying electric magnetic field and the power flow as given in Eq. (3).

$$\nabla \cdot (\vec{E} \times \vec{H}) + \vec{j} \cdot \vec{E} + \vec{H} \cdot \frac{\partial \vec{B}}{\partial t} + \vec{E} \cdot \frac{\partial \vec{D}}{\partial t} = 0 \dots (3)$$

This equation is known as the differential form of Poynting's theorem and it states the law of conservation of energy. The vector product $\vec{E} \times \vec{H}$ has the units of power density, watts per square meter (W/m^2). This equation yields the instantaneous flow of power per unit area.

Torque is depended on B and J . It is related to the geometric parameters of rotor and stator windings as well. The torque which is occurred by interaction of stator and rotor magnetic fields at rotor is given as Eq. 4:

$$T = - \int r (J \cdot B) dv \dots\dots\dots (4)$$

where; r is mean radius value of spherical motor's rotor.

The instantaneous expression for the energy densities in the magnetic and electric fields can be written as below:

$$w_m = \frac{1}{2} \vec{B} \cdot \vec{H} = \frac{1}{2} \mu H^2 \dots\dots\dots (5)$$

$$w_e = \frac{1}{2} \vec{D} \cdot \vec{E} = \frac{1}{2} \epsilon E^2 \dots\dots\dots (6)$$

The equations given in Eq. 5 and Eq. 6 are for the energy densities for time-varying fields. They are the same as those created for static fields. The fields vary with time.

In the case of the flux density increases, it will result that magnetic field intensity in the designed motor will increase. This rise provides that the torque and power density also increase. This is known from the equations above. Because as seen from Eq. 5–6, the vector terms of E and H change proportionally with the value of magnetic flux density (B). The torque and power density of the designed permanent magnet motor increase, for this reason the flux density developed in the motor is a sum of magnetic field intensity.

Figures 5 and 6 give the change of torque versus angle, when the SmCo28 and NdFeB35 type permanent magnets are used in mass of the spherical motor's rotor. Figure 5 shows a comparison of possible torque values for commercially available permanent magnets.

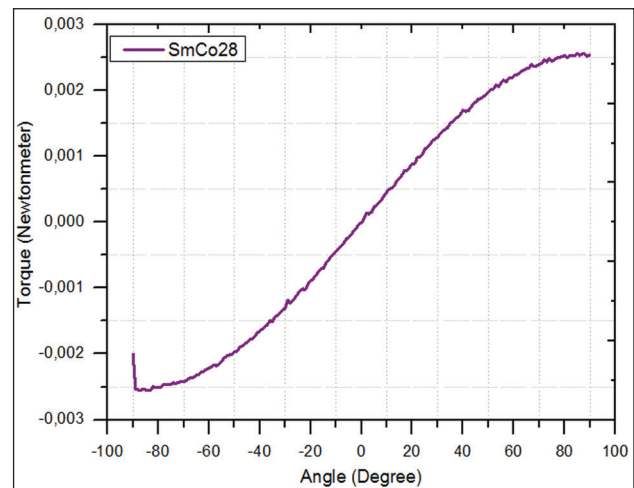


Figure 5. Torque versus angle curve of SmCo28 permanent magnet motor

It is seen from Figure 5 that if SmCo28 permanent magnet material is used in the structure of the rotor, 0.25 Nm torques would be produced by the designed spherical motor. The NdFeB35 permanent magnet material was used in the structure of the spherical motor's rotor in Figure 6.

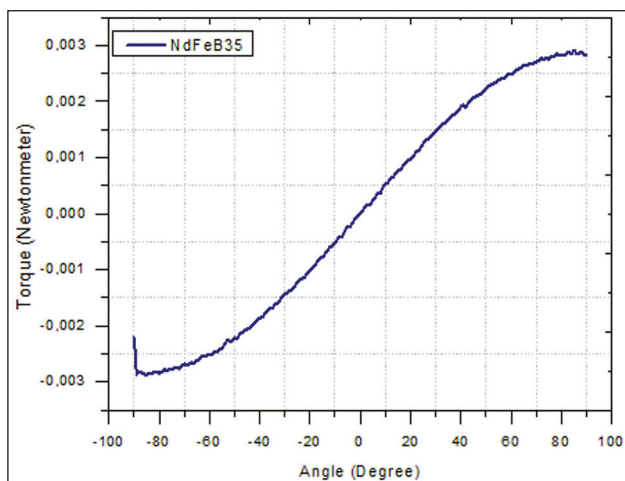


Figure 6. Torque versus angle curve of NdFeB35 permanent magnet motor

It can be said from Figure 6 that the same seized spherical motor would produce 0.30 Nm torques. This torque value is greater than the design with SmCo28 permanent magnet.

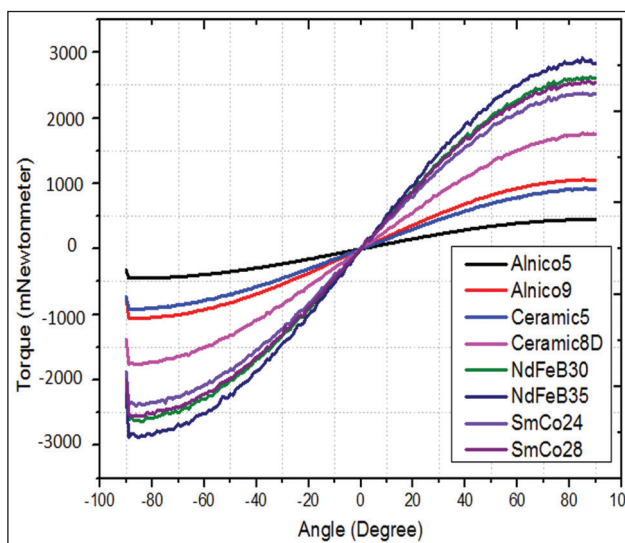


Figure 7. Comparison of torque versus angle curve of AlNiCo5 – AlNiCo9 Ceramic5 – Ceramic8D – NdFeB30 – NdFeB35 – SmCo24 – SmCo28 permanent magnet motor.

Figure 7 gives a comparison of all types of commercial permanent magnets' possible torque values. It can be seen from Figure 7, if NdFeB35

Table 3. Sizes and parameters of the designed motor

Design Parameters of Spherical Motor for Permanent Magnets	NdFeB35	SmCo28
Winding volume (mm^3)	73.479612	113.580723
Magnetic field density produced at rotor (T)	$7.34 \cdot 10^{-1}$	$1.12 \cdot 10^{-3}$
Torque produced by the motor (Nm)	0.30	0.25

and SmCo28 types magnets are used in structure of the rotor, the highest torque values would be created among all.

In this research, stator outer diameter is assumed as 15.6 mm long. As result of this size, the stator surface area is calculated as 191.135 mm^2 . On the other hand, it has been assumed that the spherical motor to be designed rotates with 2000 rpm. After calculations for both NdFeB35 and SmCo28 permanent types rotors, the parameters of the designed spherical motor have been obtained as given in Table 3.

From Table 3, it is seen that the sizes and parameters of the designed spherical motor made by NdFeB35 would be better than other permanent magnets designs. Torque production at rotor would increase, since that NdFeB35 permanent magnet has more field density.

4. Conclusion and results

In the study, magnetic static and time dependent analysis of the permanent magnets used in electrical machines (Alnico5, Alnico9, Ceramic5, Ceramic8D, NdFeB30, NdFeB35, SmCo24 and SmCo28) have been made. The torque values produced in case of using such magnets materials have been obtained. These torque values related to each magnet type have been shown by special drawing software.

It is not possible to select correct magnet by depending on torque values solely. A rise in temperature of the motor during running also effects torque and power. Excess heat on magnets should eliminate magnetic features of magnets without feedback. Therefore, it is necessary to pay attention that running and Curie temperature of the magnets should be in accessible levels when to produce a spherical rotor. Availability and cost of the preferred magnet make designers to determine their options correctly.

The highest torque values have been obtained when NdFeB and SmCo types magnets were used in the construction of the rotor since that they have the

highest energy constant. It is inferred that if the permanent magnet motors are operated at high speeds, they would give high torques and power densities. As result of this, using NdFeB35 or SmCo28 permanent magnets in rotor structure of spherical motor would increase torque and power density values up. The designed rotor structure and spherical motor can be proposed for industrial utilities.

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Testing of dust explosion characteristics of brown coal at reduced oxygen content

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Abstract

According to the test results of explosive characteristics, all types of coal dust from the mines in Bosnia and Herzegovina have been classified as dangerous explosive dust. This paper reviews the effect of oxygen volume content in air on the explosive characteristics of brown coal dust. Tests was performed in laboratory conditions by the method described in EN 14034-1. Special emphasis was paid to the efficiency of nitrogen and carbon dioxide, which were used for the reduction of oxygen content.

Key words: brown coal, dust, explosive characteristics, limiting oxygen concentration (LOC), inertisation, N_2 , CO_2

1. Introduction

Explosion of coal dust are a major risk in mines, power plants and other industries where coal is used as fuel. Inertisation of the atmosphere is one of the precaution measures in order to prevent explosions. The characteristic value about which care should be taken by these measures are the threshold concentration of oxygen, which depends on the mixture of air and dust, as well as inert gas used. Limit oxygen concentration is characteristic of combustible dust considered in systems where the explosion prevention include inertisation of the atmosphere by injecting an inert gas, usually nitrogen or carbon dioxide, in order to reduce the oxygen concentration below the concentration at which the explosive combustion is possible.

Inertisation of the atmosphere can be applied exclusively within the housing of equipment and installation. It is particularly important to take into account the sealing from the surrounding atmosphere. Equipment that uses such primary measures for preventing explosion is:

- Process equipment: closed reactors, mixers, mills, dryers, furnaces, filters, screens, cyclones, dust collectors;
- Storage equipment: hoppers and silos;
- Conveyors and elevators: pneumatic conveyors, screw conveyors, bucket elevators.

Taking into account that the underground mine oxygen content can be reduced and directly affect on the characteristics of explosive dust, as well as the fact that the threshold concentration of oxygen, at which an explosion can happen is an important parameter, we consider this as an important parameter that influences the explosiveness, and deserves special attention and further research. Limit concentration of oxygen in coal dust is highly variable and depends on a number of influential parameters: volatile content, moisture, ash, source of ignition temperature, the composition of gases in an explosive mixture etc. Inert components (moisture and non-combustible solid particles) in the coal dust and water vapor, nitrogen, carbon dioxide in air affect the characteristics of the deflagration. In the United States, Germany, England and Poland were carried out tests of damping explosion of coal dust with powdered retarders, then the impact of reducing the oxygen content using nitrogen on the explosive limits of methane and coal dust [1, 2, 3, 4, 5, 6]. Reduction of the oxygen content tests in an explosive atmosphere with gradual addition of gas was carried out in laboratory chambers with different volumes and experimental tunnels of various lengths.

Inertisation of explosive dust by reduction of the concentration of oxygen with nitrogen in an explosive atmosphere is presented in Table 1. The tests were performed in the 1 m³ laboratory chamber with different concentrations of dust.

Table 1.

Explosive dust		Limiting O ₂ conc, volume %
Type of dust	Mean value, μm	
Anthracite (fat)	17	14
Brown coal	63	12
Char	13	12
Organic pigment	< 10	12
Methylcellulose	70	10
Wood (pear)	27	10
Corn solid particles	17	9
Paraform-aldehyde	23	6
Aluminium	40	6

Source: BIA (1987)

Numerous experiments indicate that the limit oxygen concentration at which an explosion of coal dust can occur is very variable. The chemical composition of the dust, and the inert gas used for the reduction of the oxygen content, have substantial influence on the oxygen concentration threshold. Investigation of the explosive parameters in relation to the oxygen content were carried out in Central Mining Institute Experimental Mine “Barbara”, Katowice by Cybulski [2]. In studies conducted in experimental trench limit oxygen concentration of 16.5% was determined, that when mixed with coal dust, does not transfer an explosion. Determined threshold concentration is not applicable to mixtures containing methane.

By examining dust from coal seams in BiH mines it was established that there is a direct effect of moisture content and solid non-combustible particles content on the parameters that define the characteristics of explosive dust (maximum developed pressure, maximum rate of pressure rise, minimum cloud ignition energy, explosive characteristics, explosion severity) [7,8,9]. Oxygen content in an explosive atmosphere is among the parameters which influence on the characteristics of explosive coal dust but it was not precisely defined.

As a preventive measure of protection against explosion of coal dust in underground lignite and brown coal mines in BiH is used wetting dust. In practice, it was confirmed that the wetting of dust can not be considered as an effective measure of prevention of ignition, because stronger ignition sources provide a sufficient amount of heat for evaporation of moisture and ignition of dispersed

system [10]. To prevent ignition of dust, it must be so saturated with water that turbulence and cloud formation is not possible.

In order to preliminary perceive whether the adopted experience of foreign authors, which are related to a threshold concentration of oxygen, was correct and valid for the dust of brown coal, which is exploited in BiH, we performed appropriate tests on a representative sample. Reduction the volume fraction of oxygen in an explosive atmosphere was performed by the addition of inert gases N₂ and CO₂.

Explosiveness of coal dust is defined by the following parameters:

- Maximum developed pressure (p_{max}),
- Maximum rate of pressure rise (dp/dt)_{max},
- Explosion severity (deflagration index), K_{st,max}
- Explosive characteristics (E_k).

The first two parameters are tested in laboratory conditions, using method of measuring pressure explosion, according to EN 14034-1[11] and using a method of measuring the maximum increment of pressure at the time according to EN 14034-2 [12].

Explosion severity K_{st,max} and explosive characteristics E_k was calculated from:

$$K_{st} = (dp/dt)_{max} \cdot V^{1/3}, \text{ (m bar/s) (1)}$$

Where V is the volume of the test vessel (m³)

$$E_k = \sqrt{\left(\frac{dp}{dt}\right)_{max} \cdot \frac{p_{max}}{\Delta \tau}}, \text{ (bar/s) (2)}$$

2. Materials and methods

2.1 Characteristics of the dust sample

The sample of brown coal for testing explosive characteristics of coal dust is a representative of coal seams that are in operation in Middle Bosnia coal basin. Calorific value of sampled coal is 24.870 kJ/kg. The content of total inert matter was 19,03 % m/m, and content of volatiles 39,87% m/m. Granulation of the test dust was less than 75 μm.

2.2 Experimental procedure

Tests of explosion characteristics of dust were carried out in laboratory conditions. Testing apparatus is standardized according to BAS EN 14034-1 (EN 14034-1) [11] and represents a 20 dm³ spherical chamber for testing explosive dust, type KSEP 20 with accessories, manufacturer “Kühner” - Swiss. The explosion of coal dust was initiated by chemical igniters with total energy of 10 kJ.

Before the start of the experimental tests, the sample of dust was prepared on granulation below 75 µm, (BAS ISO 1953: 1994), followed by immediate analysis of dust in order to determine the value of the basic parameters that have an impact on the explosive characteristics of dust: the content of total moisture, ash and volatiles (BAS ISO 589:2010, BAS ISO 1171:2005).

Before reducing the volume fraction of oxygen in the mixture, a testing explosive parameters of dust with air was carried out (21% oxygen), in order to determine changes in dependence on the concentration of dust. Tests are performed on three different concentrations of coal dust: 250 g/m³; 500 g/m³ and 750 g/m³.

These dust concentrations were chosen empirically, namely, within the three concentrations of dust, there are optimum explosion pressures p_{max} and pressure increase in time $(dp/dt)_{max}$.

After that we started with the reduction of oxygen in an explosive mixture and tests of explosion characteristics at reduced oxygen content with N₂ (test 1), and than with CO₂ (test 2). Reducing the volume fraction of oxygen in both tests was performed in steps of 2% up to a limit of 12% which was selected based on literature references, where it is stated that the limit oxygen concentration, for the coal dust, ranging from 16.5% to 12%.

3. Results and discussion

Analyses performed on the basis of these results, were shown by curves of the movement of explosion characteristics depending on the concentrations of dust and oxygen in the mixtures.

3.1 Nitrogen as inert gas

In Figures 1, 2 and 3 the graph showing the influence of oxygen content on the characteristics of

the test dust explosion was presented. Reduction of the volume fraction of oxygen in an explosive atmosphere was made by adding nitrogen.

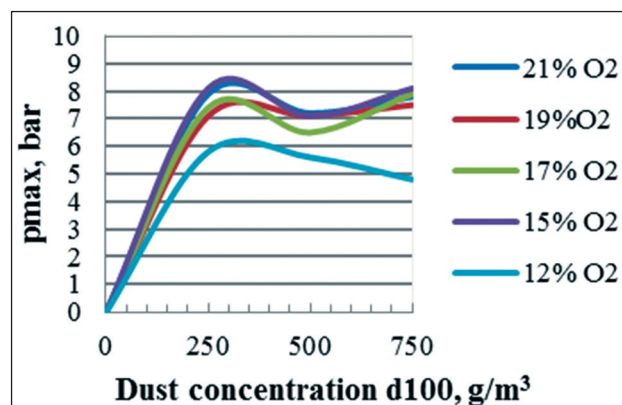


Figure 1. Influence of oxygen content in the gas on the maximum explosion pressure of brown coal dust for various dust concentrations

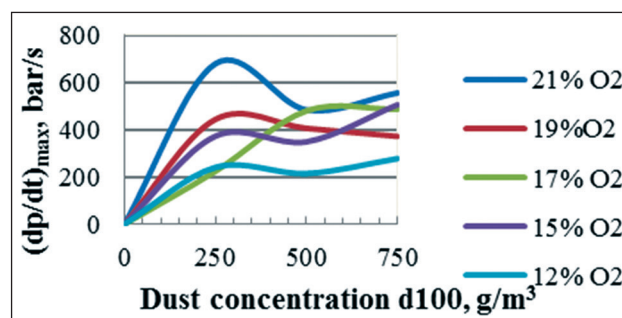


Figure 2. Influence of oxygen content in the gas on the maximum rate of pressure rise of brown coal dust for various dust concentrations

Analyzing figures 1 and 2 it can be concluded that the explosion pressure and speed of explosion pressure rise are reduced with the decrease in the concentration of oxygen. However, there are variations in the concentration of 15% and 17%, which can be explained by chemical reactions during the explosion as well as the fact that the inert components (CO₂ and N₂) may participate in these reactions. It is obvious that there has been appearance of certain gases of combustion which increase the pressure of the explosion. Depending on the chemical composition of the coal, the composition of the gaseous pyrolysis products is variable and usually is a mixture of aliphatic and aromatic hydrocarbons, which are generally flammable. Their oxidation or burning depends on the oxygen content. If the oxygen content is less, no matter how many and what types of hydrocarbons

occur in the pyrolysis process, they burn as much as there is oxygen in the air.

In addition, it was found that the dispersion of the dust has a great influence on the explosion in a spherical chamber. The explosiveness of coal dust is observed through the most important indicator of explosive characteristics (E_k), which describes the mutual interactions between the maximum rate of pressure rise, maximum developed pressure and duration time of explosion. In the norms [13] that describes the danger of explosion of coal dust is defined: "Dust of open coal seam is considered explosively non-hazardous if the highest explosive characteristics (E_k), observed by laboratory testing, does not exceed 70 bar / s".

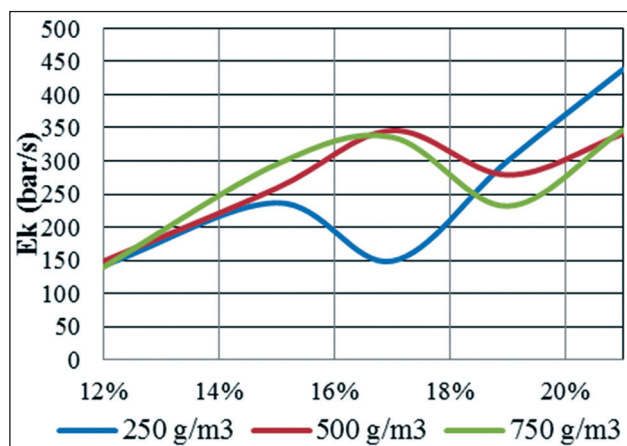


Figure 3. Influence of oxygen content in the gas on the explosive characteristics of brown coal dust for various dust concentrations

Figure 3 shows that the greatest impact of the oxygen on reducing explosive characteristics, depending on the concentration of dust, is at reduction from 21% to 19% O_2 and 15% to 12% O_2 . Reduction of the oxygen content in the range from 19% to 15% did not significantly influence the change in E_k by dust concentration of 500 g/m^3 and 750 g/m^3 . The average value of the explosive characteristics, in the optimal concentration, was 375 bar/s. Reduction of oxygen at 12% by the addition of nitrogen, resulted in a decrease in the average value of E_k to 144 bar/s.

Taking into account by experimental tests in the reduction of oxygen by adding N_2 threshold concentration of oxygen was not established, the value $E_k = 70$ bar/s at which coal dust is considered non-hazardous from the standpoint of explosion, a

mathematical treatment of the research results was carried out. It was found that for the tested brown coal dust limit oxygen concentration is 7%, in the optimal concentration, if inertisation was carried out with N_2 .

3.2 Carbon dioxide as inert gas

The influence of oxygen content on the characteristics of dust explosion test in reducing the volume percentage of oxygen in an explosive atmosphere by adding carbon dioxide is shown in diagram 4, 5 and 6.

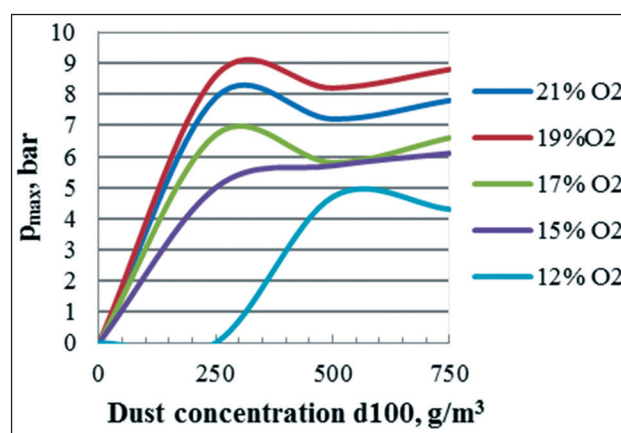


Figure 4. Influence of oxygen content in the gas on the maximum explosion pressure of brown coal dust for various dust concentrations

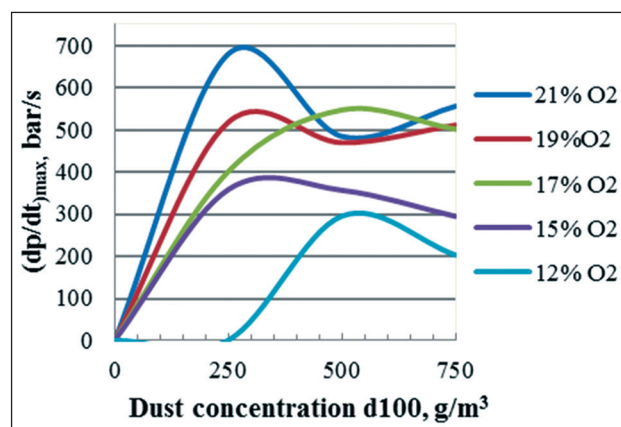


Figure 5. Influence of oxygen content in the gas on the maximum rate of pressure rise of brown coal dust for various dust concentrations

Analyzing figures 1 and 2 it can be concluded that the explosion pressure and speed of explosion pressure rise are reduced with the decrease in the concentration of oxygen in an explosive mixture. There is deviation only at a concentration of 19%

O₂. Gases generated during the explosion have a major impact on the efficiency of the inertisation. It is important to point out that at concentration of 12% O₂ and the concentration of coal dust at 250 g/m³ explosion was not occurred.

Effect of oxygen concentration in an explosive characteristic (E_k), at the reduction of the oxygen content with carbon dioxide, is shown in Figure 6.

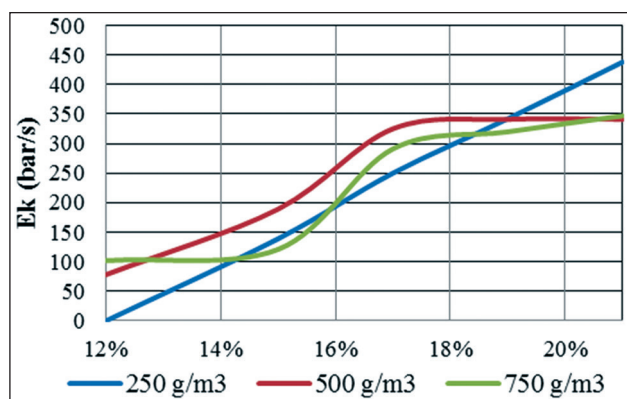


Figure 6. Influence of oxygen content in the gas on the explosive characteristics of brown coal dust for various dust concentrations

3.3 Efficacy analysis of inert gases on explosive characteristics of coal dust

Analyzing the effects of inert gases used for the reduction of oxygen in an explosive mixture, it can be concluded that CO₂ is proved to be better inert material from the N₂. When inerting with CO₂, the pressure of explosion decreases faster in relation to the inertisation with N₂ at the same concentration of oxygen. Also it can be noted that the explosive characteristics significantly faster decline in the reduction of oxygen by adding CO₂. Figure 7 shows the efficiency of N₂ and CO₂, which were used for the reduction of the oxygen concentration, on decrease the average value of E_k in the optimal concentration.

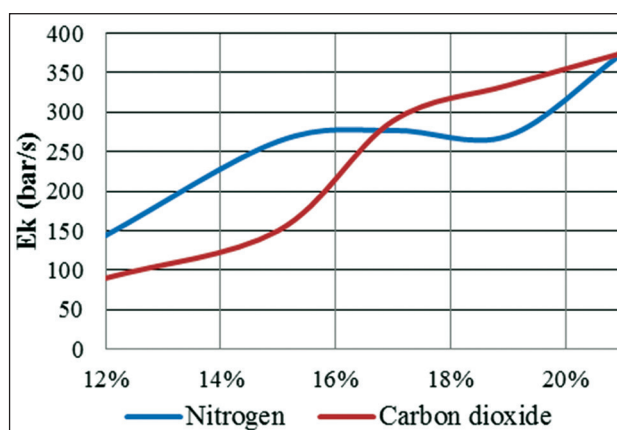


Figure 7. Influence of oxygen content in the gas on the explosive characteristics of brown coal dust

4. Conclusion

Preliminary results of these investigations indicate how brown coal dust explosion develops at reduced oxygen content and what effect N₂ and CO₂ have at the explosion, or where is the limit when the explosion can no longer develop.

It was found that the CO₂ has a greater efficacy relative to N₂ in termination of explosion. The role of oxygen in the explosion of coal dust is significant and it is very important to know the threshold concentration of oxygen in order to design safety measures to prevent coal dust explosions. It was found for the tested brown coal dust, in the optimal concentration, the oxygen concentration threshold is 11% for inerting the atmosphere with CO₂, and 7% for inerting atmosphere with N₂.

These studies shed new light on the explosive properties of coal dust that occurs in Bosnia and Herzegovina's coal mines. It is completely justified to continue the research in this area, in order to accurately define the limit oxygen concentration for brown coal dust explosion, as well as other types of coal dust used in industry. Since this parameter that highly variable, it is also necessary to pay extra attention during tests to other influential parameters.

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Architectural affairs in France

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Abstract

“The main feature that distinguishes the architectural process in France is the fact that the project can have a flexible construction execution.” [1] This means that the constructor can offer a wide range of construction methods, competences and most important prices.

In France architects are always under constant pressure from the engineers, because they not participate in the making of the construction drawing details, nevertheless clients respect their creative skills and execute the project according to the conception. Although traditionally, the Beaux-arts education bases, does not offer extensive training in technology and management and can leave architects unaware of the construction possibilities, still somehow the system has high performance and even more: never neglects the prestige of the architect’s profession.

The secret is in the working framework in France that is usually under certainty, because of tight planning regulations and public participation.¹ Studies of costs consultancy and predictability are therefore less prominent and an object of external economic analyses unrelated to the architectural process.

Today French architectural practices are generally very small, where large companies offering a wide range of skills are not common. Often the division of the architectural process and formats how to present dossiers change from practice to practice and are usually defined by the company’s working environment. Although excellent results in the conception can be reached, the execution becomes difficult, due to the time lost in synchronizing different documentations and plans that vary from agency to agency.

¹ “How come that our strict regulated projects have such errors and theirs so flexible succeed to performer successfully. It really bothers me that the more familiar I am with their work, the less I understand it! Yet, this is French way ...” [2]

However, if various specialties are divided, designated and assigned to particular individuals or companies disjoint system like this can operate very successfully. Contrary to the rest of the world, in France few companies can conclude the architectural affaire in whole, but still the architectural affair stays commercial and the design vivid.

1. Difference between public and private sector

Today the building sector of the market in France is one of the biggest, with a percentage of employment over 7.5%, and a diverse output (Figure 1).

Category	FF millions	€ millions	%
Building Output in France			
New work:			
Residential	126,106	12,301	30.39
Industrial	31,096	3,033	7.49
Offices	32,301	3,151	7.79
Other commercial	8,850	863	2.13
Education	5,613	548	1.35
Hospitals	2,342	228	0.56
Miscellaneous	14,808	1,444	3.57
Total non-residential			
Renovations and modernisation:			
Residential	114,536	11,172	27.60
Non-residential	79,342	7,739	19.12
Total renovations and modernisation			
	193,878	18,911	46.72
Total	414,994	40,479	100.00

Figure 1. The distribution of architectural affairs in France [1]

The first division of building affairs in whole is by ownership rights. The private building sector affairs are flexible, open for options, where the

public building affairs are tightly controlled by law and regulation [3].

The maitre d'ouvrage or the client for a public architectural affair is usually a state organization, where the affair itself is controlled by the Code des Marchés Public (Public Tender Procedures). The maitre d'ouvrage for private affair is a developer, where the process is controlled by contract. In this case the maitre d'ouvrage can delegate his interests to a maitre d'ouvrage délégué.

The most significant person in the affair is the maitre d'oeuvre, or the project (team) leader (often architect) that has the responsibility of the affair in whole, and who defines the controleur technique that has the safety responsibility.

The concepteur, or the designer has a leading role of making the architectural project. It can be an architect and bureau d'études for the private sector, or an architect and engineer, and a BET bureau d'études techniques for the public sector. Usually the Bureaux d'Etudes consist of the Bureau d'Etudes Sol, Bureau d'Etudes Structure, Bureau d'Etudes Fluides and the Bureau d'étude acoustique. They often work with the assistance of the pilote, who makes the documentations for that are of a separate profession. Other parties involved in the process can be: the économiste that is concerned for the cost of the project, the ingénieur for the construction, specialists for diverse regulations, the geometre as land surveyor and etc. The closing of the affair is done by the ensemblier (contractor) who puts together the affair, and communicates with the enterprise or the constructing company.

In practice possible arrangement of key parties and work groups involved can be as such (Figure 2):

In the private building affair the maitre d'ouvrage surveys the project but assigns a conducteur to manage it. The architect is a party with professional responsibilities, and is assisted by the economist and geometre. The construction is carried out by the maître de chantier, but also coordinated by trades from the pilote. In the public building affair the maitre d'ouvrage has delegated most of his functions to other organizations. The BET structure takes all professional responsibilities, requiring an engineer and other professionals. The entreprise generale conducts the main construction and employs specialist subcontractors.

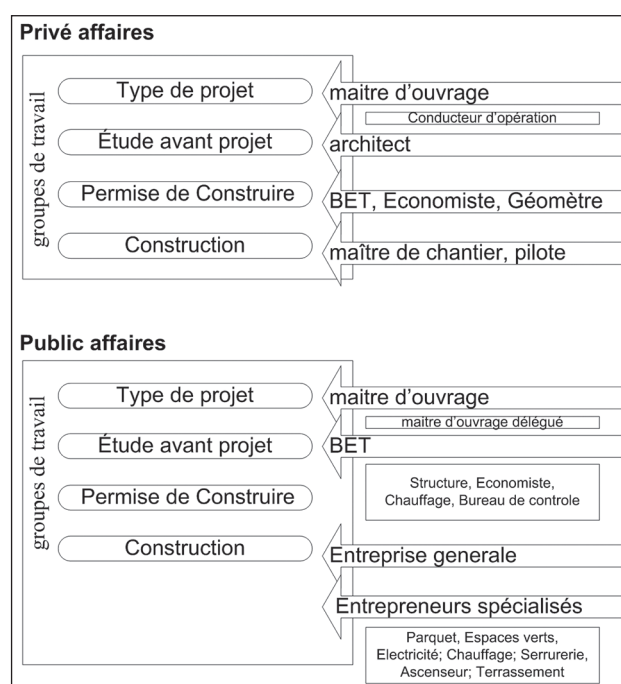


Figure 2. Organization of two types of affaires [Source: RIBA p. 41]

2. Private architectural process phases

There are few legal controls in the private sector, and the choice of professionals and contractors is free. The private affairs are usually restricted to residential and housing undertaking, where the industrial, office and commercial commissions are rare. The private client has the responsibilities to carry out contracts, and is the directeur d'investissement and a maitre d'ouvrage. As the maitre d'ouvrage he is authorized to sign all documents, and as the directeur he has to supervise the project by cost, time and contents.

At the beginning the client has to prepare the brief. It is a program, often known as the cahier des charges that contains 4 chapters. The first gives information about the architects, climate and geography of the location as well as the topographic plans. The second chapters explains the needs of the client indicating the program, cost and time duration. The third deals with external matters such as planning regulation and ownership rights, where finally, the fourth chapter, lists client restrictions such as design requirements.

The next phase of the private architectural affair is the selection and appointment of the Design Team or the concepteur. Here the role of the architect is less important than in the public sector.

Competitions or concours are rare, so usually the selection is done by recommendation. Sometimes even the contractor that closes the affair can influence the decision. Usually the architect is retained throughout the process, where he merely watches the construction of the design. This is why the supervision of the site can be often undertaken by another architect known as architectes d'opération.

By election, the concepteur becomes a maitre d'œuvre, who appoints the professionnelle and the bureaux d'études. Now the contract can succeed. Contractual forms are usually standard types issued by the Order des Architectes, Union National des Syndicats Français d'Architectes and the Syndicat National des Architectes Agréés et des Maitres d'Oeuvre et Batimen. The same is with the method of remuneration (payment) [4].

The most important phase of the private architectural affair is the design and documentation making process. After the primary study and sketch a full architectural project is made. This project is used to make the dossier for the permis d'construire that is perhaps the most significant document of them all.

In France permissions have to be obtained for all development. (Even for changing windows in your own house.) Some rare exceptions are exposition building, street furniture, statues, urban mobilier, private walls and etc. This means that anyone who wishes to construct a building has to obtain a permis d'construire, which is the main instrument of urban development control, where for each building sector there are different control procedures.

If the commune approved the Plan de Occupation des Sol, and the cadastre is inside an area regulated by the Plan Local d'Urbanisme de Paris, the maire will take the decision to sign the permit. One must mention that higher levels of approving development such as Region and Département permis exist. The explained decentralized system allows the architect to have consultations in a very early stage, so the process usually has clear understanding. If an application is properly completed and complies with the POS and urbanism regulation there are no reasons for a refusal. All rules for processing an application are laid in the Code de l'Urbanisme. Statistics indicate that 95% of all applications usually are granted. This is why one can

say that architectural affairs in France are conducted in certainty.

During contemplation the administration has a time limit of 2 months to investigate technical details (fire, traffic, security and other departments) and after these enquiries has to grant full or conditional permit. In France more than 85% of applications are delivered within three months. The permit appendix usually regulates the constructor obligation to start building within 2 years after approval, and specifies the time for finishing.

Throughout the explained administration process (usually the same party that made the permis d'construire) knowing that the documents shall be approved without objections, the concepteur of the project can immediately start to refine the design and prepare more detail drawings. Also at the same time more detail estimates of cost must be prepared and transmitted to constructors. At the end, some changes may involve in the original design conception, but they must stay within a reasonable level.

As soon as the design is sufficiently detailed and settled, it is possible to start the selection of the entrepreneurs (contractors). Having received appel d'offres, usually between 4-6 contractors, offer bids to the maitre d'ouvrage (client). After negotiation on the price, time and design he can select the most appropriable. However, because the tenders are based on project designs, and not detail specification, each contractor must determine his way of building. Usually the offers comprehend slightly different finalizations, so therefore the selection has to be considered by all aspects and not just the costs. This is why a common practice in private building affairs is to choose a satisfactory partner from the past.

Finally, when the entrepreneur has been selected the designs and project documentation can be finalized. Usually the architect that is the concepteur shall have discussions with the constructor before he finishes his own detail designs. Approving the constructor's documentation the maitre d'œuvre shall transfer his power over the project but shall keep the professional responsibility. This is why the management of the work site is organized in a way that the concepteur is responsible for the general control of work, but the architect stays responsible for the quality.

To coordinate between, usually a *pilote* is employed that regulates various on site trades and adapts them to direct preferences of the client. Frequently the pilot shall be the one with the greatest value of work, synchronizing the *Récollement* (Build design) and *Dossier d'Execution des Ouvrages* (Documents of execution) while monitoring the cost.

During construction the payment of accounts is prepared by the economist where all the finance must be signed by the client. All changes should be provided by necessary drawings end overrun costs. Disputes are rare because problems are usually settled as they arise during the process, and are not left as law claims.

The closing of a private architectural affair starts with the *reception des travaux* (handover). This is the dividing line between the execution and the commencement of the exploitation period that includes insurance. The great importance of his phase comes from the fact that, agreeing that the contractors has fulfilled their obligation, all care concerning the project is transferred to the client (with all technical, legal and financial consequences). This is why an independent *contrôleur technique* has to check the affair in whole. He shall analyze the dossiers of executed work and other documents that all parties must provided. At the end he shall declare the completion of work, and *rapport* how the *permis de construire* was integrated. With this reception the architectural process ends.

3. Public architectural process phases

Public affairs have a tight control by legislation, laws, decrees and codes included in the *Code des Marches Publics*. As in the private sector the client has the obligation to see out the whole process, but can delegate certain tasks (administrative, financial and technical) to a third party. Key decisions, such as the appointment of consultants and contractors, must remain in his domain. The client as the *maitre d'ouvrage* has the same role as before but it is less flexible in operating, because of the competition selections. This is why sometimes the authority organizing the functions of the *maitre d'ouvrage* will appoint a *conducteur d'opération* for control.

The prime function of the *maitre d'ouvrage* again is to prepare the brief that is unambiguous on all major matters. This brief shall be used for selecting the architects and engineers by *concours* (competition). The guide *Concours d'Architecture* that is published by the Editions du *Moniteur* regulates all of these competition procedures. Today the *concours* is a standard way for selection in publicly funded projects. It is a useful system because it brings out new ideas and acknowledges young architects, but is however expensive as a process.

“Nowadays almost all prestigious projects in France are a subject of open competitions, where only 10% of them are just for domestic registered architects. The competition must be announced in the *Bulletin Officiel des Annonces des Marches Public* and in press, notably in the *Le Moniteur*.” [5].

As the *concours* is a costly affair for architectural agencies, a pre-selection is necessary usually based on a sketch. After this selection a fee is submitted to all that shall put an effort to continue making the design, and this amount is relevant to one off an *Avant Project Sommaire*. All additional enclosures (models, technical proposals etc.) must be paid separately.

Standard *concours* documentation usually comprehends: block plans 1:1000, plans of principal levels 1:500, axonometric or perspective views (before *précised*), significant facets such as sections and elevations 1:200, a free sheet (used for presenting best design review) and the explanation of approximately five pages of the principal features of the project.

By closing of the *concours*, a jury consisted one third of architects (sometimes half) with the *maitre d'ouvrage* as *concours* leader, has to make a decision, who shall make the project, or who shall be the *maitre d'oeuvre*?

The next stage is to select the team. At the head of the team must be both an architect and an engineer. Their work must not be separated.

Usually the same group that won the *concours* shall continue working on the project. In general the architect and engineer as *maitre d'ouvre* appoint the *bureau d'études* that shall work closely with the economists (that makes the estimation and calculation of costs) appointed by the *maitre d'ouvrage*. These parties can be paid by the architects and engineer as their subcontractors, or they

can be an external group that is a co contractor paid directly by the maitre d'ouvrage.

Once the organization and negotiations with the client are completed a contract must be signed with the maitre d'ouvrage. Usually the architect and engineer become the concepteur, but sometimes their mission extends from monitoring just the design and comprises the project in whole. Their payment is done on requirement of the Permis de Construire. As concepteurs, they do less detail design as this work is undertaken by others. The working drawings as explained before are submitted to them for approval by the construction company. At all time they are the maitre d'ouvre with all professional obligations and responsibilities defined in the Acte d'Engagement.

As in the private architectural process the documentation making process succeeds. As before, during waiting for the permits, the documentation for the tendering process is prepared (Figure 3). The main difference between the private and public architectural processes is in the selection of the entrepreneur that shall carry trough the construction.

In the public architectural processes the contractors is usually a more complex group. It can be an enterprise general (main contractors), lots separe (separate trade contractors) and groupment entrepreneur (grouped contractors). All of these forms are, just like the concepturs, always selected by public competition base on a combination of design and construction factors known as the appel d'offres avec concours. The choice is made by analyzing the tender offer and after an in-depth study of all technical and aesthetic requirements (done by the concepteurs working together with the bureau d'etudes). Further negotiations (as those concerning security etc.) are permitted. All documents required for the selection of contractors, are defined by norms of the Code des Marches Public, and are listed in the table below.

When the contractor has been selected, the designs for the project can be finalized more or less in the same way as in the private architectural process. The construction and handover that follows usually has the same algorithm as well.

At the end, one must emphasize that each architectural process is repeatable the same as the here explained one. The difference can exist just in the variation of time and recourses of realiza-

tion. The subject of how to estimate and plan an architectural affair shall be further investigated in this paper. It will use real values and cases applied in managing architectural processes in the traineeship company concerning the private architectural process that is usually most common in practice. Naturally before the study begins one must understand the working environment of architectural process, so the next topic to be presented is the architectural agency itself.

Documents to be provided	Appel d'offres	Appel d'offres avec concours
Very detailed drawings (as defined in <i>Spécifications Techniques Détaillées (STD) and Plans d'Exécution des Ouvrages (PEO)</i>)	eventually (c) (possibly)	
Detailed drawings as defined by <i>Avant Projet Détaillé (APD)</i>	obligatory (c)	
Summary of project as defined in <i>Avant Projet Sommaire (APS)</i>		possibly(i)
Detailed specifications as defined in <i>Cahier des Clauses Techniques Particulières (CCTP)</i>	obligatory (c)	
Brief		obligatory (c)
Quantities	possibly(c)	
Priced quantities	possibly(c)	
Schedule of prices (for simple projects only)	possibly(c)	
Schedule of rates	possibly(c)	possibly(c)
Schedule of supply rates	possibly(i)	possibly(ii)
Breakdown of prices of major components	possibly(ii)	possibly(i)
Dossier of administrative requirements <i>Cahier des Clauses Administratives Particulières (CCAP)</i>	obligatory (c)	obligatory (c)
Timetable of execution of work	obligatory (c)	obligatory (c)
Detailed timetable for execution of work	obligatory (c)	
Contracts for each type of contractor	obligatory (c)	obligatory (c)

Figure 3. Standard documentation for Selection of Contractors [1]

4. Conclusion

Today, managing issues have moved into mainstream architecture. Growing economical challenges face each new project. As there is a greater awareness, we are slowly building a collective momentum, not only toward solving problems, but toward recognizing new aspirations. Our aspirations can lead us to reorganize the way we conduct architecture, but perhaps the biggest chal-

lenge is simply to get started. This paper is intended to help start the architectural process.

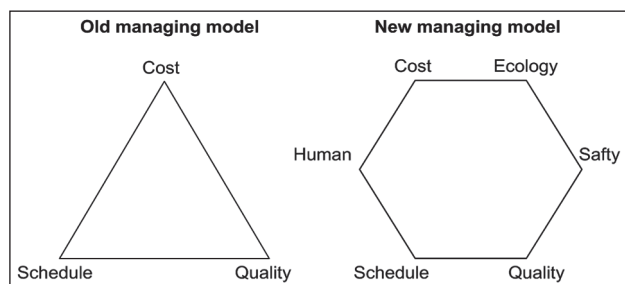


Figure 4. Appearing complexity [6]

The paper shows in depth different project phases of the architectural process. It contains descriptions of each phase and lists other topics that embrace relevant facts concerning problems of organization. This report may help beginners not only to deal with numerous information that appear in practice, but also to clarify their work tasks. The study assembled focused on topics how to:

- get familiar with the vocabulary
- identify the complexity
- understand the interrelations
- recognize the legal environment
- conceive basic managing skills
- get familiar with the informational organization system of the architectural process in France.

“Contemporary European architectural market is seeking for new opportunities abroad. The global building market with multi-national clients still does not have a long hold in Serbia to be considered a proven practice. Although it has an affirmed tradition, the existing expertise is not regarded as a European standard.” [1] One can just add that the inflexible and strict organization of the architectural process that was inherited from the communist era blocks the inflow of new regulations (innovations) demanded by the growing economy.

Today the time frame of an architectural affair in Serbia has not decreased considerably compared with the one 10 years ago. The organization of “nabavljanje dozvola” (gathering the legal regulation), “projektovanje” (executing the project) and “izgradnja” (realizing the construction) is the same, were just the planning administration and political procedures have been simplified.

As the Serbian construction market is depended on the inflow of foreign investments, there is a constant demand for reorganizing the architectural process into a more business oriented one. Nowadays, as the actual issue is to make the performance more transparent, what better example to take then that of France? With more then 80% of all public commissions executed by foreign practices Paris, together with New York and London, is the center for global real-estate investments. [7]

The architectural process in France, being always open for innovations and new capital, is very different from the one in Serbia. Common in practice the standard phase division of the Serbian architectural process, with phases linearly succeeding one another is more simplified. Many sequences from France still in Serbia do not exist, and changes that will modify the system into a more complex one with coherent interdependent sequences did not appear.

The main characteristic of the French architectural process is that at the beginning during evaluation and planning, it is very flexible. Still once established the process ensures that the project is performed interactively according with the plan, and that all conflicts are resolved, reviews submitted and payments achieved. Eventually the architectural process in France has the lowest rate of legal complains in the world. It succeeds to be arrange in such manner that it can coup with all contemporary management needs modifying its contents during performance

A study of different project phases and their context, performance, legal and procedural framework with an example of an agency that has know-how in organization and synchronization, can give useful information especially to colleagues (architects / engineers) and agencies less familiar with the process. It can be a guideline to reorganize the architectural process in Serbia as well.

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Soft Lithography: Part 2: Tailored Polymer Cholesteric Liquid Crystalline Particles

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Abstract

Soft lithography is a simple, inexpensive technique and low-expertise route for the fabrication of two- and three dimensional micron- and nano-structures that replace standard lithography process. It includes a number of techniques based on molding, embossing and printing. In this study, the soft lithographic technique is used for shaping a polymeric material into tailored micron-sized particles. Particularly, polymer cholesteric liquid crystal (PCLC) material is shaped within an elastomeric polydimethylsiloxane (PDMS) mold into micro-particles with defined shapes and dimensions. PDMS mold that contains a relief structure is an inverse replica taken from a rigid patterned template substrate (replica molding). Tailored PCLC particles were characterized for their uniformity, reproducibility and dimensions by variety of techniques such as: scanning electron microscopy, polarized optical microscopy and light interferometry. The presented technique of soft lithography is an as easy way to manufacture large quantities of PCLC micro-particles that can be used in a variety of applications *viz.* optical, photonic and electronic applications. Moreover, in the past decade or so, tailored micro- and nano-particles have been increasingly used in pharmacy and medicine as drug- and vaccine-carriers with controlled release of the active substances.

Key words: soft lithography, PDMS mold, polymer patterning, PCLC microparticles.

1. Introduction

Soft lithography is an inexpensive and versatile technique compared to conventional lithography. In general, lithography is a process in which the substrate to be patterned is covered with a layer of radiation-sensitive polymer, called a photoresist.

Conventional lithography includes photolithography, electron-beam or ion-beam lithography. Originally, lithography was developed to deal with semiconductors and microelectronics industry, but soft lithography extends the possibilities of standard photolithography. The field of soft lithography has expanded rapidly especially in the last two decades. The growing importance of this technique for research in micro- and nano-science and different technologies suggests a bright future for this field.

Soft lithography has been used as patterning technique for micro- and nano-sized topographies for variety of applications, like microfluidics, flexible electronics, displays, MEMS, biological systems, etc [1-15]. It includes a wide range of techniques, among which are replica molding, embossing, printing, and others [16, 17]. Actually, soft lithography is based on use of a mechanically-soft or elastomeric stamp according to which was named as soft technique. One of the most used material for this purpose is poly(dimethylsiloxane), but also polyurethanes, polyimides, and polyacrylates can be used [11, 18-20]. Poly(dimethylsiloxane) or PDMS is optically transparent elastomer, which beside its mechanical flexibility and durability, is inexpensive, biocompatible and hydrophobic material with low toxicity and chemical inertness to most of the chemicals [6,7,9,12-14,21-24]. The elastomeric stamp (PDMS mold) in soft lithography with patterned relief structures on its surface is used to generate patterns and structures with feature sizes ranging from ~30 nm to 100 μm [19].

In this study, the use of soft lithography as a technique for shaping a polymeric material is presented. Particularly, polymer cholesteric liquid crystal (PCLC) was used and formed into micro-particles with customized shapes and sizes by use of a flexible PDMS (replica) mold. PCLC is a material that possesses unique optical character-

istics, such as the selective reflection and circular polarization, and have potential in many optical, photonic and electronic applications [25-31].

2. Experimental

Manufacture of shaped PCLC micro-particles by use of a soft lithography technique has been shown to be very effective and fast method to generate big quantities of these particles. Namely, shaped PCLC particles are made in a flexible PDMS mold with patterns on it. PDMS mold was a replica mold (or stamp) taken from the rigid master that is patterned silicon wafer in this case [26, 28].

The process begins with the master fabrication, made of silicon wafer that has topographical features (trenches and ridges) as shown in Figure 1a) and 1b). The patterned silicon wafer was prepared by e-beam lithography and here is used as a rigid master. Different patterns on the silicon wafer are shown in Figures 2 and 3, characterized by scanning electron microscopy (SEM) and light interferometry, respectively. Once the rigid silicon master is created, it can be used multiple times.

The process of making PDMS mold is shown in Figure 1(b) [26]. Namely, PDMS mold was created by use of a liquid precursor mixture (pre-polymer and curing agent, polydimethyl siloxane elastomer, Sylgard 184, Dow Corning Corp., Midland, MI.) that is poured and cured over the silicon master. The liquid prepolymer conforms to the form of the master and exposure to UV radiation or suitable temperature induces the crosslinking and making the polymer solid. Usually, air curing of PDMS mold over the template takes ~24 h at room temperature until the mold becomes solid. After hardening, the PDMS replica is peeled off from the silicon wafer to give an inverse replica of the silicon wafer (Figure 1c). This replica constitutes a flexible mold for making shaped particles from polymeric material, e.g. PCLC material.

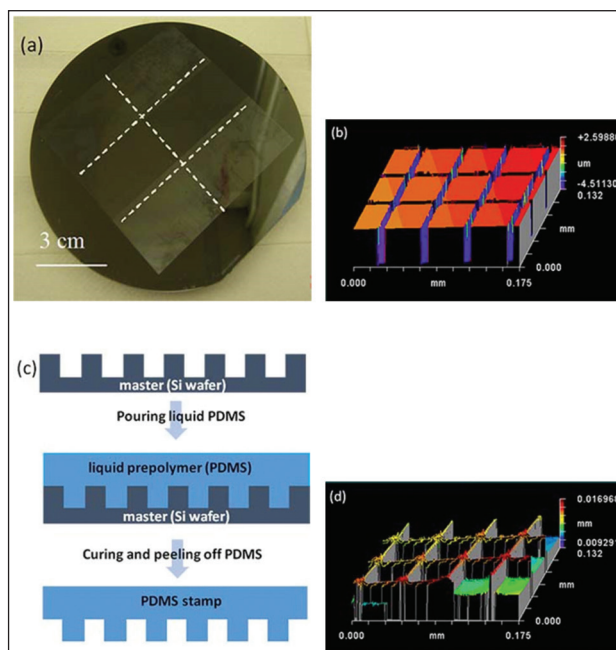


Figure 1. (a) An image of a silicon wafer with six different pattern designs; (b) Square pattern on a silicon wafer given in (a), characterized by white light interferometer; (c) Schematic of the process of making PDMS mold over a rigid patterned silicon wafer; (d) PDMS replica with a square pattern made from patterned silicon wafer in (b), characterized by white light interferometer; dimensions of side square features are $40 \mu\text{m} \times 40 \mu\text{m}$.²⁶

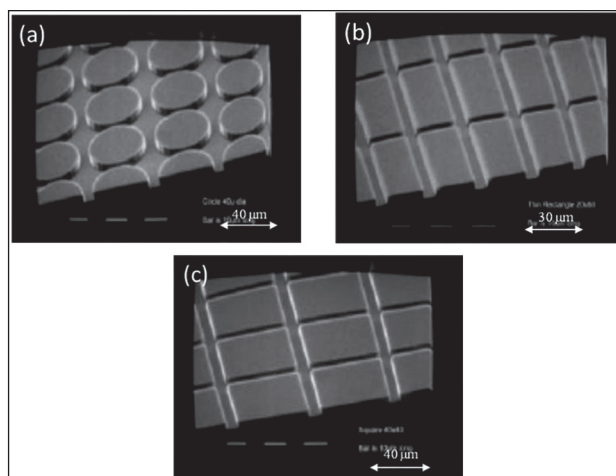


Figure 2. Silicon wafer with different patterns characterized by SEM: (a) $40 \mu\text{m}$ diameter; (b) $60 \mu\text{m} \times 30 \mu\text{m}$; (c) $40 \mu\text{m} \times 40 \mu\text{m}$

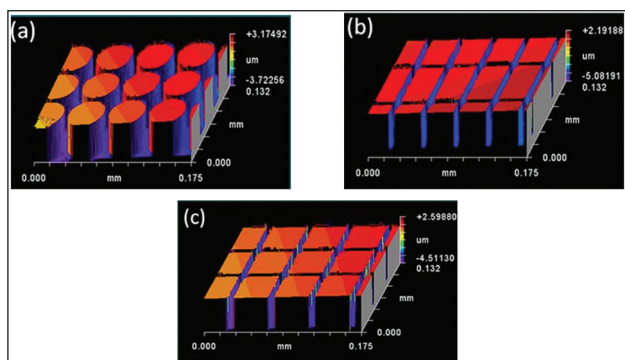


Figure 3. Silicon wafer with different patterns characterized by white light interferometer: (a) $40\ \mu\text{m}$ diameter; (b) $60\ \mu\text{m} \times 30\ \mu\text{m}$; (c) $40\ \mu\text{m} \times 40\ \mu\text{m}$.

Depending on the design of the patterned silicon wafer, different shapes of PCLC particles can be manufactured in PDMS molds. For example, in Figure 4a) is shown segment of silicon wafer with ellipsoidal patterns on it, and consequently, in Figure 4b) is presented piece of PDMS mold where ellipsoidal shaped polymer particles can be made (Figure 4c).

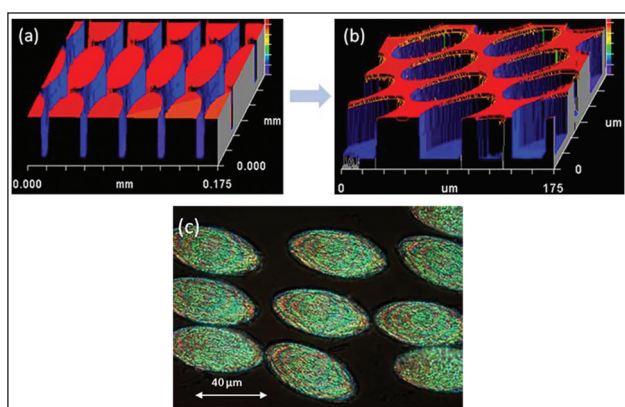


Figure 4. (a) Ellipsoidal shaped pattern on the silicon wafer scanned on white light interferometer; (b) white light interferometer image of a PDMS mold as an inverse replica of the patterned silicon wafer shown in (a); (c) ellipsoidal PCLC particles made in PDMS mold shown under b).

The method for manufacturing regularly shaped PCLC particles from polysiloxane PCLC material (product by Wacker Chemie GmbH, Germany) is presented in Figure 5 [26]. In this figure a mold replica containing $13\ \mu\text{m} \times 13\ \mu\text{m} \times 5\ \mu\text{m}$ square wells was used, as an example. The method consists of: a) placing the PDMS mold on

a microscope slide, placing the slide on a glass-ceramic plate, and heating the assembly to $\sim 130\ ^\circ\text{C}$ on a hot plate; b) filling the mold with a solution of $\sim 25\ \text{wt.}\%$ PCLC dissolved in toluene (or methylene chloride) or dry neat PCLC material as well; c) evaporating the solvent from the filled mold (for manufacturing from the PCLC solution), and “knife coating” the sample with another microscope slide used as the “knife” to establish a good planar alignment; d) quenching the microscope slide and mold on a metal substrate to room temperature; e) examining the wells under a microscope to determine the level of fill, and f) bending the mold over a collecting dish, and ejecting the PCLC particles from the mold. Steps a) through d) may be repeated in order to either fabricate layered particles or to increase their thickness. The same mold may be cleaned with suitable solvent and reused multiple times to make additional quantities of polymer particles [26].

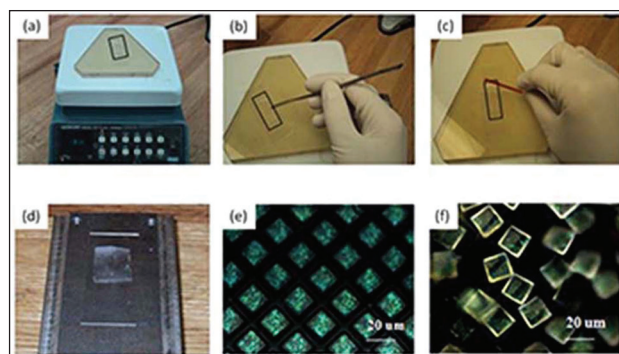


Figure 5. Process for formation of regularly shaped particles: (a) preheating the PDMS mold on a hot plate; (b) filling the mold with a PCLC material; (c) knife-coating; (d) quenching the filled mold on a cold metal slab; (e) microscopic examination of the filling level; (f) bending the PDMS mold and collecting the micro-particles.²⁶

3. Results and Discussion

Different techniques were used for characterization of patterned PDMS molds taken as replica of silicon wafer (master) and shaped PCLC particles manufactured in these soft molds. Figure 6 presents examples of PDMS molds with different patterns, characterized by polarizing optical microscopy (POM) and white light interferometer, respectively.

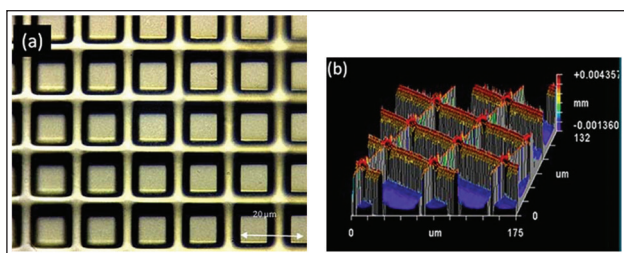


Figure 6. PDMS replicas taken from patterned silicon wafers characterized by: (a) polarizing optical microscopy (50x magnification), dimensions of side walls are $13 \mu\text{m} \times 13 \mu\text{m}$; (b) white light interferometer, dimensions of side walls are $60 \mu\text{m} \times 30 \mu\text{m}$.

PCLC micro-particles made in PDMS molds are characterized for shape, surface structure and uniformity using polarized optical microscopy, white light interferometry and scanning electron microscopy. Under illumination at near normal incidence, three colors (red, green, blue) are apparent in the true color images taken with POM in reflection mode (Figure 7) [26]. These colors originate from the selective reflection property of the PCLC material used for making the particles. Particularly, each cholesteric liquid crystalline material exhibits the unique property of selective reflection and circular polarization of the reflected light due to its helical molecular arrangement [25-31]. When this selective reflection happens in the visible spectral range, then the cholesteric material exhibits bright iridescent colors, viz. red, green, blue, etc.

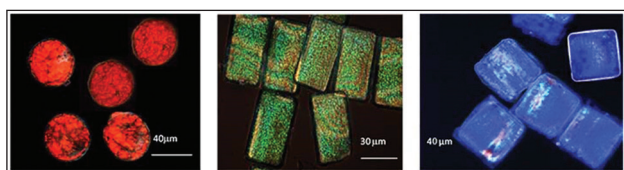


Figure 7. Tailored PCLC micro-particles characterized by POM in reflective mode between crossed linear polarizers.

Image analysis using white light interferometry confirms the lateral dimensions and thickness uniformity of the microparticles (Figure 8).

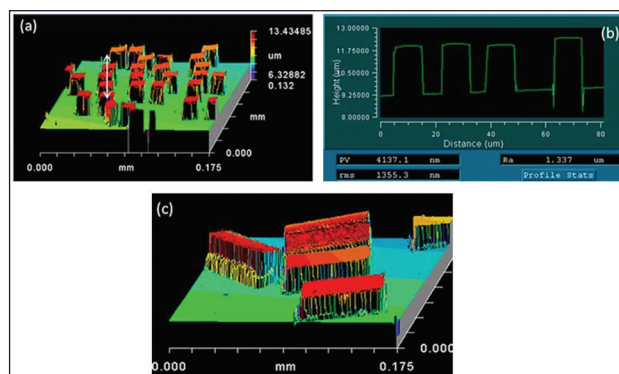


Figure 8. (a) Tailored PCLC micro-particles characterized by white light interferometer; (b) line scan over 4 micro-particles designated by the arrow superimposed in (a) to show thickness uniformity; (c) rectangular shaped PCLC particles show the uniform lateral dimensions from particle to particle.²⁶

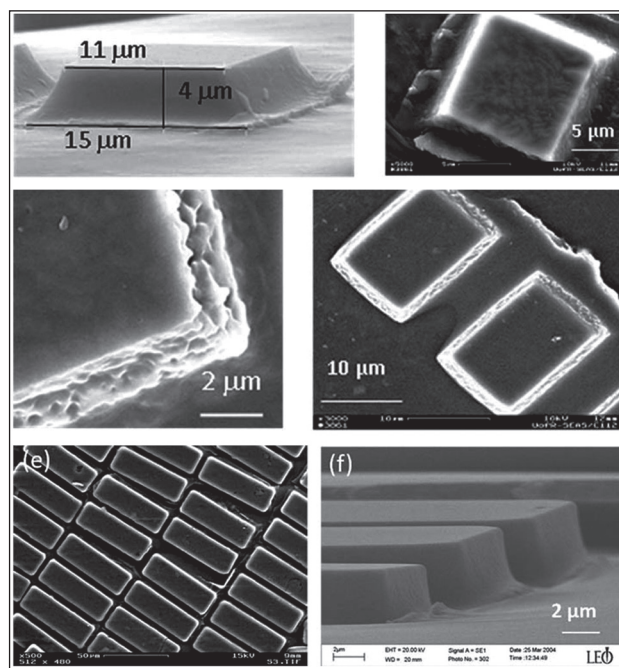


Figure 9. Shaped particles characterized by SEM: (a), (b) single filling to produce square-shaped particles; (c), (d) multiple fillings of rectangular-shaped particles; (e), (f) dimensional uniformity of rectangular-shaped particles.²⁶

Shaped particles have clean and smooth edges [26]. Figures 9a) show SEM pictures of a square particle. The first picture (left) reveals clean, sloped edges on a particle that copy the side-wall contour of the PDMS mold. The second picture (right) is a top view of a square flake. Figures 9b) are SEM pictures showing a layered structure of particles

made with multiple fills (~3 layers- image on the left) and the bottom sides of two particles joined by excess PCLC material (these particle surfaces were in contact with the mold surface - right image). Figure 9c) confirms good uniformity in particle dimensions and thickness [26].

Also, tailored PCLC particles were made in stretched PDMS molds with different shapes/dimensions (Figure 10).

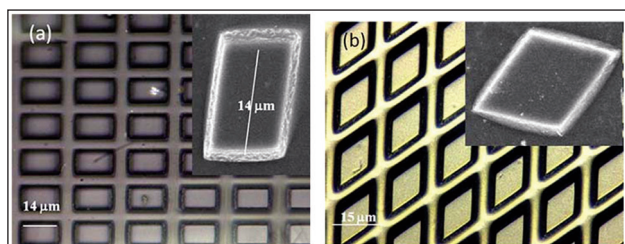


Figure 10. Tailored PCLC particles made in stretched PDMS molds and characterized with POM and SEM: (a) stretched rectangular mold and particle made from it; (b) stretched diamond-shaped mold and particle made from it

3.1. Application of PCLC micro-particles

PCLC particles can be used in various applications. They possess bright reflective colors and inherent circular polarization that make them very promising candidates for passive applications (signature recognition, selective light filtration) and active applications (switchable reflective conformal coatings and flexible displays). Particularly, PCLC micro-particles have the potential to become an attractive alternative to materials and mechanisms currently used in existing reflective, particle-based display technologies. Due to their intrinsic cholesteric nature, they exhibit bright and saturated reflective colors and circular polarization effects, without the need for expensive color filters and polarizers used in many display configurations. These advantageous properties of PCLC particles make them candidates for a new generation of thin, multi-color, low-power, low-cost reflective display (i.e., electronic paper) on rigid or flexible substrates. Depending on the polarity of the applied voltage and the charge on each particle, the reflected colors can be switched. A PCLC particle display can achieve more than 50% reflectivity with switching times from tens to hundreds

of milliseconds by using a power of tens of millivolts per micron thickness of a display.

A potential PCLC micro-particle based reflective display device is shown in Figure 11. In Figure 11 a) and b) is shown the mechanism of operation of a display device based on PCLC micro-particles dispersed in an appropriate host fluid. As an example only, the particles presented selectively reflect in the green spectral visible range. The OFF-state of display is actually the bright state (in this case - green) because PCLC particles are “laying” in their lowest-energy state and reflect the incoming light (Figure 11a). The ON-state of display is the dark state; particularly PCLC particles reorient in the direction of the applied electric field and do not reflect the incoming light (Figure 11b). The photographs of the actual reflective display prototype, prepared by the author utilizing PCLC micro-particles made by soft lithography is presented in Figure 11 c) and d). Tailored PCLC particles, which reflect green light, dispersed in an appropriate host fluid reorient from a bright color (reflective, OFF-state, Figure 11c) to a dark (non-reflective, ON-state, Figure 11d) under an applied AC electric field. Maxwell-Wagner polarization is confirmed as the main mechanism for the particle reorientation. This electro-optic effect is created by extrinsic charges that migrate to the surface of a dielectric micro-particle, when an electric field is actuated, inducing a dipole moment on the micro-particle. The particle reorientation depends on many factors, including the dielectric properties of both, the particle and the host fluid, the particle geometry, the host viscosity and the electric field (frequency and magnitude). Modification of shaped PCLC micro-particles by doping with conductive or dielectric dopants increases the particle conductivity and/or dielectric constant. Doping of PCLC particles reduces the reorientation time of devices comprising the particles and extends the response to the DC regime [26,28-30].

Two more display devices are given in Figure 11: a display device made with glass substrates and filled with PCLC particles that reflect green light (Figure 11e), and a multi-colored display device made on flexible substrates, where display cells are filled with PCLC micro-particles, which reflect green, red and blue light (Figure 11f).

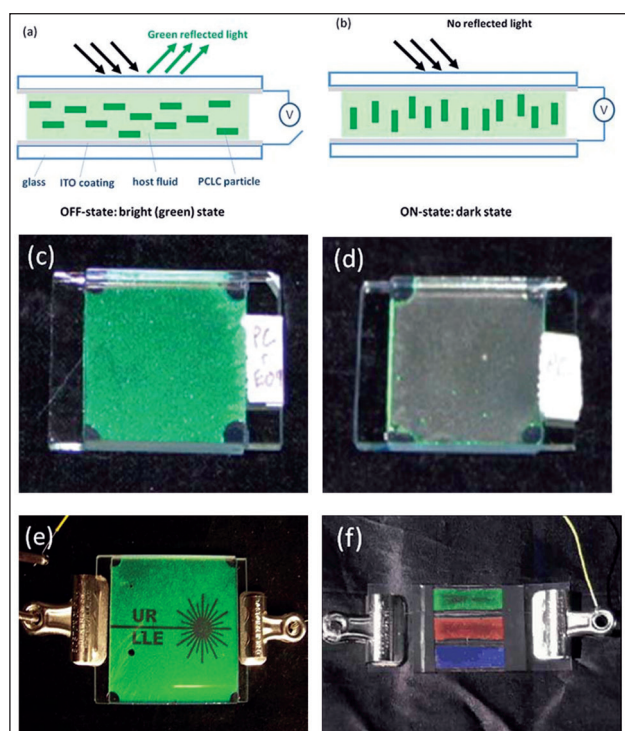


Figure 11. (a) and (b) Schematics of the mechanism of operation of reflective particle-based display. The display cell is filled with PCLC micro-particles in a host fluid (the particles presented selectively reflect in the green spectral range). (a) OFF-state of display = bright state: PCLC particles are in the lowest-energy state and reflect the incoming light; (b) ON-state of display = dark state: PCLC particles reorient in the direction of the applied electric field and do not reflect the incoming light; (c) and (d) Photographs of the actual reflective display prototype in ON- and OFF-state, respectively; The display cell is filled with PCLC particles, fabricated by soft lithography, which selectively reflect green light. (e) Display device made with rigid (glass) substrates with logo UR-LLE; (f) Multi-colored display device made on flexible substrates, where display cells are filled with PCLC micro-particles, which reflect green, red and blue light

Sensor devices based on PCLC flake/host systems are envisioned, as well. For instance, a possible operational mechanism of the sensor is based on voltage-coded micro-particles, which show a brightness change, or a color shift, for a given applied voltage that depends upon particle shape, size and/or composition. Another possible operational mechanism would be a color change due to helical dilation/contraction could be observed as a result of exposure to a certain chemical vapor [28, 31].

The tailored PCLC particles fabricated by soft lithography enable their uniform and reproducible electro-optical behavior under an externally-applied electric field that has been widely studied by the author [26, 28-31].

Yet another very promising applications of tailored micro- and nano-particles, fabricated by soft lithography, are found in pharmacy and medicine. The particles with precise shape, size and surface chemistry can be loaded with various drugs, vaccines, chemotherapeutics, magnetic resonance contrast agents, and fluorophores, and used in a wide range of applications, viz. to deliver the medicine in the body in a controlled way, to target certain organs with disorders, or for imaging purposes of body parts difficult to access [32,33].

4. Conclusion

In this study, soft lithography was used as an inexpensive method to produce a large quantities of precisely-shaped polymeric micro-particles. A particular strength observed for the used soft lithographic method is that it provides precise control over shape, size, and surface chemistry of the micro-particles.

Flexible PDMS mold that was taken as an inverse replica of a rigid silicon wafer template, was used for shaping polymer particles in tailored dimensions. PCLC material was used as a material to be shaped into tailored micro-particles. Shaped PCLC particles can find different passive applications, such as: decorative inks/paints, use for document security, filters, color filters, but also could be used in active applications like, smart windows, multi-color flexible displays, smart cards, electronic labels and billboard signs, particle display technologies, drug and vaccine-carriers.

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Investigation of possible borrow pits of building stone for rehabilitation of the Aladza mosque in Foca

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Abstract

For the purpose of rehabilitation, that is the construction of destroyed Aladza Mosque in Foca, it was necessary to overview the type of material it was previously built of. It was noticed that a part of original fragments, namely stones, is missing, so it was of great importance to find borrowing pits of this type of stone in immediate vicinity. Since the Aladza Mosque is under the state protection and it has been listed in the World Heritage by UNESCO, the originality of its constructions is obviously related to its importance.

Investigations were conducted firstly on existing original fragments and on that basis possibilities of finding suitable borrow pits of stone in immediate vicinity were overviewed. Based on determined mineralogical – petrological and geomechanical properties of original fragments originating from particular structural parts of the mosque, six investigation location of possible borrow pits were selected. Five locations are situated in immediate surrounding while the sixth is connected to the borrow pit in Kosjeric / Uzice, Republic of Serbia. Testing of extracted samples was carried out. Obtained results revealed that samples taken at four locations can be used as a rehabilitation material because they match the original fragments by their properties.

Key words: Aladza Mosque, original stone fragments, borrow pit, laboratory test

1. Introduction

Aladza Mosque in Foca, which was built in the first half of the XVI century, presents a significant religious and also a cultural-historical object. It has been classified as the object of cultural heritage of Bosnia and Herzegovina, and listed as a

World Heritage object by UNESCO as well. It was typical for its Ottoman style of the construction that spread over this area with the expansion of the empire. The manner of the construction and materials used presented such a connection that kept the object stable until the end of the XX century. When the object was destroyed, a typical manner of the construction for that period was noticed, in terms of both foundation and connecting blocks of stone the mosque was built of.

By destruction of the object, a part of original fragments disappeared. The construction, that is reconstruction of destroyed object required to be performed with same materials and in same dimensions, considering that the object was classified as a national monument.

Launching of activities related to the rehabilitation of the Aladza Mosque, demanded consideration of the actual situation in the field. Since the object was built of several types of rocks, all types of original fragments - stones situated near the mosque were listed previously. It was determined that a certain part of material needed for the construction of the object in its previous form [1, 2] was missing. Given the time distance from the date of the facility construction as well as today's more contemporary and stronger construction methods, it was necessary to provide significant borrow pits of various building materials.

Since the starting point was the fact that material for the construction of the object was located somewhere in the immediate vicinity, the investigation on possible borrow pits of rock material started. First of all, whether there was such a material, data on quantities if any, and if they were petrographically compatible with the rock material found at the location of the demolished mosque.

2. Investigation of possible borrow pits of rocks

In the area near Foca there are no known significant borrow pits of the stones that the mosque was built of. Smaller borrow pits had not been investigated except during the work on Basic Geological Map of SFRJ 1:100000, sheet Foca [3], when they had only be listed. Particular locations of possible borrow pits of building and decorative stonewere selected around Foca, Figure 1, where reconnaissance of the terrain was conducted in following order:

- Nozdre – Kapak – Miljevina
- Potok Skakavac – Vukušić – Slatina
- Golubnjak – Miljevina
- Pucani kamen – Vukušić – Slatina
- Zakmur – Brod – Foča

During a data collection procedure in borrow pits, data on geographic location of rock beds, road infrastructure, type and ownership of land, estimated reserves and possibilities of exploitation were significant [4, 5,6]. At each possible borrow pit, samples were taken for laboratory testing, Table 1.

Immediately near the mosque, an object of Serbian Orthodox church was built. It is lined by tufa – travertine, which is macroscopically similar to travertine that was used for the construction of the

mosque. A sample was taken from the construction site and all necessary examinations were carried out although travertine originates from deposit Kosjeric, near Uzice. This is going to serve as an alternative solution in a case of failure to exploit tufa – travertine in Slatina area or if it is of more favorable characteristics. Laboratory testing was conducted in the same institutes as it was done with original fragments.

Table 1. Sampling fields of possible borrow pits

No.	Sample label	Location
1.	SK – 1	Nozdre – Kapak – Miljevina
2.	S – 2	Potok Skakavac – Vukusic – Slatina
3.	S – 3	Kosjeric – Uzice
4.	K – 4	Golubnjak – Miljevina
5.	MDK – 5	Pucani Kamen – Vukusic – Slatina
6.	ZK – 6	Zakmur – Brod – Foca

Test results of mineralogical-petrographic and physical-mechanical properties of the stones are presented in Table 2.

Travertine limestone site Nozdre – Kapak – Miljevina

Deposit of architectonic building stone Nozdreis situated immediately in the basin Miljevina, about 2.00 km west from Miljevina, site Golubn-

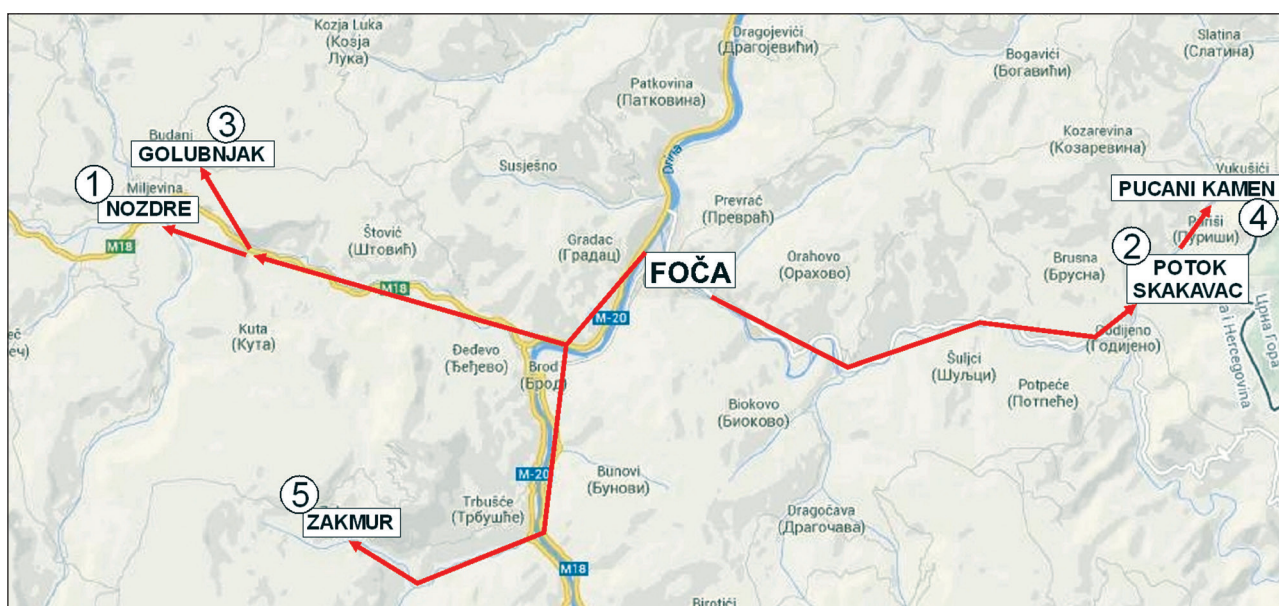


Figure 1. Locations of possible borrow pits of decorative rocks

1. travertine limestone deposit, Nozdre, 2. travertine limestone deposit, region of the village Vukusic- spring Skakavac, 3. technical building stone – limestone, site Golubnjak-D. Budanj, 4. marbled dolomite deposit, Pucani kamen-Vukusic, 5. brecciated limestone, site Zakmur

Table 2. Mineralogical-petrographic and physical-mechanical properties of stones

Sample label	Location of borrow pit	Mineralogical-petrographic provision	Volumetric weight		Water absorption	Uniaxial compressive strength	
			with pores γ_v	with no pores γ_s	u_v	in dry state σ_z	in water-saturated condition σ_z
			kN/m ³	kN/m ³	%	kN/m ²	kN/m ²
SK-1	Nozdre – Kapak – Miljevina	limestone	21.90	24.10	12.50	24 203	17 834
S-2	Potok Skakavac – Vukusic – Slatina	tufa	18.10	20.03	13.42	8 280	7 640
S-3	Kosjeri – Uzice	tufa	14.70	16.10	15.81	3 180	2 929
K-4	Golubnjak – Miljevina	marbleized limestone	33.20	33.21	0.38	69 430	63 060
MDK-5	Pucani Kamen – Vukusic – Slatina	marbleized dolomite	35.60	35.70	0.36	113 380	77 710
ZK-6	Zakmur – Brod – Foca	brecciated limestone	34.10	34.10	0.19	115 920	100 460

jak D. Budanj. It extends over the area of approximately ten (10) hectares and is located near the highway Sarajevo-Foca.

In geological terms, terrain is built of banked and layered limestone of middle Miocene M_2^2 with layers of marl and marly clay. Travertine limestone deposit is a minor part of limestone massif. It is composed of banked travertine limestone of grey, grey-white and yellowish color. Nowadays it is rarely exploited and can be used for the purpose of rehabilitation of the Aladza Mosque. A rock sample was taken from deposit.

Sample no. SK-1, Nozdre-Kapak-Miljevina

Macroscopically observed, a rock is of ocher color, crystalline structure and massive texture, dotted with tiny cracks and pores, with a crumbling surface leaving powder on hands, Figure 2. "Circles" of different dimension originating from accumulation of iron oxides deposited from the solution are noticed. Reddish haloes of iron hydroxide appear around them, giving a special aesthetic effect since they are clearly observed.

Microscopic appearance of the rock is of cryptocrystalline structure and porous texture. It is built of calcite of micritic type that presents the base of the rock. Rock mass is permeated with holes of mostly elongated and irregular forms of various sizes, about 0.8 mm to less than 0.1 mm in length.

The amount of holes makes over 35-40% of total volume of rock mass. Macroscopically and microscopically observed, and according to the properties of complex and mineral composition, the rock is micritic limestone.



Figure 2. Macroscopic and microscopic appearance of the sample SK-1

Deposit of tufa – travertine in the area of the village Vukusic

Deposit of decorative and building tufa – travertine stone lies in the area of Slatina, Vukusic site, about fifteen (15) km east from Foca. There is an inactive quarry of marbleized dolomite, "Pucanikamen", near the road Foca – Slatina – Cajnice. In the valley of the spring, that descends below the Pucanikamen towards Slatina rivulets, in its headwaters, powerful layers of tufa – travertine were formed making two terraces. Tufa is massive, compact with karst channels and caverns, and belongs to Quaternary Q_1 sediments. There are sufficient reserves of tufa – travertine.

Sample no. S – 2, Skakavac stream – Vukusic - Slatina

The stone is ocher, of crystalline structure and porous texture. Pores are irregular, of various sizes and probably interconnected. By its macroscopic properties, it is very similar to samples of original fragments T-1 and T-3. Rock mass is built of calcite, Figure 3.

Microscopically observed the rock structure is cryptocrystalline and the texture is porous. Compared to previously described samples of tufa – travertine, this sample is typical for the presence of finest grained aggregates of calcite, which makes the base of the rock.



Figure 3. Macroscopic and microscopic appearance of the sample S-2

Microscopically observed the rock structure is cryptocrystalline and the texture is porous. Compared to previously described samples of tufa – travertine, this sample is typical for the presence of finest grained aggregates of calcite, which makes the base of the rock. Cavities are of irregular shape and vary widely. The sample is different from previous tufa – travertine samples because it has a specific growth of coarse-grained calcite crystals along the rim of cavities. Crystallization of coarse-grained calcite along the rims of cavities most likely occurred during the circulation of solution in diagenetic processes. It reduced the primary porosity of the mass but it does not significantly affect physico-mechanical features of the rock. According to the properties of the complex and mineral composition, examined rock is tufa – travertine.

Deposit of tufa – travertine – Kosjeric near Uzice

Direct screening of decorative–building tufa–travertine stone deposit that lies in Kosjeric area near Uzice-Srbijawas not performed during the geological exploratory work. Samples intended

for laboratory testing were taken from the adjacent site and the deposit was suggested as an alternative solution in a case of failure to exploit deposit “Skakavac stream” – Vukusic.

Sample no. S – 3 – Kosjeric – Uzice

The rock is ocher, of cryptocrystalline structure and porous texture, Figure 4. Macroscopic properties are very similar to the properties of previous sample, as well as of the tufa sample used for the mosque construction, but this specimen appears somewhat sturdier.

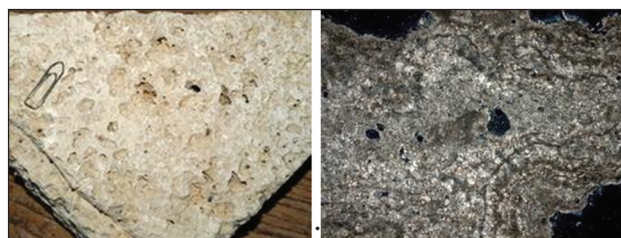


Figure 4. Macroscopic and microscopic appearance of the sample S-3

Microscopically observed the rock is composed of calcite, cavities are irregular, different in shape and occupy 35-40% of total rock volume. The sample differs from previously described samples of tufa – traavertine in the presence of banded texture within the rock mass between cavities. The stripes are in different tones of brown. According to the characteristics of the complex and mineral composition, examined rock is tufa – travertine.

Deposit Golubnjak – Miljevina

Deposit of technical building stone is settled in the area of Miljevina, site Golubnjak D. Budanj. It extends over four (4) ha and is next to the highway Sarajevo – Foca. In geological terms, the deposit presents minor part of limestone massif of Middle-Upper Triassic [7, 8]. It is simple in geological composition and mostly intact in tectonic terms. Limestone occurs in varieties from light grey to ocher.

Sample no. K – 4 – Golubnjak - Miljevina

The rock is ocher and it shows crystal structure and massive texture. Cracks and caverns are noticed, mostly elongated and containing deposited milky-white calcite crystals, Figure 5. Certain parts of rocks have developed light brown coats of limonite composition.

Microscopically observed it has coarse crystalline structure and a massive texture. It is built of calcite crystals that had recrystallized providing the stone with elements of granoblastic structure. Recrystallization proceeded along the straight edges that sometimes make the angle of 120° , which points out to metamorphic recrystallization in stable conditions and under steady lithostatic pressure. According to the characteristics of the complex and mineral composition, examined rock is marbled limestone.



Figure 5. Macroscopic and microscopic appearance of the sample K – 4

Deposit of marbled dolomite Pucanikamen – Vukusic – Slatina

Deposit lies in the area of Slatina, site of the village Vukusic, about fifteen (15) km east from Foca. Within the past period the deposit was exploited. With the cessation of exploitation, the quarry was abandoned and the access is rather difficult. White marbled dolomites occur in quite thick banks, sometimes more than 1,50 m in thickness and by general orientation it extends along the east – southeast direction. They are of primary origin, namely they were formed during the process of sedimentation. Marbleizing process is related to dynamo-metamorphism. In the stratigraphic column, they lie across yellow dolomites and belong to Upper-Triassic (T_3) layers[9].

Sample no. MDM – 5/1 – Pucanikamen – Vukusic – Slatina

Rock is ocher, macrocrystalline structure and massive texture, Figure 6. In certain part of the rock coarse dolomite crystals are developed. Rock mass does not react with cold and dilute HCl, showing that the carbonate that builds the rock is dolomite.

Microscopically observed, the structure is microcrystalline to granoblastic. The texture is massive and homogeneous. It has monomineral composition and is built of dolomites. Dolomite

crystals occur in the form of idiomorphic rhomb-shaped crystals presenting dual cleavage properties. Their average size is about 0.2 mm. Dolomite grains mosaicly coalesce whereby crystal edges often make an angle of about 120° . This composition points on stable conditions during the crystallization. The rock is marbled dolomite.



Figure 6. Macroscopic and microscopic appearance of the sample MDM – 5/1

Deposit of brecciated limestone Zakmur – Brod – Foca

Deposit of decorative-building stone of brecciated limestone. Zakmur has not been exploited yet although there is an open incision along the local road of about 30,0 m in length. Rocks belong to Triassic layers, namely to Middle Triassic, Anisian floor (T_2^1)[10]. They were continuously deposited across the formations of Lower Triassic.

Sample no. ZK – 6/1 – Zakmur – Brod – Foca

Macroscopically observed, the rock is light grey and of crystalline structure. Inhomogeneity of the rock is defined by the presence of deformed stylolites – cracks marked with reddish coats, and the presence of lenses filled with milky-white calcite crystals, Figure 7.



Figure 7. Macroscopic and microscopic appearance of the sample ZK – 6/1

Microscopically observed, the rock is of cryptocrystalline structure and inhomogeneous texture that gives it a brecciated character. Rock base is made of micrites, remains of fossil shells and

calcite deposited in stylolitic fissures. Fossil contours are marked by somewhat coarser calcite. According to the properties of the complex and mineral composition, the examined rock is brecciated limestone.

3. Matching analysis of rocks characteristics

Mineralogical-petrographic research included two groups of samples:

- The first group of rocks used for the construction of the Aladza Mosque
- The second group of samples collected from possible borrow pits of decorative and building stone, aiming to compare characteristics of their structure and composition and to point out possible similarities.

For the construction of the Aladza Mosque two types of rocks were used:

- tufa – travertine, used for walls
- limestone varieties
 - micritic limestone, used for minaret and corona
 - micritic organogenic limestone, used for foundation

Stones collected from borrow pits are presented by tufa, limestone and dolomite.

Tufa is a rock previously used for minaret. Two borrow pits of this type of rock were sampled:

- Skakavac stream – Vukusic – Slatina, sample no. S – 2/1)
- Kosjeric = Uzice, sample no. S – 3/1.

Macroscopic properties of stone used for the construction and samples from the quarry are very similar. There are no significant differences in colour and texture, namely in the size of cavities. Microscopic examinations of the sample S–2/1 determined the occurrence of coarse-grained calcite crystals on the walls of cavities whereby the sample S–3/1 is characterized by the presence of microbanded texture. Yet differences are not significant enough given that mineralogical-petrographic analyses indicate satisfactory match.

Micritic limestone, with or without organogenic components, was used for minaret, samples

no. T-1 and T-5, foundation T-4, and corona T-6. Samples were compared to samples from borrow pit Nozdre – Kapak – Miljevina, sample SK–2/1 and Golubinjak – Miljevina, sample K–4/1. By its macroscopic and microscopic properties, the most similar sample to previously used stones is the sample SK–2/1, which is defined as micritic limestone [1, 2].

Sample no. K–4/1 is marbleized limestone, which has a different complex. Ingredients are more densely packed, porosity is reduced which might significantly influence behaviour of the stone after its installation.

Marbleized dolomite and brecciated limestone show the largest mineralogical-petrographic differences compared with the stone used for the mosque construction. Marbleized dolomite, sample no. MDK–5/1, is the only milky-white rock out of all twelve samples and at first glance it differs from other samples. Apart from that, this rock is built of dolomite minerals which are a little more resistant to environmental effects. Brecciated limestone, sample no. ZK–6/1, has several characteristics that set it apart from the other samples, such as expressed stylolitic cracks, pink scum that creates a particular color tone and the size of micritic calcite in the base of the rock.

Having in mind these characteristics, these two types of rocks should not be considered as a possible material that could be used for the rehabilitation of the Aladza Mosque.

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The cantilever in the Macedonian national architecture-aspects of the function, construction and materials for its application

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Abstract

The usage of the cantilever expanding of masses, upper floors, from functional, particularly architectural reasons, represents an element in the Macedonian autochthon ethno architecture which is very characteristic and important, as well as the need for its complete research and examination.

Throughout history the Balkan Peninsula has constantly been a battlefield of wars and conquering. This part of Europe has been conquered by many soldiers' legs and many civilizations have come and gone. If we remind ourselves of Greeks, Romans, Byzantium, Turkish, Serbs, Bulgarians, then, establishing this on historic facts and truths, we can claim that every civilization has left a sign during its ruling. The influence of each one is inevitable on the different aspects of life, as well as on the architecture, and also on the formation of the Macedonian national architecture and culture in general.

This study will also cover the Macedonian national architecture from another angle i.e. the impact of the multinational structure of the population and the consequences of the historic immigration and migrations. Both are extremely obvious.

Key words: cantilever, autochthon, Macedonian national architecture, function, construction, constructing materials.

1. Introduction

The term cantilever means everything that is expanding on the upper floor out of the area of the facade wall of the down floor. This expanding of the console offers maximal emphasizing of the beauty of the construction, and it is created as a result of knowledge for the quality of the material which is used as well as from the knowledge for its constructive possibilities i.e. the disbanding of

the forces and the transmission of the load. It results in a larger space on the upper floors.

The cantilever helps in creation an eager vertical gradation, emphasizes on the horizontals, creation of a second level plastics, dynamics and dramatics, deriving from the perfect knowledge of the statics and laws of balance.

The cantilever firstly is a utilitarian element with large esthetic values and expressing opportunities for emphasizing: strength, dynamics, braveness, tension, logic and release; it is organically tied with the construction and it depends on the material which is used and it is a positive result of the concise knowledge of the technical and esthetic principles in composing the dwelling or the complex of dwellings.

The cantilever presents quality in the composition of the house, the street, the ambient or the town.

While searching for elements which are important for the development and the creation of the cantilever, of course, the touch of the village and the town architecture is inevitable.

Analyzing the characteristics of the village architecture, according to its regional position, there are:

- terraced villages (with dwellings far away from one another)
- villages with near-by houses, built according:
 - a) Turkish - eastern type
 - b) Greek - Mediterranean type and
 - c) Villages with mixed types of houses

1.1. Terraced villages (with houses far away from one another)

Main characteristic of these dwellings is that the houses are far away from one another. Depending on the inhabitants' occupations, isolated houses had been built as a whole with the economy part, or only the housing part.

This type of villages is mostly divided into neighborhoods, and the terrain is always smartly used for this division. Each neighborhood is a small group of 30-40 houses, which in its position amphitheatrically gravitate towards the central part, i.e. the “down village”, where the facilities of mutual interest such as churches, shops, schools etc. are located.

The examples for these types of villages in Macedonia are as follows:

- Kostur (Kochani) with 7-8 neighborhoods
- Gjavato (Bitola) with 3-4 neighborhoods
- Delchevo with 3 neighborhoods
- Tresonche (Galichnik) with 11 neighborhoods. [1]

For the cantilever as a subject of this study we should say that it rarely appears in this type of villages.

1.2. Villages with near-by houses

These villages are complete contrast to the previous type i.e. terraced villages.

A characteristic for this type is that the houses are so close to each other that they visually look like they lie over another. The usage of the gentle or the steeper tilt of the terrain makes this visual look even more realistic.

The houses in this type of villages are characteristic because of the absence of the yard around the houses which is not the case with the other village houses.

The near-by houses, built without any specific order, were placed next to each other, because of the curving paths and lines and because of the terrain where they were built.

As more characteristic examples of this type of villages should be mentioned the villages: Ghary, Janche and Bitushe (Rekansko), whose urban and architectonic setting impresses.

As a contrast to the previous type of villages, the cantilever here is often present, which emerges from the configuration, the functional, the visual, the constructive and other reasons.

2. Cantilever from the historic aspect and from the aspect of function and necessity

Analyzing the cantilever from the historic aspect, and its appearance as possibility for accomplishing certain needs and solving certain functions, we should also analyze the climate conditions, the economic and political factors, the customs, the mentality and the living culture of the citizens in a certain period of time. The attention will be put mainly on the territory of the Republic of Macedonia, by using examples from the Macedonian national architecture.

In order to study and search the Macedonian old architecture, it is necessary to go back in the past, to analyze the political situation several centuries ago. Today, only 100-years old to 300-years old objects which still exist, can be used for this study.

One or two centuries back in the past, seen from historic point of view, is not a long period, but it is extremely difficult to reconstruct the complete picture about the life in the Macedonian towns and villages from that time.

The quick jump from one society formation to another i.e. from feudalism to capitalism, is very sharp margin which makes it impossible for clearer and more realistic analyses of the life in that period.

In the second half of the XIX century the society life was closed in the frame of the Muslim egocentric and distant tradition of the orient, specific for a certain mentality. Without public society institutions, the life was only limited on the intimate circle of the private house. It can be said that this situation has led to creation of completely divergent attitudes and understanding in the architecture, comparing to the architecture in the Western Europe. The architecture there is built according the measures of the society dimension, and out of the human measurements. At the same time in the East in the orient there is no society measurement for the private house, the man is inside, in the architecture.

The study and the research start from those objects where the human appears with their measures, through the brilliant intuition for building. The question about who were the constructors and the builders of these objects is inevitable. It can be said that the Turkish conqueror, a soldier and a feudal, could not deal with civil engineering. From this derives the fact that the builders of

these houses are from the central part of the Balkan Peninsula. They were very good craftsmen, even virtuous; which shows a tradition in building throughout generations.

It is understandable that the Turkish accepted the style and already developed Byzantium house, with a slight difference by modifying it according to their program.

The Turkish neither religiously nor politically had a reason for forbidding the tradition of the Slav builder and therefore there are two types of houses built at the same time: Muslim and Christian, in the same town, in the same ambient, where every object is unique, something that is not a scheme or a copy.

2.1. Muslim house

The Turk - Muslim rules with the space and spreads in the spacious grassy areas. Their life is indoors between the walls and they do not want to have any contact with the street life. In that isolated ambient they have intimacy, space and enjoy the grassy areas, the water and the sun. A typical example of this kind of object is the Pasha's house in Tetovo (figure 1).

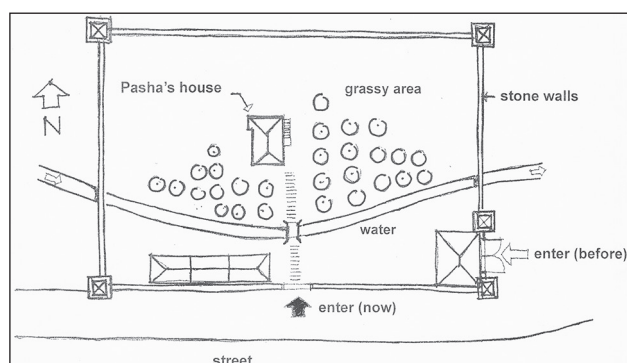


Figure 1. Pasha's house in Tetovo

Having this location, free in the choice, and having all material possibilities, the Muslim develops his dwelling horizontally, in contrast to the Christian house which is limited in space and terrain and therefore it is build vertically.

From the objects built in Tetovo, especially those belonging to the Muslims, it is obvious that they are spread horizontally and there is only one floor, which is spread vertically, above the ground floor.

The subject of this study, the cantilever is mostly found in the construction of the terrace (chardak) or

the open living space i.e. divan- haneh. Analyzes made on this space, can lead to a conclusion that there are different kinds of solution. Mainly there are closed types of terraces, taking into consideration the position of the terrace with the object, its dimensions and its purpose (figure 2 and 3).

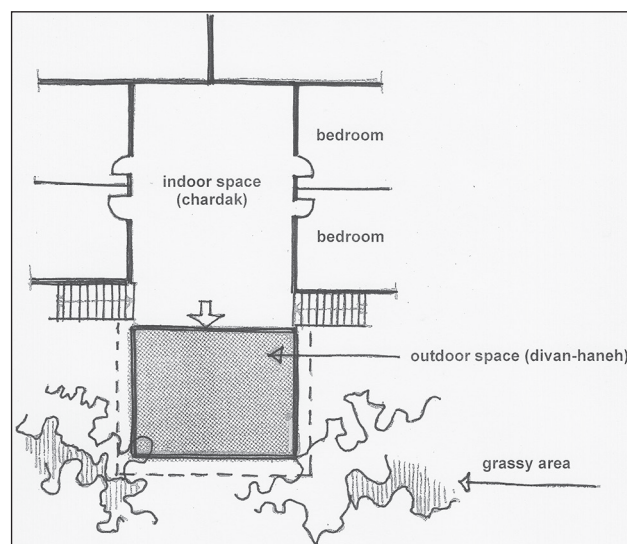


Figure 2. Integration of the outdoor space (divan-haneh) with the indoor space (terrace - chardak).

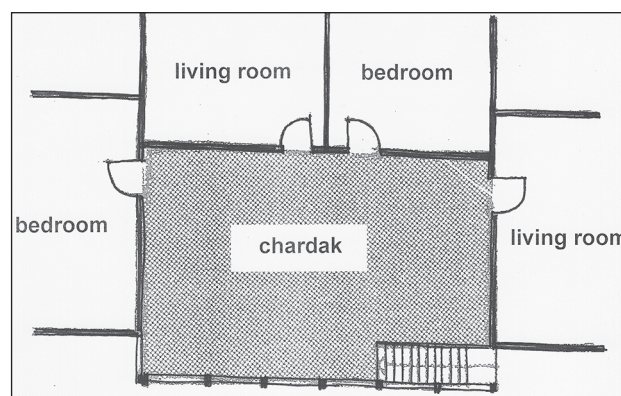


Figure 3. Large and spacious terrace closed from three sides. Entrances in the bedrooms and the living rooms are directly from the terrace.

This kind of architectural plan and solution in the living space, clearly and logically derives from the mentality and the culture of living of the Muslim life. The religion has an important role in this. The religious belief and the dogmas of the Muslim religion had completely influenced the life of the believers and therefore they had created a specific architecture of the dwelling, different from the Christian type of the housing facilities.

The superiority of the male, his needs for enjoying the life, seems to be the only elements which influence the exterior of a dwelling. On the other hand the space of the interior, where only the female lives, is hidden from the eyes of the foreigner. All these facts, which are result of a specific mentality, create the object itself.

The following mutual elements can be found in the Muslim type of dwellings:

- formation of open space for enjoyment i.e. divan – haneh, which were used for having a conversation (with a cup of coffee or tea, only among the male population)
- formation of a terrace closed from three sides, where they lived during the warm period of the year.
- the arrangement of the yard, especially near the divan – haneh, with grassy area, most often with vines and flowers, elements that always accompany this area.

2.2. Christian house

While the Muslim house spreads in the flat part of the town, the Christian house spreads on the steep terrain of the hill. The superiority of the Muslims in a way had subordinated the culture of living and the way of living of the Christian population. The process of construction and building on the rocky and steep terrain was a complex and a hard task. Maybe this fact helps in building and forming architectural assemblies with a beauty and proportion rarely seen anywhere else, proportion with humanized space. The bazaar, which intensively develops in the XIX century, is the third area which is situated in between the hill and the lowlands. (figure 4)

The terrain and the location of the dwellings were the main problem in the development of the Christian house. The national builder was founding solutions for the problems in a logical and intuitive way. Using the local constructing materials such as wood, rock, clay mud and using grid made with adobe and wooden frame, created a wonderful architecture which can somewhere be compared to the impossible.

It witnesses for a highly developed constructing skill and a national ability, which harmonically unites and integrates all forms in the way of living, mainly happening on the steep terrain.

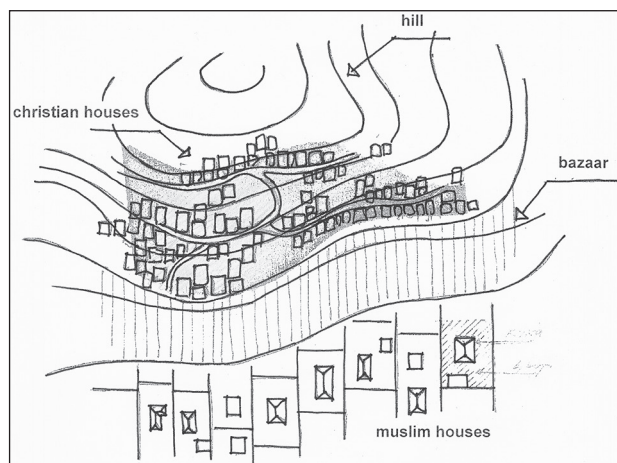


Figure 4. The position of the Muslim houses (in the lowlands), the Christian house (on the hill) and the bazaar as a tampon zone between the two mentioned before.

The configuration of the terrain, the curving paths (steep and narrow) very effectively fit into the architecture which follows and adapts to them. The cantilever is the last mean for coordination between the minimal constructing area and the maximal program.

3. Examples of the most characteristic Macedonian towns and places

Foe understanding this study, there will be a short review of several towns and regions, which thanks to their specific geographic, climate, social, economic, political and cultural conditions for progress, offers the most beautiful pearl of the traditional Macedonian architecture.

3.1. Ohrid

In the treasure of the Macedonian history and culture Ohrid represents its biggest pearl. Ohrid – the town –museum, full with cultural and historical monuments, for the first time has been mentioned in the VI century BC with a Greek name “Lichnidos” which means *light*, being the capital of the Desaretia region.

In the IX century, the famous literate Kliment of Ohrid created the Cyrillic alphabet in this town as well as the first Slavic university. Later on, tsar Samuil chose Ohrid for a capital of the Macedonian state, renewing the town and from this period until these days it is famous as the Samuil’s fortress.

The city is with mild climate, with natural beauty, with the lake - warm, clear and unique. This is a town where a lot of roads, many cultures influencing the architecture and traditions were crossing and they make the town different and exceptional.

Above all, the existence of the lake is one of the most important facts in forming the urban physiognomy of the town. The arrangement of the objects, the orientation of the space in them, is directly in balance with the view towards the lake. It was natural for each house when being located, to use the configuration of the terrain and to have a view at the lake wideness, opening itself amphitheatrically towards it.

This is especially pointed out through the houses built on the Ohrid hill with a very steep tilt to the lake. Here the formed urban zone is unique and the only one of its kind, which is a symbol and a landmark of the town.

The terrain and the climate conditions as well as the existence of the lake influenced the orientation, the position and the conception of the houses, and its architecture. Taking all this conditions under account, the national builder created specific architectural and urban assembles where the cantilever got special functional constructive and logical architectural importance. [2]



Figure 5. What the cantilever is with its qualities for the construction that is the construction for the narrow path. The passer-by has perfect views towards the architecture and the sky.



Figure 6. The facade is modulated. The surfaced flat and broken façade elements follow the gentle curving of the street. The cantilevers on the floors point it out and create the space street plastics.



Figure 7. The house at the corner stands as a "controller" or "traffic lights" at the crossroad directing the passers-by.



Figure 8.

3.2. Krushevo

It is a characteristic town in Macedonia with a rare geographical location, in an inaccessible mountainous configuration. Located in the high mountainous areas, at 1250 m. above the sea level, the town Krushevo has an amphitheatric position concerning the “central nucleus” where the public facilities such as the bazaar, the church, the post office etc. are located. The housing area is spread at the periphery of this amphitheatre.

Based on the specific elements such as the climate factor and the geographic - terrain conditions, the different ethnic constitution of the population, the people’s tradition as cattle breeders and traders; can lead to a conclusion that the formation of the town housing area and the town architecture in Krushevo is based on the well developed trading connections with different cities in Europe and their influence in the creation of one of the most specific and unique architecture. [3]

On the other hand, the inner rooms of the Krushevo houses, especially the ones belonging to the better-off people, represent examples of perfectly differentiated space for meeting guests and representativeness, with a separated space for sleeping and with separately formed rooms for a kitchen and housing economy.

The way of constructing, of the ground floor with stones, roof with flat rocky slates, the choice and the usage of the wooden skeleton in combination with stone and something else at the floor is brought from the tradition of the Mijaci region. Pressed in relatively small space, with an amphitheatric disposition of the terrain all houses are located in a way that their views are facing the nucleus - forming a perfect wholeness and a wonderful panorama, where density of the housing facilities from the center decreases when going to the periphery, and therefore larger grassy areas appear, so that at the end the green forest closes the composition.

The architecture of the dwellings is with calming forms and dimensions, re-freshened with second hand plasticity and color (tympanum on the wreath with frescoes and pictures by naive painters, baroque forms with metal frames of the balconies, yellow and white color).



Figure 9. Characteristic example of a Krushevo house with broken and asymmetrical geometric form at the ground floor is accomplished and flattened at the floor by using the cantilever, that way forming also a porch. The characteristic and conspicuous tympanum on the roof, the top open balcony at the floor disturbs the harmony of the rhythm of the windows aperture.



Figure 10. Cantilevers with curving baroque forms exposing the floors, forming dynamic housing facility as a contrast to the harmonic rhythm of the windows and the simplicity of the stone walls. The traditional compatibility of the blue color on the stone, the white one on the stony walls and the dark color on the window frames made of wood is present.



Figure 11. Cantilevered differentiation at the top floor which continues the line of the street facade is enriched with baroque forms at the vertical supporters.

3.3. Kratovo

The location of this town is far away from war events and trade communications, with a mountainous configuration of the terrain, rich in ores. Even in Roman time, there was a settlement called *Kratiskara* on the location where the town Kratovo is nowadays. It was called *Koritos* or *Koriton* by the Byzantium. From the Greek scripts it is known that its Greek name has been *Avtokrator*. In the Middle Age this town became a very important mine where the settlers known as *Sasy* (Germans), who came from far away, expanded the mining industry in this area on a higher level. [3]

The existence of the two rivers passing through this old settlement as well as the mine ore as a specific of the configuration of the terrain had influenced the urban position and the development of the settlement.

Even today we can notice a large number of housing facilities with ancient architecture, which although renewed, are real narrators which retell the stories about the rich period of time in this mining town (XVI-XVII century). Each one is amphitheatrically turned towards the two rivers offering wonderful views and getting most of the sun rays during the days.

The architecture of this town with the free cantilevered motions on the upper floors as a contrast to the ground floor, which was built with stone, is actually one of the pearls in Macedonia. Here the

creativity of the national builder is fascinating especially in finding the solution of the indoor conception and the usage of the space.



Figure 12. A solution for the triangle cantilever with wooden supporters at the corner of the house - simple and easy solution for the problem.



Figure 13. The line of the stony wall at the ground floor directed by the path, is straightened on the upper floors with triangle cantilevered extended supporters. [3]

3.4. Veles

One of the older towns in Macedonia, located on both sides of the river Vardar. Even in the III century BC in Peonia, this town is mentioned for the first time under its name *Vilazora*, and it is believed that the name of the town nowadays is taken from this ancient name. In the Turkish period it was called *Kupurly*, which means town of bridges, the same meaning with its Roman name. [3]



Figure 14. Typical example of triangle cantilevers. A strong contrast on the rustic surface of the wall made of stone and the white surface on the upper floors. A logical position of the supporters which changes the angle of transmission of the load. [4]

The natural location of the river Vardar, as well as the configuration of the terrain, as an urban place influenced the development of this town. The extremely steep configuration on the right side, and the gentle on the left one, influenced each of the housing facilities to be pointed out separately. With a correction at the ground floor by facing the river Vardar and with the perfect feeling for balancing the masses, the upper floors are maximal exposing, creating astonishing creations in architectural and constructional sense. It is also created thanks to the perfect knowl-

edge for the principles for transmission of the load, the static reasoning and the qualities of the constructing materials. Without fear and hesitation, the constructor intuitively applied the cantilever as a mean for solving the given task and by using the terrain and the exposing to the river as much as possible.



Figure 15. The asymmetrical base of the ground floor, dictated by urban and terrain conditions, is straightened on the upper floors by expanding the triangle cantilevers in order to create standard rooms and a terrace.

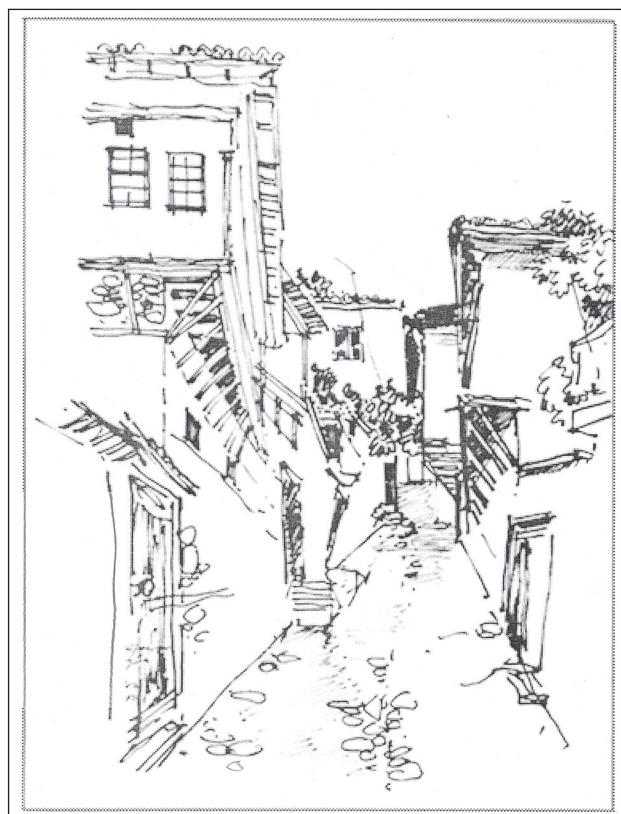


Figure 16. Characteristic narrow path in Veles. A composition of houses, which by having the cantilevers on the upper floors, pierces to the narrow path, offers wonderful views by opening the large number of windows. [3]

3.5. The monastery St. Jovan Bigorsky

Suspending over the canyon of the river Radika as an eagle nest, the monastery St. Jovan Bigorski, with the whole construction (an inn, a church, a dining room etc.) presents one of the most valuable architectonic assemblies in Macedonia.

It is amazing how the builder has succeeded to create such harmonious volume masses on such a small location.

The inn integrates in itself all basic characteristics of the Macedonian national architecture.

The cantilever here offers complete functional, architectonic and esthetic value. It is especially important to point out the solution of the outdoor stairs leading towards the terrace.



Figure 17. The brave construction solution with a console expanding of the flooring and the staircase part makes this architectonic element unique and unrepeated. The supporter is repeated in the same form and by supporting the angle from the extremely expanded eave so that the builder creates a visual ending of the building.



Figure 18. A rare sample of a cantilever, which can be found at searching a solution for expanded fireplaces. The example is a part of the dining room of the monastery, where the polygonal form is transformed into a cone ending. Tending to hide the wooden supporters which cross themselves unevenly, in order to create a visual statics, the cone ending is covered with mortar.

4. Materials for creation and constructing a cantilever

While building houses in the Macedonian national architecture, natural materials and materials found in the surrounding are basically used which dictated the construction technique. At the beginning the houses were with small dimensions. The functional treatment is only a simple closing of the space and creating rooms for living, as a protection from the weather conditions.

Later, with the beginnings of the migration movements, the thought and the idea enrich. The tradition of the neighboring people as well as the impact of the Orient influenced the concept and the enrichment of the program, as well as the experience of the building with a logical application of the constructing materials in the building technique.

For making a constructive conception of the constructions in the Macedonian national architecture, the following constructing materials are mainly used:

- portions of soil, loam,
- non-baked bricks, adobe,
- clay, mud,

- stone,
- wood,
- baked bricks.

The constructive systems of the building objects are:

- massive construction system, with strong thick walls made of portions of soil, non-baked bricks and stone,
- mixed constructive system, most often found at the built objects with several floors, where the ground floor is built as a massive system, and the floors are built as a wooden skeleton – grid made with adobe and wooden frame, which is constructively justified.,
- wooden skeleton system, which is made just above the rising wall which is most often built in stone.

Above mentioned constructive systems and the applied building materials of course influenced the architectural expression, the volume plastics, the relation light-dark, empty-full.

The cantilever as an element of the volume plastic, depending on the above mentioned circumstances evaluated by the time, so at the beginning it was with modest dimensions. The upper floor partially or completely is stretched by extending the joist of the construction between the floors, without using any tilt supporters for decreasing the console span. Tilt supporters are used for larger cantilevered exposing. (figure 19).

It is interesting to point out that the wooden supporters as a constructive element, can be found as straight beams (figure 20) or slightly curved, visible or hidden (figure 21).

The slightly curved supporters follow and visually point out the line of the static deformations, and in certain way the usage of slightly curved supporters is an expression of the Baroque influence on the Macedonian national architecture. These forms and curving, in certain cases are revival of the Greek classical forms, but they are rudiment and they do not have that strength and monumentality. The curved line, except for being present when forming the cantilever, is also met when treating the eaves, framing the windows, forming the saddles under the beams, as well as in the interior, which also point out the sense for

successful application and repetition of forms and creation of an art balance.

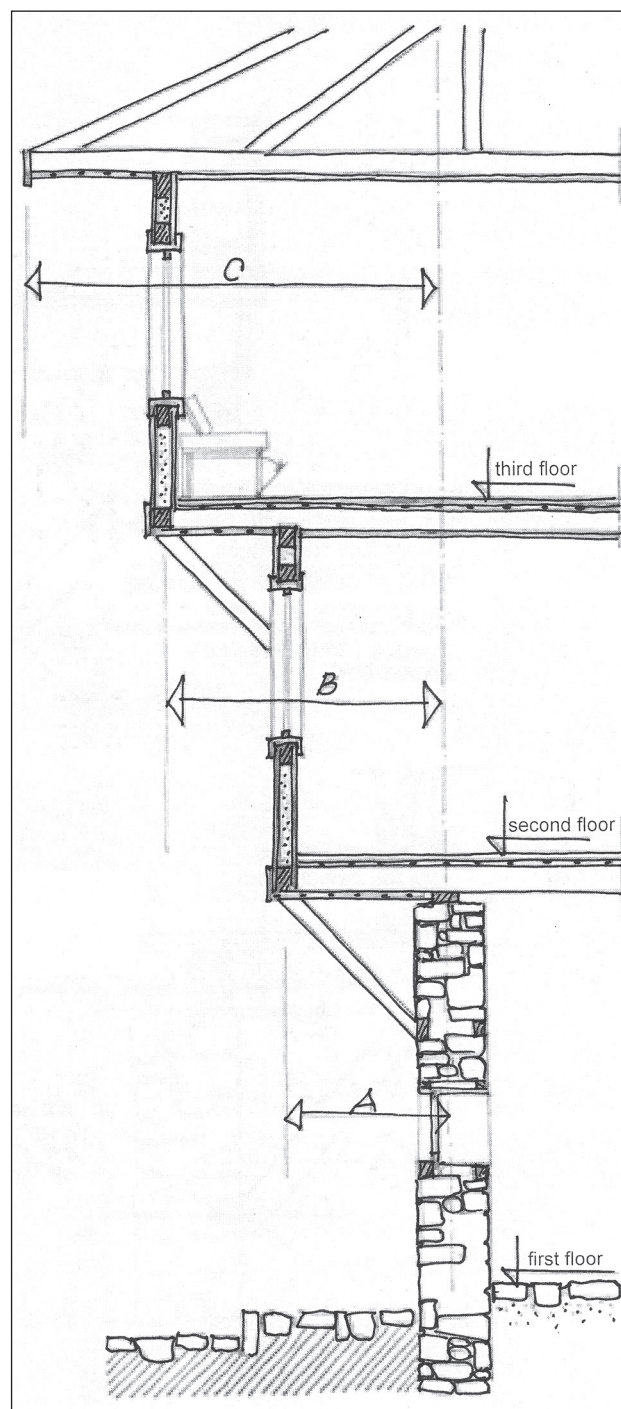


Figure 19. Expansion of the vertical surfaces. Creation of a cantilever as a set of steps. [5]

The harmony and the proportion of the constructive and non constructive elements logically derive also from the knowledge for the coordination of the measurements in the architecture where man appears as a main criterion. When measuring certain dwelling, the main measure for measuring

the architectural elements is the *arshine-old Turkish measurement* (the arshin appears with dimensions of 60cm. - endeze, 68cm. - the bazaar arshin, 75cm. - the building arshin, or 92cm. - the city arshin). [5]

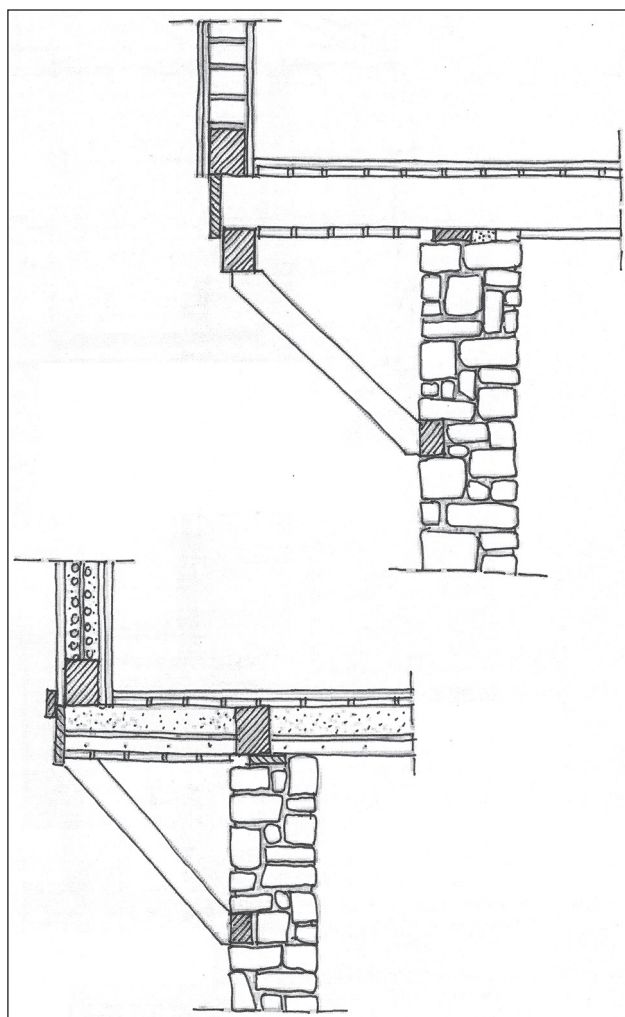


Figure 20 [4]

The outer cantilevered extended skeleton wooden walls are mainly solved as light sandwich walls with small own weight, because the wood is a basic most important constructive material of the construction elements. These kinds of walls most often get many openings – windows, which make them even less heavy. The higher they go, at the upper floors, the harmony of the openings is constructed without full masses between the windows, and at the down floors, the relation full-empty, the wall takes larger part with smaller number of windows which is statically and constructively very logical.

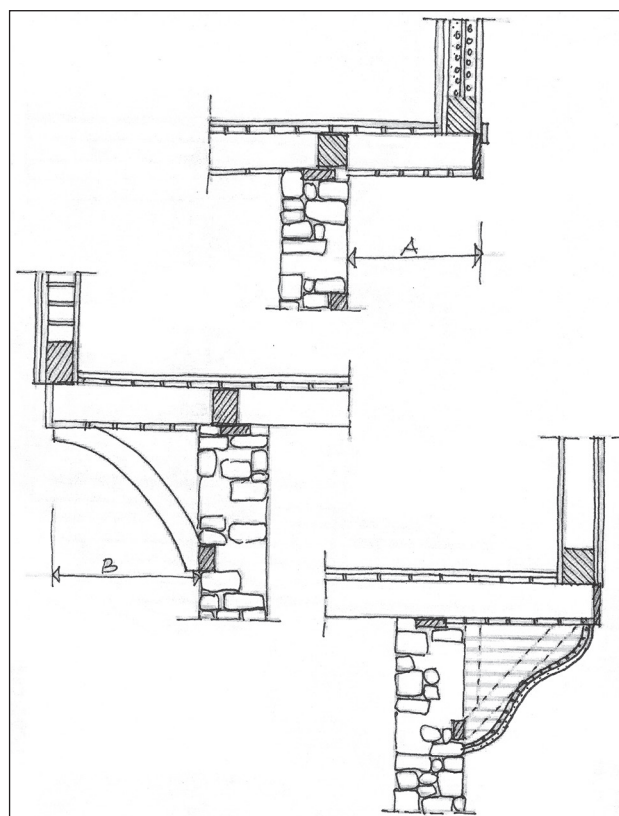


Figure 21 [5]

The sandwich wall is, on the other hand, constructively formed by a system of vertical hinges, horizontal and diagonal obstacles and from the outside and inside as a cover there are certain materials which are used, such as: non grated wooden planks and boards, reeds, jointed birch stalks or branches covered then with mortar, and from the inner side it is made with cover of processed beams or it is plastered (figure 22). The fulfilling is made by using mud and cut straw, non baked quivers (later on baked quivers), wooden shavings, pieces of wood, dried maze leaves, straw or other materials found in the nature.

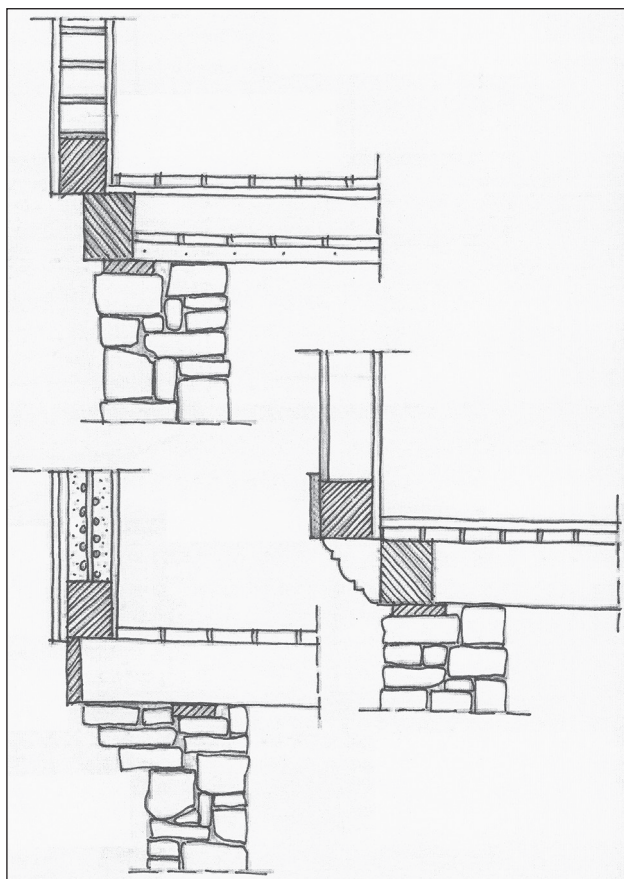


Figure 22 [5]

According to the form in the base (figure 23) the cantilevers are classified as follows:

- cantilevers parallel with the wall, which are extended and go along the whole length of the façade,
- cantilevers parallel with the wall which do not go along the whole length of the façade,
- cantilevers which do not go along the whole length of the façade and which have polygonal form,
- triangle form of cantilevers (with a tendency for straightening space with the rooms on the upper floors, or for creating better views)
- trapezoid cantilevers (at specific forms of space in the ground floor dictated by the small path, street, views etc),
- cantilevers as a basic element of the terrace which is inserted,
- cantilevers as a basic element of the extended terrace (at the Muslim conception and functioning of the house called “divan-haneh”.

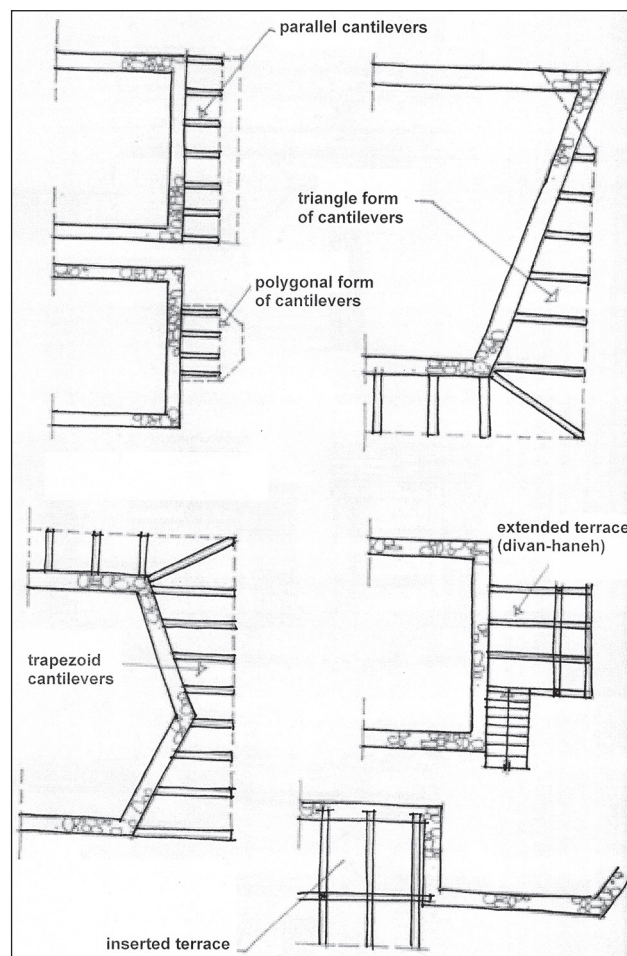


Figure 23. Most often examples of cantilevers in base. [5]

5. Conclusion

The purpose of this study is to attract the attention to the big values and qualities which are present in the Macedonian old ethnical architecture, by pointing out the town architecture of the dwellings, which is still in front of us and around us, which unfortunately disappears. The architecture which reminds us to a past time, when it had been created honestly and fairly, when it had been built with an instinct for what was beautiful, human and sociable, when the principles of building had been respected and which should be respected even today.

We are hundred of thousands times ready to be enthusiastic about the architectural complexes and certain dwellings, about the wonderful details of the Ohrid, Krushevo, Veles, Kratovo, Debar Teto-vo and Galichnic dwelling, and the same visions to be forget or neglected at the moment when we face with certain new architecture–urban problems, problems which appear on the same kind of

configuration, for the same people, for the same life philosophy, although in different circumstances and conditions. It looks as if it is easier to follow the accomplishments in other regions and with other nations through publications, and if we are more prepared to accept the “imported”, universal and foreign, than with proper analyses to find the ways and approaches for a reasonable logic in creation forms and architectural expression which should derive as an organic product, following the intuition, being supported by the most modern scientific achievements.

That “old” urbanism and architecture which had been developed more by intuition, by the perfect feeling for what was logical more than by the intellect, tells us about a history, about a certain time when the human and people common sense and organism were fighting and living in pain. Romanism and humanism are present in the creation of outdoors and indoors spaces. It looks as if there is endless number of variations in the subtle measurements and dimensions, in the choice and the composing of the materials and colors, in finding the solution for the construction and the architectural details. In conclusion, there is a coincidence, there is a similarity, but there isn't any repetition. Ohrid, Krushevo, Veles, Kratovo, Debar Tetovo, or Galichnik are all towns with specific architectural marks, but with the same needs.

If there is certain vertical gradation of each individual dwelling, with harmonic inter relations concerning the used material, color, height, percentage of outdoor and indoor spaces, the general vision of the dwelling grouping as a composition, offers an organic harmonic agglomeration of regular interrelations, with an exposed horizontal of windows which are interrupted and continue in one rhythm. The continuity is interrupted by the inter supporters, in a specific rhythm which is directed by the construction of the wooden carcass. They point out the static tension, and at the same time, as a composition, they bring the so called materialized relaxation and comfort as a contrast to the dematerialized extended white facades.

The towns receive differentiated agglomerations which function in three dimensions, even cubistic. They are experienced throughout the space, movement and time, throughout the change of the light in relation to the intensity, or through-

out the change of the angle of its action. Even in relatively peaceful ambient, the time is included as an experience factor. The view does not have a definite ending, but goes through the deliberately left spaces which always offer new qualities. These are qualities of new valuable dwellings, details or natural values, wood, hill, green areas, water, stone, fortress, etc. The dwellings watched by the eye of the passer-by walking along the street, create a non-defined architectural relief-sculptural line, along which the eye glides. The dwellings create such a composition that has a rhythm of a lyric melody, emphasized from time to time with pointed out, masses and spaces which are exposed or drawn into. This kind of melodic rhythm of the dwellings or elements is accomplished and enriched by the “pauses” of green and colorful spaces and points. The exposed cantilevers and masses are emphasized as inserted sculptures at exactly defined places. By this the builders show a high level of art point of their intuition for harmony and beauty. They had smartly used the correction which they found necessary and inevitable, had made the correction of the terrain and used the opportunities which it offered.

When analyzing this valuable architecture and searching for mutual values, the specifics which can be pointed are as follows:

- the perfect measure and the proportion which are in harmony with the town, the distances for the human movement in or out of it;
- the used construction material: stone, wood, mortar, adobe;
- the characteristic colors which are used: white, yellow or ochre, green, blue and red;
- the vegetation: vine, locust tree, white berry tree, willow fig, pomegranate;
- architectural and constructive elements: terrace (chardak), (balcony) doksat, eave, roof and cantilever;

The above mentioned specific elements, all together helps in creating plasticity, three dimensions vision, physiognomy of the street and the town, characteristic housing architecture, vertical and horizontal gradation.

The analyses are made mainly on the cantilever as a constructive element, on its reflection on the general architectural composition.

We live and create in an ambient and in an environment with such a valuable old architecture, which has been and is so much a matter of studies, analyzed by famous architects.

One thing that we must be aware of, is that the creation of something valuable and new, must be based on the old, valuable and autochthon. Our philosophy in the developing line for creating new and contemporary must take into consideration the specific and the characteristic.

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How social networks affect the learning performance among engineering students

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Abstract

This paper presents an exploratory, data-analytic investigation among groups of engineering students from two countries, Slovenia and Hong Kong, regarding their social network and learning performance. Literature review suggests social networks and peer collaborations are the major elements in team learning. Specifically, the influences of peer relationships, social networks on one another as well as on effecting learning performance of groups of engineering students taking engineering management related courses, are identified. How to achieve the optimal social networking status so as to best facilitate the team learning is still a question faced by educators or learning advocators. This project aims to explore how the students perceive their peer classmates and how they are clustered to form into teams, and how these clustering and networking explain the impacts of social network on academic performance. One important highlight based on the network analysis results of this research shows, social relationships may have direct impact on students team learning performance. In this paper, graphical visualization of the analysis results enables methodological prioritization of various learning motivation factors. Also, this paper attempts to demonstrate how advanced network analytic tools can be applied to study these social phenomena, which has not been discussed previously.

Key words: social network analysis, engineering education, learning performance, collaborative learning, learning communities

1. Introduction

Educating our future engineers so that they can gain high proficiency in computational thinking is essential for their career prospects. As educators, acquiring a good understanding of the various learning motivation factors as well as their

inter-relationships is a significant step forward in achieving this goal. In this article, we describe an exploratory, data-analytic investigation among groups of engineering students from two countries, regarding their social network and learning performance. A review of the literature on the team learning suggests social networks and peer collaborations are the major elements in team learning. There have been numerous of discussions addressing the significance and the impact of social networks in organizational learning and knowledge management aspects [1, 2, 3]. Learning appears to be a social and collective outcome achieved through seamless communications, interactions, sharing and networking of social connections [4]. Expanding individual social network to team network will create meaningful ties for the team to be connected and bring synergies that can be used to facilitate the team level learning.

Little research has been conducted to address relationships between social networks and the academic performance of students working in project teams. How to achieve the optimal social networking status so in order to facilitate the team learning the best is still a question faced by educators or even organizational learning advocators. Therefore, this is one of the research motives of this project to explore how the students perceive their peer classmates and thus how they are clustered to form into teams, and how these clustering and networking can be used to explain the impacts of social network on academic performance. Using network analysis to advance the understanding of an educational topic is a new attempt.

Specifically, we identify the influences of peer relationships, social networks on one another as well as on effecting learning performance of groups of engineering students taking engineering management related courses. Present study explores how the students perceive their peer class-

mates and thus how they are clustered to form into teams, and how these clustering and networking can be used to explain the impacts of social network on academic performance. Another research highlight is that based on the network analysis results, concrete ideas that social relationships may have direct impact on student team learning performance are obtained. Last but not least, we will describe how the graphical visualization of the analysis results enables us to methodologically set priority on attending to various learning motivation factors in a team learning environment. These are among some of the new insights not obtained from a previous confirmatory-based analysis.

2. Background

2.1. Team learning and social networks

Researchers agree that team culture and individuals are correlated [5, 6]. An individual's mindset that interacts with facets of situations within an organization or a team is crucial to the learning [7]. Aspects of individuals, such as values and beliefs, interact with facets of situations to affect the individual's attitudinal and behavioural responses [8]. A key issue in the literature on organizational learning is the permeability between individual and collective learning, that is, to what extent the characteristics and processes by which individuals are extended to the collective level.

Argyris and Schon [9] noted the paradoxical nature that collective or organizational learning is not merely the collection of individual learning, but is more than the cumulative sum of individual learners [10]. In recent years, human resources professionals have been focusing on ways which promote learning in teams and in organizations [11]. It has been theorized that systematic approaches to learning in teams are tied to team performance and are therefore of value. Additional insight into the potential impacts of the environments of individuals is crucial for learning and developmental practice [12]. Personal attitudes towards learning have been found to interact with environmental factors that influence intrinsic values [13], and thus motivation to learning.

The importance of motivation to knowledge transfer and collective learning has been advocated by researchers [14, 8, 12]. Motivation in learn-

ing is described as the desire to use the knowledge and skills mastered in associated learning activities [15], it constitutes a central force throughout the process of organizational activities [16].

2.2. Friendship networks

Having friends in the classroom can bring along with several positive effects. Friendship offers emotional support and reliable source of companionship [17]. 'Friendship' enhances social behaviour skills related to social, emotional and also cognitive growth [18]. It is not surprising that friendship is extremely important for low-performing students and those with mild disabilities. 'Friendship' can serve as compensation since such 'low-performed' students are typically less accepted than their more successful colleagues [19, 20]. In addition, friendships serve as emotional resources, for having fun and adapting to stress situations, and cognitive resources. The latter potentially includes peer tutoring, cooperative learning, peer collaboration and peer modelling [21].

The first studies on friendship networks appeared in 1930s. With the help of sociogram, Moreno [22] graphically explored friendship choices between primary students. Since then many researchers have been successfully using network analytic tools to explore friendship phenomena. Granovetter [23] argued that the ranking of friendship can be interpreted as 'strength level of ties' among individuals. Dynamic of friendships networks through time was examined by researchers [24, 25], who proposed a class of actor-oriented statistical models for friendship networks. One of the most replicated finding in the analysis of friendship networks is the tendency of individuals to associate and bond with similar others, this is known as the homophily process [26, 27, 28].

However, measuring friendship among a group of students is not an easy task. To collect data, researchers typically ask the students to nominate a small number of their friends. This kind of reciprocal nomination method [29] requires each student in the classroom to nominate at least three peers, whom he or she likes most and the questions could be positive and/or negative phrasing (e.g. "nominate three peers who are in your opinion the most/least successful in your class").

Ball & Newman [30] argued that rankings of the students in friendship networks are correlated with other characteristics of the participants, such as 'age' and 'overall popularity' measured by total number of friends. Whilst, Yamaguchi [26] conjectured that the strength of 'subject-by-friend' or 'friend-by-friend' association depends on the number of friends. The 'subject-by-friend' association indicates the strength of discussion of among students with different levels of college education. On the other hand, the 'friend-by-friend' association measure the tendency to choose friends with mutually similar discussion statuses. Both associations are proven to be stronger when the number of friends is smaller [26].

2.3. Social network position and learning performance

Network analytic tools provide quantitative understanding of the human interaction of collective behaviour and have been a long-term subject of interest in the field of theoretical and empirical studies of social systems [31, 32]. The use of network analysis not only provides the list of individual interactions among units presented in a network, but also a holistic view of a social system. In the past, centrality indices are more often used to determine the position of an individual actor in a given social network. Wasserman & Faust [33] suggested four indices: 'degree', 'closeness', 'betweenness' and 'information'. Lately, some sophisticated algorithms are propose, for instance, PageRank algorithm [34] was used for ranking actors in bibliometric networks [35, 36] and sport networks [37, 38, 39]. Hubs and authorities algorithm [40] has been increasingly used to calculate actors' centrality measures.

The position of an individual actor in a general social network is recognized as highly important [41]. Specifically, a position of the student in a network of education nature is highly related to his or her learning performance [42]. For example, the friendship relation or so-called the strength of friendship has been the subject of many studies [43, 30]. We can find various applications of social network analysis in different fields and education is not an exception [44, 42]. Generally, actors occupying 'advantageous' positions in social net-

work are expected to outperform their peers because they share enhanced access to resources as social support, strategic information, peer advice and similar [45, 46].

3. Methodology

3.1. Design and Method

In order to examine the impact of existing friendship and social network qualities on learning performance of students working in project teams, the study attempted to measure several main aspects. The core aspects are: acquaintanceship, relationship, perception on best candidates (here refers to the students participating in the study) and intention on working with others. Data collection was through a self-administered questionnaire composed of five sections:

Section 1 (Demography): Demographic details

Each student was asked for the personal particulars such as gender and age.

Section 2 (Acquaintanceship): Students were asked to evaluate how good they know each of their classmates.

In this section each student has the list of all classmates and he/she evaluated the 'acquaintanceship' with each of them. Acquaintanceship was measured on a five-point scale, ranging from (1) "don't know this classmate" to (5) "close personal friend".

Section 3 (Relationship): Students were asked to assess the relationship to each of their classmates.

Similarly to the acquaintanceship section, relationship was coded into 5-point status score (from (1) "very bad" to (5) "excellent"). If the student did not know the colleague (e.g. acquaintanceship was in previous section assessed with (1) "don't know this classmate") then the relationship was marked as (0) "no relationship".

Section 4 (Best): Students were asked to identify (at most) three in their opinion the best students in the class studying the selected subject.

The students were asked to nominate three or less students that they perceive as the **best** students in the course they studied. Same as in Sections 2-3, each student was given the list of all classmates and was asked to indicate the nomination by a mark "X".

Section 5 (Group): Students were asked to choose three classmates (at most) with whom he/she wanted to work in a group.

Similar to Section 4, each student is asked to indicate their choices of group mates to work with by putting a mark “X”.

3.2. Data collection

Samples were selected from two batches of engineering students from Slovenia and Hong Kong. Students are assumed to have similar educational backgrounds: pursuing engineering degree and studying some engineering management related subjects. Paper-and-pencil surveys were administered during class on a regular school day. A total of 36 students in Slovenia and 27 students in Hong Kong completed the survey. The 36 students from Slovenia were from the same class studying an engineering management subject, so as the 27 students from Hong Kong were from the engineering management class. The demographic detail of the respondents is shown in Table 1. There is no significant difference regarding the ‘age’ variable. However, the ‘gender’ of students is not of same compositions in both samples. In Slovenia, female students are in majority and in Hong Kong the situation is reversed. Therefore, the ‘gender’ variable should be controlled during the analysis.

In addition to the questionnaire, the academic performance (final results of the corresponding subject) of all students who participated in the survey was collected.

3.3. Network Analysis

In sociology, a (social) network is defined as a final set (or sets) of actors (represented by nodes) and the relation or relations (represented by edges or arcs) defined on them [33]. More precisely, social network analysis focuses on social relations rather than personal attributes which is in domain of traditional social science. Each participant in this study represents an actor in a network. Rela-

tions in the network can actually be interpreted in a number of ways. For instance, in acquaintanceship network, each actor in the network would be linked with all other actors and weights on links should be answers on acquaintanceship question (with (1) “don’t know this classmate” to (5) “close personal friend”). However, the resulting network would be fairly dense as all possible links among actors are implemented. For the purpose of analyzing network structure in our study, the acquaintanceship and relationship networks were dichotomized, thus links with values lower than 4 were removed (or substituted with value ‘0’) and links with values ‘4’ and ‘5’ were replaced with value ‘1’. The other two networks, ‘best’ network and ‘group’ network, were determined with the straightforward relation obtained (Section 4 & 5). Thus the directed link among actors in ‘best’ and ‘group’ networks exists if some student (the initial actor) identified his/her colleague (the terminal actor) to be best student (or to work with as group). It can be easily observed that the network relations defined in this study are unreciprocated. That is, if we consider a network with a relation acquaintanceship, person A can claim to know a person B very well (a weight on an arc should be large) but person B can assess their ‘acquaintance’ differently.

There are many procedures for ranking ‘actors’ in directed networks according to their social network features. The term ‘*ranking*’ is meant to identify and to list the actors in the network from the most important actor to the least important. In this study two social network ranking methods were applied. First is known as the ‘hubs and authorities’ algorithm and second as ‘Page Rank’ algorithm.

Good hubs in the network are entities which are pointing to many good authorities and similarly good authorities are entities which are pointed to by many good hubs [40]. This method uses two vectors, first vector is called a hub vector and second vector is an authority vector. High vector value of individual entity indicates its hub and/or authority tendency. In the case of acquaintanceship network good hubs are students who know

Table 1. Demographic detail of respondents

	Slovenia	Hong Kong
Gender	Male=8 Female=28	Male=16 Female=11
Age	Mean=21.44 SD=2.14	Mean=22.04 SD=1.22

most colleagues and good authorities are students who are known by most colleagues.

PageRank algorithm is well known in the world of computers and is based on the assumption that the relevance of the article depends on the number of citations it has the article in other articles. We used the PageRank algorithm to rank students in each of the last three sub-network representations. That is, each student in the (sub) network carries a unit of prestige which flows in the network along its weighted links. The PageRank algorithm is based on the premise that the ‘prestige’ of each student in the network can be judged by the number of incoming links the student got from other students in the network. Moreover, links from better students should carry more weight than links from less successful students. Visualization of networks is an important tool for exploring network’s structure and more importantly it communicates the obtained results of analyses to others. Graph automatic procedures were used for nodes placement. Among the many analytical tools, algorithms based on the energy minimization method (spring embedders), such as traditional, the Kamada-Kawai algorithm [47] are most popular. Spring embedders position

the nodes linked by ‘springs’ in such a place that they are in a state of equilibrium. Some of the analytical tools are based on local optimization procedures and therefore we must not rely on just a single run of these procedures, but have to repeat them until a satisfying solution is obtained. Additionally, some manual editing to improve readability of the obtained layout was considered.

3.4. Supporting tools

For standard statistical analysis the open source statistical programme R was used [48]. R was also used to transform the data into networks. Network analysis and network visualization were carried out with the programme Pajek [49].

4. Results and discussion

4.1. Results

Network analysis is applied to analyze both Hong Kong and Slovenia data sets, and results in the form of network relations are presented. The resulted network relations are discussed respec-

Table 2. List of variables

Name	Abbreviation used	Description
Acquaintanceship hub	A_hubs	Ranking the students from the one who know <i>the most</i> students and <i>the most important</i> students to the one who know <i>the least</i> students and <i>the least important</i> students in the acquaintanceship network.
Acquaintanceship authority	A_auth	Ranking the students from the one who is known by <i>the most</i> students and by <i>the most important</i> students to the one who is known by <i>the least</i> students and by <i>the least important</i> students in the acquaintanceship network.
Relationship hub	R_hubs	Ranking the students from the one who choose <i>the most</i> students and <i>the most important</i> students to the one who choose <i>the least</i> students and <i>the least important</i> students in the relationship network.
Relationship authority	R_auth	Ranking the students from the one who was chosen by <i>the most</i> students and by <i>the most important</i> students to the one who was chosen by <i>the least</i> students and <i>the least important</i> students in the relationship network.
Best PageRank	B_Page	Ranking the students from the one who was recognized as <i>the best</i> student by other students to the one who was recognized as <i>the least successful</i> student by other students with the help of PageRank algorithm.
Points at the final exam	Points	Ranking the students from the one who achieved <i>the highest score</i> to the one who achieved <i>the lowest score</i> at the final exam.
Group PageRank	G_Page	Ranking the students from the one who was recognized by other students as <i>the most preferred</i> to work within the group to the one who was recognized as <i>the least preferred</i> to work within the group with the help of PageRank algorithm.

tively (acquaintanceship, relationship, best relations, group and correlations).

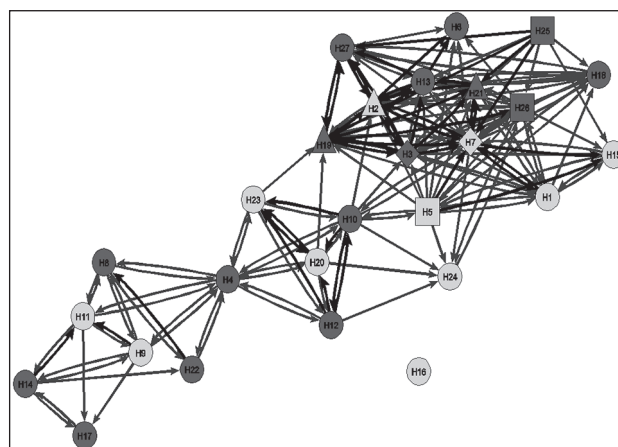
In this section the measures in networks obtained by four relations were calculated. More specifically, hubs and authority weights of nodes in the acquaintance and relationship networks were determined. In addition, in ‘best’ and ‘group’ networks the PageRank algorithm was applied with the resulting values for each actor obtained. The list of all variables (together with variable measuring points at the final exam) and their abbreviations is presented in Table 2.

4.1.1. Acquaintanceship

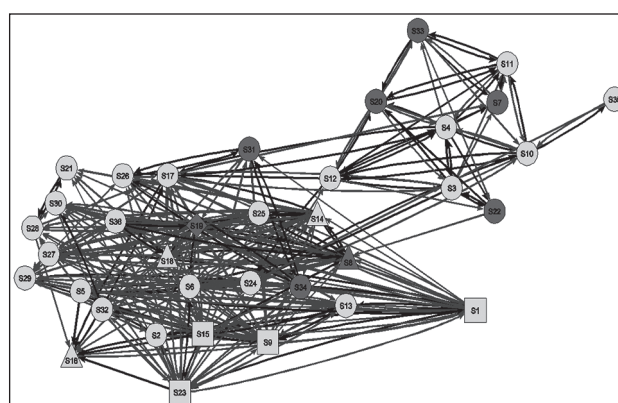
As stated in subsection 3.3, acquaintanceship and relationship networks were dichotomized. The acquaintanceship networks for Slovenian and Hong Kong students are shown as in Figure 1 (in all figures, female student are displayed by light grey colour and male students by dark grey).

The densities of acquaintanceship network were calculated (for Slovenian and Hong Kong network separately), i.e. the proportion of all arcs in the network and the maximum number of arcs among nodes. There is almost no difference between ‘density’ of acquaintanceship network of Hong Kong students (0.239) and Slovenia network (0.237). In Hong Kong network, female student denoted by H16 is the only student who is not connected to any other student. All students in Slovenian network are connected to at least one student. With reference to the ‘density’ of the network, there is no significant difference in students’ acquaintanceship between both networks.

On the other hand, hubs and authorities weights were calculated for each student in these networks. By definition of a hub, the students who are more well-known in the group would ‘share’ larger hub weights. Similarly, the students who know better of other students in the group would share larger authority weights. Five students with the largest hub and authority weights in each network were identified. Students with largest hub (authority) weights in Figure 1 are ‘spotted’ by rectangle (triangle) shape and students with largest values in both weights are ‘spotted’ with diamond shape. Both measures would be further elaborated in the Section 4.1.5.



(a) Hong Kong

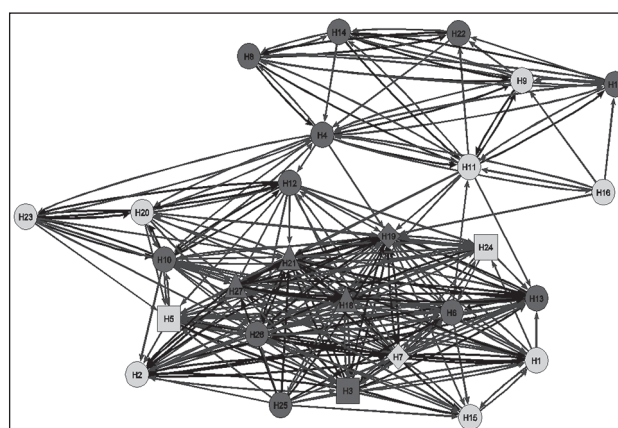


(b) Slovenia

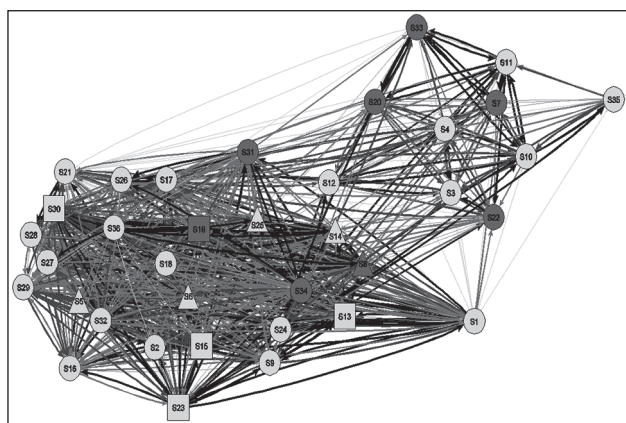
Figure 1. Sociograms of acquaintanceship network

4.1.2. Relationship

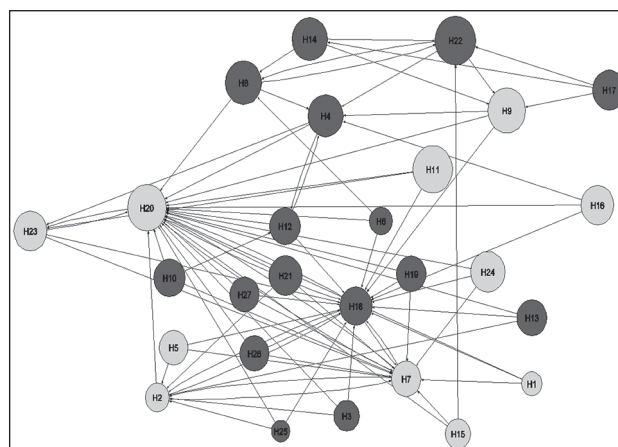
Dichotomized relationship networks of Hong Kong and Slovenian students are shown as in Figure 2.



(a) Hong Kong



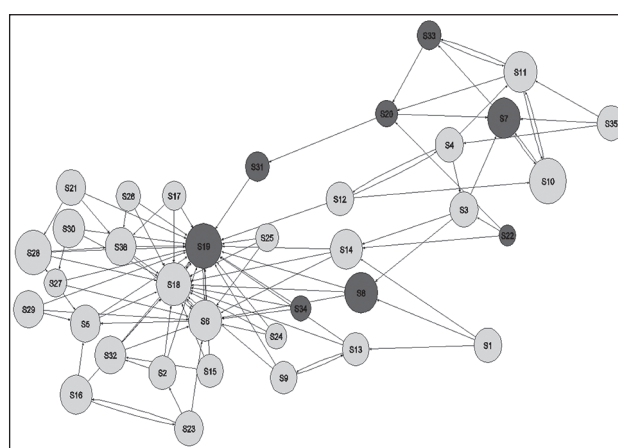
(b) Slovenia



(a) Hong Kong

Figure 2. Sociograms of relationship network

There are no isolated students neither in Slovenian nor Hong Kong relationship network. The Slovenian network is denser compared to the Hong Kong network (SVN density = 0.407; HK density = 0.372). However, both networks are fairly dense as, for instance in Hong Kong, each student claims he/she is in very good relationship (marked with 4 or 5, on a 5 point scale) with 37.2% of all other students. In Slovenian network that percentage is even higher (40.7%). Closer look inside Figure 2 suggests that relationship network of students in Hong Kong (Figure 2a) is basically divided into two parts (smaller top part and larger bottom part). Some students, i. e., H4 and H11, play a **bridge role** between both parts. In the relationship network of Slovenian students (Figure 2b) a majority of actors in the bottom part of the figure can be observed.



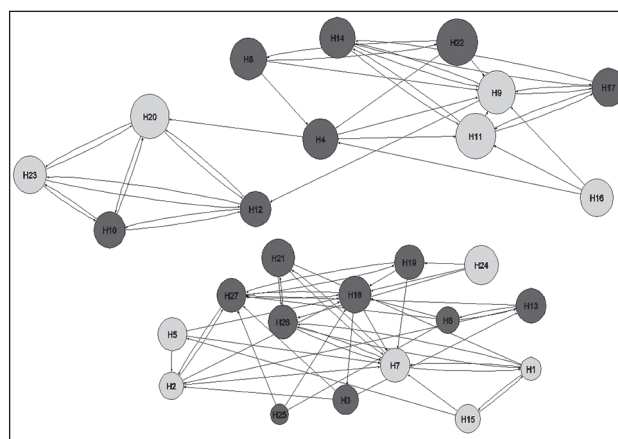
(b) Slovenia

Figure 3. Sociograms of best network

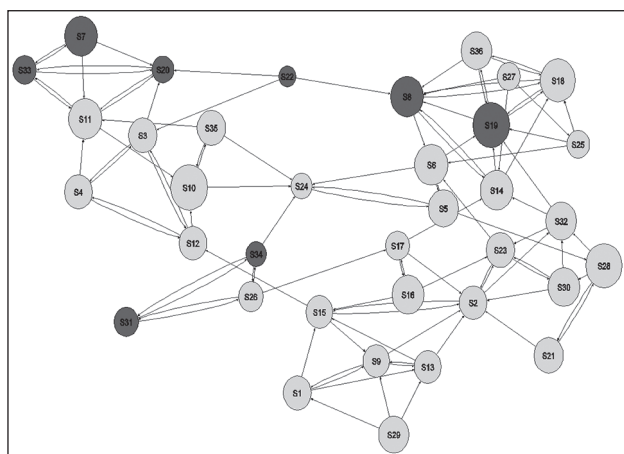
4.1.4. Group

4.1.3. Best relation

Both networks obtained by best relation are presented in Figure 3. The size of each node in Figure 3 is proportional to the academic performance (final exam result) of a particular student. In Figure 3a, the student denoted by H22 in Hong Kong network with the relation ‘best’ had the highest score at the final exam but was not perceived as the best by other students. On the other hand, in Slovenian network with the same relation (Figure 3b) the best student at the final exam (the largest node denoted by S19) was also considered the best by other students.



(a) Hong Kong



(b) Slovenia

Figure 4. Sociograms of group network

The relation ‘group’ in Figure 4 revealed two completely separated groups among Hong Kong students. By the size of the nodes it can be concluded that students with better results at the final exam are joined in the top part in Figure 4a. In Slovenia, interestingly, the less successful students are in the centre of Figure 4b forming a bridge between the left and the right part.

4.1.5. Correlations

Correlations between variables listed in Table 2 were calculated. The results of correlation are reported as Spearman rho coefficients as shown in Table 3. Best PageRank is significantly correlated to ‘Points’ at the final exam in both, Slovenian and Hong Kong network. As correlation coefficient is positive (Spearman rho; HK = 0, 3752 ($p < 0,05$), SVN = 0, 5833 ($p < 0,01$)) this is indicating good students’ perception of who is the best student in the group.

Correlation coefficients between all acquaintanceship and relationship variables are highly statistically significant and positive in both networks. It can imply that students who know their colleagues very well (and are in good relationship with them) are also recognized as the most distinctive and are the most desirable for student relationship, that is, more welcomed by others.

Other correlation results are more difficult to interpret. It seems that in Hong Kong network, being the most recognized student has negative correlation with the achieved academic result. In other words, the students who are *the most acquainted* in the group and students who are *having the best*

Table 3. Correlation matrix among items (Hong Kong and Slovenia)

Hong Kong							
	A_hubs	A_auth	R_hubs	R_auth	B_Page	Points	G_Page
A_hubs	–	–	–	–	–	–	–
A_auth	0.635***	–	–	–	–	–	–
R_hubs	0.803***	0.628***	–	–	–	–	–
R_auth	0.655***	0.940***	0.667***	–	–	–	–
B_Page	-0.092	-0.023	-0.324*	-0.111	–	–	–
Points	-0.574***	-0.497***	-0.656***	-0.502***	0.375**	–	–
G_Page	0.307*	0.133	0.115	0.382**	0.265*	-0.044	–
Slovenia							
	A_hubs	A_auth	R_hubs	R_auth	B_Page	Points	G_Page
A_hubs	–	–	–	–	–	–	–
A_auth	0.629***	–	–	–	–	–	–
R_hubs	0.894***	0.604***	–	–	–	–	–
R_auth	0.608***	0.862***	0.536***	–	–	–	–
B_Page	-0.090	0.011	-0.063	0.053	–	–	–
points	0.074	0.234*	0.117	0.233*	0.583***	–	–
G_Page	0.131	0.133	0.224*	0.133	0.627***	0.462***	–

^a Spearman correlation coefficients.

* $p < 0.1$

** $p < 0.05$

*** $p < 0.01$

relationship with other students were less likely to get good results at the final exam. That was not confirmed in Slovenian network. Moreover, in Slovenian network, to know most colleagues and to have positive relationship with them is positively correlated with the result at the final exam.

The difference between ranking male and female students corresponding to the seven variables (Table 2) in both countries was tested by Mann-Whitney-Wilcoxon test. Results of the test are presented in Table 4. No significant difference between ranking male and female students was found in both countries. Therefore, ‘gender’ variable does not affect the ranking by any means.

4.2. Discussions on the findings

4.2.1. Acquaintanceship and cultural background

From the results obtained (Sections 4.1.1-4.1.4), it is found that the relational and acquaintanceship networks of the two batches of students from two countries of different cultural backgrounds (Slovenia and Hong Kong) are of similar pattern and densities. Moreover, students are noted to be comparably sociable and no big dif-

ference between the two batches of students was detected. It was assumed from the beginning of the study that the students chosen from the two very different countries (West vs. East) might be of somewhat difference in acquaintanceship.

It is quite interesting that the results may imply that the national culture is not the most significant factor affecting the acquaintanceship, while previous researches have confirmed that friendship groups performed significantly better than acquaintance groups on both decision-making because of a greater degree of group commitment and cooperation [50]. The result may bring in a new idea on enhancement of group performance by facilitating the friendship among group mates.

4.2.2. Reputation and performance

The academic performance of a student is in general positively correlated to the degree of ‘being well-known’, according to the results from the Slovenia batch; however, this is opposite to the result obtained from the Hong Kong batch, whilst a student being ‘well-known’ seemed to be negatively correlated to his/her academic performance. This interesting finding may imply that the ‘being well-known’ could be a kind of projection or ‘re-

Table 4. Comparison between male and female students by Mann-Whitney-Wilcoxon test.

Hong Kong			
Variable	W-value	Significance value	Significant difference between male and female respondents
Acquaintanceship hub	89.5	0.9606	No
Acquaintanceship authority	84.5	0.8823	No
Relationship hub	80	0.716	No
Relationship authority	76	0.5765	No
Best PageRank	102.5	0.4376	No
Points at the final exam	90	0.942	No
Group PageRank	100.5	0.5533	No
Slovenia			
Variable	W-value	Significance value	Significant difference between male and female respondents
Acquaintanceship hub	153	0.125	No
Acquaintanceship authority	129	0.5374	No
Relationship hub	159	0.07656	No
Relationship authority	136	0.3785	No
Best PageRank	75	0.1569	No
Points at the final exam	142.5	0.2533	No
Group PageRank	104.5	0.7899	No

flection' of a student's performance in Slovenia, but not in Hong Kong.

The abovementioned finding has been a well-proven topic in the field of management, that reputation plays a key role in the effort to understand why someone outperforms others. Rindova, Williamson, Petkova & Sever [51] advanced the knowledge of the reputation-performance relationship by proposing that reputation consists of separate dimensions that have independent value-adding effects. Rindova et al. [51] further acknowledged that reputation can act as a resource that has performance implications, they do not conceptualize and test a resource-based explanation. Yet, based on the meta-analytic evidence presented [52], there is reason to believe that such an explanation has significant merit. However, this appears to be a new idea in the field of educational studies, and requires more research.

In Slovenia batch, the degree of 'being preferred' for group work is significantly and positively correlated to the academic success. This phenomenon can be easily understood while students of higher chance of having better academic performance are likely the preferred team mates for group work. However, this is again different from the results obtained in Hong Kong. Among the Hong Kong students, the being 'well-known' is of no significant or no correlation with the academic performance, which is quite different from the Slovenian batch. *This may imply that the students are of different values in mind of selecting the 'best'*. The Slovenian students normally perceive academic performance is the foremost critical value in the learning environment, whilst students from Hong Kong do not value academic performance as the sole criteria for defining the 'best'. It is quite interesting to know that Hong Kong students *may* also refer to an individual's charisma and attractiveness when they have to choose the 'preferred' group mates. This may be explained by the education background as well as the cultural backgrounds that brought up these groups of youngsters. However, for this, we cannot make a conclusion at the moment until we have some further investigations.

While there are no statistically significant differences between male and female students, in both countries (Table 4), it thus implies that gender has no significant influence on analyzed relations.

5. Conclusions

5.1. Practical implications

With the aim to explore how students' perceptions on the others and their social network induce influence of their academic performance, this study has brought some important implications for engineering education. Engineering programs and courses to be constructive and facilitate potential of students, should consider how the social networks affect the learning performance of students. Under the circumstances of team 'stereotypes', friendly 'teams' are found to be more likely to perform better.

Firstly, in this study, by applying the network analysis, knowing what in the social network affecting the learning performance is not sufficient to foster the learning intention. The results imply that students ascertain acquaintanceship is also important to their learning, while they can feel being supported. Teachers should also pay more attentions to understand how the students are working in teams.

Secondly, provided the friendship network is very relevant to giving supports (psychological and technical) and confidence to students. Social learning theory holds that role model plays an important role in providing learning motivation, confidence, knowledge and resources [53]. The opinion, suggestion and inspiration of the social network models can be a powerful source of encouragement, recognition and qualification to students. Also, being 'recognized' as well-performing can be kind of motives toward students' learning. From this study, the relationship between reputation and academic performance is ascertained and is also verified by the social learning theory [53].

Thirdly, creating facilitative and friendly atmosphere and culture within the campus, is important to learning, given the strong association between normative belief and cultures. A supportive culture and social network help approve and validate attempts of learning, hence improves the learning intentions of students.

The abovementioned highlights responds to the research questions posed early in this study, it proves social network imposing sufficient effects toward learning among engineering students, through the creation of 'friendship' or 'acquaintanceship'. The application of network analysis

demonstrated the appropriateness of application of analytic approach on the exploration of associations among factors within a network.

Limitations and future research

With the promising results obtained, there are limitations in this study are also identified. First, both student groups in this study are of relatively small and homogenous learning groups. Though to us acceptable, studying social phenomena using small sample size is not unusual in social network research [33], but from statistical point of view it is difficult to generalize the findings with a relatively small sample size. Therefore, we hope that findings of this study can be further extended for better generalization.

Furthermore, students participating in this study are from different cultural background, while this research is limited to comparison between students groups of only two countries. Though we have attempted to control the samples by selecting all samples from engineering programs, but it is still advised to generalize the findings by collecting data from other social setting of different social structures.

It is believed that the findings of this study offer a good stepping stone for further studies, ideally employing larger samples from different cultural and social backgrounds. Lastly, longitudinal approach may also be adopted so as to have a better picture of the social structure over time.

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MLTAM: technology acceptance model for mobile learning

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Abstract

A new mode of learning named mobile learning is gradually well known to all with the development of information technology. However, it is not guaranteed that all the new systems of m-learning would be accepted effectively by the users. The Technology Acceptance Model for Mobile Learning (MLTAM) is proposed in this paper as a way to analyze the acceptance before actual deployment of a new system. We analyzed the relevant variables affecting the users to accept the mobile learning based on the theoretical framework of technology acceptance model 3(TAM3) in this paper. A survey about the acceptance of mobile learning was conducted with 275 valid samples of different groups via the Internet. We used SPSS and Amos as the statistical methods to measure the explanatory ability of the model. The result shows that it is viable to explain the acceptance of mobile learning using TAM3 with strong stability; Systematic cognition, social impact and perceived ease of use affect positively to the perceived usefulness; System characteristics, individual differences affect positively to the perceived ease of use; perceived ease of use and perceived usefulness affect positively to the mobile learning intention; mobile learning intention affects positively to the behavior. This fact makes MLTAM easy to implement and use for forcing the development of m-learning.

Key words: technology acceptance model 3(TAM3), mobile learning (m-learning), mobile phone

1. Introduction

In recent years, with the constant fusion of mobile communications and computer technology and the growing popularity of technology of wireless mobile, Bluetooth and WAP, the new concept named mobile learning came into being. Mobile learning is the extending of e-learning, which is the

reflection of education needs and career development needs of people in knowledge and economy society. With the work flow frequently and time tension of people in modern society, it caused more people to pursue new methods of learning and self-improvement. Mobile learning is considered to be a new learning mode, or will be an indispensable learning model in the future. According to the 34th statistical report of China Internet development by China Internet network information center, up to June of 2014, the number of Internet users reached 632 million in China, and Internet penetration is 46.9% [1]. Internet is developed from extensive to deep, which profoundly changed the life of users through the Internet applications. Along with the deepening applications of Internet, the resources of mobile learning appeared endless, such as open class of Khan Academy, Sina classes and so on. Whether the mobile learning could be accepted effectively by users is the key factor to the success promotion of mobile learning.

Most mobile learning models focus on the technology acceptance model. A well-known model to predict technology usage is the Technology Acceptance Model (TAM) [2] [3], which is based on the theoretical framework of “the intention affects positively to the behavior” and the users’ perceptions regarding the system usability and usefulness. Many models inspired by TAM had been designed [4], for instance TAM2 [5], UTAUT [6] and TAM3 [7]. TAM2 is a model to explain perceived usefulness and behavioral intention through two dimensions of social and cognition tools. The Unified Theory of Acceptance and Use of Technology (UTAUT) is another one, being very effective in predicting the acceptance of IT solutions. TAM3 is an integrating model with identifying determinants of perceived usefulness and perceived ease of use.

In contrast, TAM3 was proposed in 2008. Up to now, the further study of mobile learning using model TAM3 is few, and the empirical research of

mobile learning based on TAM3 also is few, therefore, we attempted to use the theoretical model of TAM3 to analyze the affecting variables of users' acceptance of mobile learning in this paper. Next section reviews the related work. Section 3 presents the research design. Section 4 evaluates the acceptance model of mobile learning. Section 5 presents the conclusions and discussions.

2. Related work

2.1. Review of general studies in mobile learning

Mobile learning refers to study at any time, any place by mobile devices, such as to read, to do open discussions, to learn a foreign language. Most study of mobile learning developed since 2000, although many scholars have devoted a great deal of enthusiasm for mobile learning, the research has been developed slowly due to the limitations of technology in previous years. Until recently, with the rapid development of mobile devices and wireless networks, the works on mobile learning presents unprecedented development rapidly.

Many scholars paid attention to the research field of mobile learning and formed a series of research results, which contained three main levels. Firstly, most scholars had hold positive views on the future of mobile learning. Motiwalla [8] argued that the prospects of mobile learning would be bright, the key restricting factor to develop the mobile learning would be the technical level. Secondly, some scholars had done research on the factors of mobile learning. Selim [9] pointed out that teachers, students, information technology and support of schools were the key factors affecting the success of mobile learning. Vavoula [10] noted that the influencing factors of mobile learning evaluation included obtaining the context, measurement process and results, respecting the privacy of learners, the usability and accessibility of mobile access technology, wide range of organizations and the social aspects of culture and forms of assessment. Liu Aijun [11] analyzed the four factors influencing acceptance of mobile learning, such as mobile devices, mobile learning acting, learning resources and cognition situation. Although the mobile learning is widely accepted, lack of professional resources

or less ease of use would be the main factor causing user's dissatisfaction. Thirdly, some scholars had analyzed the mobile learning with models [12] [13]. Park SY.[14] constructed the mobile learning mode from seven dimensions, including self-efficacy, subjective norms, system functions, perceived usefulness, perceived ease of use, learning attitudes and intentions based on the technology acceptance model (TAM). Gu Xiaoqing [15] finished an integrated model in the basis of the successful model of information system and technology acceptance model, and pointed out that the experience was the key factor of users' adoption of mobile learning. Xie Aizhen [16] had done the research about college students' willingness of mobile learning based on the UTAUT model, and she thought that the factors impacting on the mobile learning were expected as performance, expected effort, community and the perceived of interest.

2.2. Technology Acceptance Model 3(TAM3)

Venkatesh and Bala proposed the theoretical framework of TAM3 with a clearer explanation of model TAM3 (Fig.1) [5]. The figure shows that the perceived usefulness and perceived ease of use are determined by four different factors, which contain individual differences, system characteristics, affectivity for working in teams and conveniences.

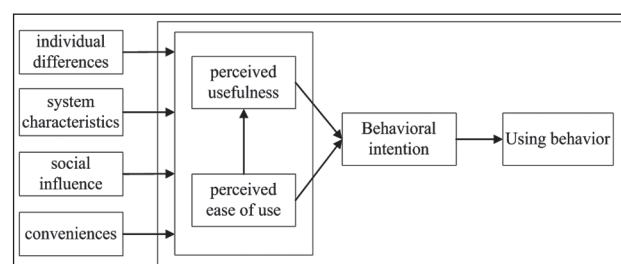


Figure 1. The theoretical framework of TAM3

TAM3 states that the determinants of perceived usefulness include affectivity for working in teams, system cognition and perceived ease of use. Affectivity for working in teams refers to the perceived boot process of different aspects of the information technology with different individual in different social processes and mechanisms, which also refers to the impact on the users who perceived whether the significant person around him is using the information technology. Perceived usefulness

could be explained with two related variables, which are social norms and user perceived images. System cognition represents the supporting degree of users to use information technology by organization, which could be explained with three related variables such as work relevance, quality of output, demonstrations of result. Other more, perceived ease of use is the important influence factor of perceived usefulness.

TAM3 also states that the determinants of the perceived ease of use conclude individual differences and system characteristic. Firstly, individual difference refers to the factors effecting the perceived usefulness and perceived ease of use in personal characteristics or demographic variables, which could be explained with the factors such as sense of self-efficacy, anxiety, sense of entertainment and external control sense. Furthermore, sense of self-efficacy refers to self perception of users to finish specific tasks by information technology; anxiety refers to the possible anxiety levels of users using the information technology; sense of entertainment refers to the levels of perceived entertainment during the interaction between users and devices; external control sense refers to the users' perceived level about related resources. Secondly, System characteristic refers to the prominent features of personal likes or dislikes in a system to help the users to perceive usefulness or ease of use, which could be explained with the factors of perceived pleasure and objective possibilities. Furthermore, perceived pleasure refers to the possible pleasantness of users to use the specific information technology; objective possibilities refer to the actual level of users' effort to finish the same task with different technology.

Perceived usefulness and perceived ease of use play a decisive role to the behavioral intention of mobile learning by users, and behavioral intention plays a decisive role to the using behavior of mobile learning by users.

3. Research design

3.1. Work hypotheses

Since the previous description of MLTAM is made on a tentative basis, it is necessary to validate the assumptions made. Therefore we have defined

various work hypotheses, which are presented below. We built the relatively simple work hypotheses on the acceptance model of mobile learning by eight factors, which are affectivity for working in teams, system cognition, system characteristic, individual differences, perceived usefulness, perceived ease of use, behavioral intention and using behavior based on the theoretical framework of TAM3 (Figure 2).

H1: Affectivity for working in teams, systematic cognition, perceived ease of use affect positively to the perceived usefulness of mobile learning by users.

H1a: Affectivity for working in teams affects positively to the perceived usefulness of mobile learning by users.

H1b: Systematic cognition affects positively to the perceived usefulness of mobile learning by users.

H1c: Perceived ease of use affects positively to the perceived usefulness of mobile learning by users.

H2: Individual differences and system characteristic affect positively to the perceived ease of use of mobile learning by users.

H2a: Individual difference affects positively to the perceived ease of mobile learning by users.

H2b: System characteristic affects positively to the perceived ease of mobile learning by users.

H3: Perceived usefulness affects positively to the behavioral intention of mobile learning by users.

H4: Perceived ease of use affects positively to the behavioral intention of mobile learning by users.

H5: Behavioral intention affects positively to the using behavior of mobile learning by users.

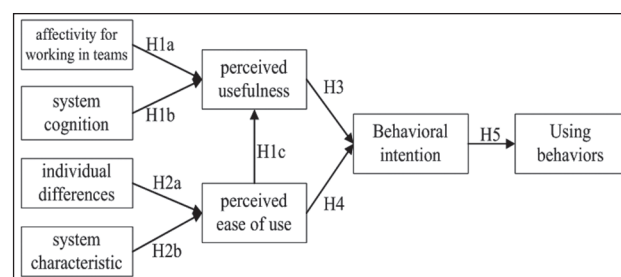


Figure 2. Work hypotheses on the acceptance model of mobile learning

3.2. Scale design

We designed a scale for the technology acceptance model of mobile learning reference to relevant literature and revised repeatedly based on the situation of mobile phone applications. Final scale

is comprised with affectivity for working in teams, system cognition, system characteristic, individual differences, perceived usefulness, perceived ease of use, behavioral intention and using behavior. It contains eight components with twenty-four questions. (Table 1)

Perceived usefulness was formally introduced to the research field of information technology when Davis proposed TAM theory. Davis and his group [5, 6] usually used four questions to measure the perceived usefulness with good reliability (Cronbach Alpha=0.95 and 0.92) [3], which were improving work performance, productivity, effectiveness, and discovering the usefulness of information technology. For this reason, this study uses four questions to measure perceived usefulness.

Perceived ease of use was formally introduced to the research field of information technology as the same time of perceived usefulness when Davis proposed TAM theory. Venkatesh used four questions to measure the perceived ease of use with good reliability via three measurement in different time

points(Cronbach Alpha=0.92,0.93 and 0.96) [20] , which were to interact with information technology is clear and understandable, easy to use , easy to do the right thing and to interact with the system with less brainpower. Follow-up studies used the same four questions [6], so this study uses four questions to measure the perceived ease of use.

Behavioral intention was measured in three aspects: intending to use information technology in the next month, predicting to use the information technology in the next month and planning to use information technology in the next month, which was proposed by Venkatesh, Davis and their group in 2003[6] and with good reliability via six measurement in different time points (Cronbach Alpha=0.88 and 0.92) [5]. So we use the same measuring method in this paper.

Using behavior was measured in two aspects, the using breadth and depth which was proposed by Burton-Jones [21] who had done deep research in using behavior. Using breadth is measured by frequency of use and using depth is measured by usage.

Table 1. Related indexes of scale for the acceptance model of mobile learning

Type	Theoretical components	Related indexes	References
Antecedent variable	Affectivity for working in teams	social norms	Devaraj et al. ,2008 ^[17] ;
		user perceived images	
Antecedent variable	system characteristic	perceived pleasure	Agarwal et al.,2000 ^[18] ;
		objective possibilities	
Antecedent variable	individual differences	sense of self-efficacy	Gao Furong,2010 ^[19]
		anxiety	
		sense of entertainment	
		external control sense	
Antecedent variable	system cognition	work relevance	Gao Furong,2010 ^[19]
		quality of output	
		demonstrations of result	
Antecedent variable	perceived usefulness	improving performance	Venkatesh&Davis,2000 ^[5]
		improving productivity	
		improving effectiveness	
		discovering usefulness	
Antecedent variable	perceived ease of use	clear and understandable	Venkatesh,2000 ^[20]
		easy to use	
		easy to do the right thing	
		requiring less brainpower	
Outcome variables	behavioral intention	intending to use	Venkatesh et al.,2003 ^[6]
		predicting to use	
		planning to use	
Outcome variables	using behavior	frequency of use	Burton-Jones&Hubona,2006 ^[21]
		usage	

4. Model evaluation

Many studies have suggested that Internet survey has more advantages than the traditional survey, such as low cost, high speed, accuracy, flexibility, multimedia, across space and time, fixed time[22][23]. So the questionnaires of this paper were collected via Internet. The questionnaire is measured according to Likert scale of five points, 1 indicates very unfavorable, 2 indicates unfavorable, 3 indicates neutral, 4 indicates favorable, 5 indicates very favorable.

4.1. Data collection

There are 275 valid samples in this survey. The number of male is 124(45.1 percent), and female is 151(54.9 percent). Respondents include college students (86 percent) and staff (14 percent), whose age mainly between 20 and 30. The majors of respondents are different, such as management specialty (42 percent), science specialty (16 percent), literature and history specialty (13 percent) and so on. The questionnaire is submitted through mobile phone (47 percent) or computer (53 percent). Result shows that the average amount of time as users spending on line with mobile phone is nearly three hours every day, in which about one hour is to learn new things. That is to say, the users of mobile phone would spend certain time every day on the Internet, and also prefer to spend nearly one third online time to do learning.

The data process is completed by SPSS and the model is build, tested and corrected by AMOS.

4.2. Obtained results

We used inherent reliability Cronbach's Alpha to test the reliability in this paper. The total Cronbach's Alpha is 0.964 and the Cronbach's Alpha of all variables were more than 0.80. So that the internal reliability of this study scale is good.

We used KMO (Kaiser-Meyer-Olkin) and Bartlett's Chi square value with the method of factor analysis to test the construct validity. The KMO value of most variables is above 0.7 except the outcome variables of behavioral intention and using behavior. Since the KMO value below 0.5 is considered unsuitable for factor analysis, the value in this test is all acceptable. The significance level of Bartlett's spherical test of all variables is 0.000($p < 0.001$). Therefore, the construct validity of this scale is good. As shown in Table 2.

4.3. Model validation

The structural equation model of mobile learning acceptance is tested by AMOS. Referring to international general evaluation standard, we test the model with the following measured indicators: Chi-square value (p), Chi-square/Degrees of freedom, GFI, AGFI, NFI, TLI, CFI, RMSEA and IFI. The results of assumption model and fitting models are shown in Table 3.

As shown in Table 3, assumption model is fitted repeatedly to get model A4 eventually, the indicators of which are meet the judge guideline of structure equation model except Chi-square value (p). The main reason might that the Chi-square value (p) is affected by sample size easily. Gener-

Table 2. Test result of reliability and validity

Latent variable	Number of measurable variables	Cronbach's alpha	KMO Test	Bartlett's spherical test		
				Approximate Chi-square	Degree of freedom	Significance level
affectivity for working in teams	2	0.829	0.794	622	15	0.000
system characteristic	2	0.895	0.848	1090	15	0.000
individual differences	4	0.841	0.724	468	6	0.000
system cognition	3	0.893	0.883	1273	36	0.000
perceived usefulness	4	0.847	0.750	487	6	0.000
perceived ease of use	4	0.841	0.724	468	6	0.000
behavioral intention	3	0.860	0.695	425	3	0.000
using behavior	2	0.881	0.500	264	1	0.000

Table 3. Fitting results of technology acceptance model for mobile learning

model	p>0.05	CMIN/DF<3.0	GFI>0.90	AGFI>0.80	NFI>0.90	TLI>0.90	CFI>0.90	RMSEA<0.10	IFI>0.90
A1	0.000	6.118	0.784	0.674	0.822	0.788	0.845	0.137	0.847
A2	0.000	4.798	0.819	0.694	0.874	0.840	0.896	0.119	0.897
A3	0.000	3.077	0.908	0.794	0.939	0.913	0.957	0.088	0.958
A4	0.000	2.883	0.916	0.809	0.944	0.921	0.962	0.084	0.962

Table 4. Standardization factor load of each latent variable

Latent variable	factor	standardization factor load
affectivity for working in teams	social norms	0.41
	user perceived images	0.48
system characteristic	perceived pleasure	0.80
	objective possibilities	0.76
individual differences	sense of self-efficacy	0.77
	anxiety	0.68
	sense of entertainment	0.65
	external control sense	0.72
system cognition	work relevance	0.58
	quality of output	0.88
	demonstrations of result	0.62
perceived usefulness	improving performance	0.42
	improving productivity	0.88
	improving effectiveness	0.76
	discovering usefulness	0.90
perceived ease of use	clear and understandable	0.69
	easy to use	0.60
	easy to do the right thing	0.68
	requiring less brainpower	0.60
behavioral intention	intending to use	0.78
	predicting to use	0.78
	planning to use	0.69
using behavior	frequency of use	0.73
	usage	0.68

ally, we think model A4 is acceptable and fitting well as acceptance model for mobile learning according to integrated judge of other indicators. So the model proposed in this paper is right basically.

4.4. Factor analysis

We carried out validating factor analysis in order to understand and evaluate the influence degree of latent variables on index system. The value of standardization load factor of latent variables in the model almost is greater than 0.5, as shown in Table 4. That is to say, the latent variables in this research could be explained and measured by the questions in this research.

4.5. Path coefficient

We also got path coefficient by model test, as shown in fig.3. The result shows that the eight number of standardization path coefficient all above 0.01 and reached significance level, which means the eight work hypotheses in this paper is reasonable. The important factors influencing perceived usefulness include system cognition, affectivity for working in teams and perceived ease of use in order. The important factors influencing perceived ease of use include system characteristic and individual differences in order. The important factors influencing behavioral intention of users to do mobile learning include perceived usefulness and

perceived ease of use in order. Behavioral intention impacts on the using behavior directly.

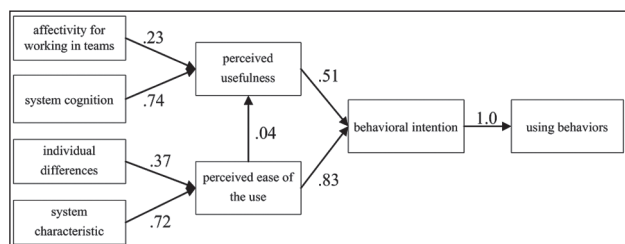


Figure 3. Path coefficient of structural equation model

5. Conclusions and discussion

The mobile learning environment is dynamic, collaborative and its supporting software is changing all the time, according to the evolution of technology opportunities. M-learning organizations and other highly competitive service providers have to deal with this issue.

It is analyzed the relevant variables affecting the users to accept the mobile learning based on the theoretical framework of technology acceptance model 3(TAM3) in this paper. We also test the robustness of TAM3 further. The result shows that TAM3 model has strong stability, which is feasible to explain the acceptance model of mobile learning.

System cognition, affectivity for working in teams and perceived ease of use affect positively to the perceived usefulness, in which system cognition explained by work relevance, quality of output and demonstrations of result has greatest impact on the perceived usefulness, but perceived ease of use has the weakest impact on it. That may be explained that the perceived ease of use has direct impact on behavioral intention as the development of information technology continually. And the influence degree from perceived ease of use to perceived usefulness is waning.

System characteristics and individual differences affect positively to the perceived ease of use. System cognition explained by perceived pleasure and objective possibilities has more impact on the perceived ease of use. Meanwhile, the individual difference has less impact on the perceived ease of use. The possible reason may be that the individual differences between users reduced gradually as the popularity of mobile phone applications.

Perceived ease of use and perceived usefulness affects positively to the behavioral intention of mobile learning by users. Perceived ease of use has more impact on the behavioral intention of mobile learning by users. That may be explained that the usefulness of mobile learning by users has been recognized by more and more people. If the mobile learning application system can interact more pleasant and convenient, it will attract more users to participate in mobile learning. Behavioral intention affects positively to the using behavior of mobile learning by users. That is to say, the intention impact on the using behavior directly.

Although the preliminary results are encouraging, the model needs to be applied in more organizations to determine its real strengths and weaknesses. Since the experimental work was done in China, we cannot ensure the model suitability to other cultures. A next step in this research initiative considers applying the acceptance model of mobile learning in a larger number of samples, even in other countries. The model can also be used to determine the suitability of technological solutions similar to mobile learning.

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Differences in balance between combat sports assessed by BBS

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Abstract

Aim of the research was to compare balance ability of karate athletes to taekwondo and boxing athletes. It is hypothesized that due to movement structure karatekas should perform better in balance tests. Thirty athletes performed balance ability test protocol on Byodex Balance system. Byodex balance system is apparatus made interlay as stationary platform. System measures and assesses dynamic stability true numeric output of three indexes – overall, medial-lateral, posterior anterior stability index. When balance is assessed aim is to maintain dot mark on monitor using balance board. Results revealed similar values of balance indexes for all three groups. Karatekas had significantly better balance ability of the dominant leg compared to boxing group. In overall it is concluded that all three groups of athletes tend to have similar balance ability, and that karate athletes do not differ from boxers and taekwondo fighter.

Key Words: Byodex Balance system, equilibrium, martial arts,

Introduction

Balance can be described as the ability of maintaining optimal magnitude of the center of body posture (CoP) displacements in area of supporting foundation without risk of falling. Act of maintaining, or restoring balance during any activity is postural control [1]. Balance and postural control have significant role in maintaining movement patterns characteristic for each sport. Physical activity can improve balance ability [2]. Sport athletes when compared to the non-active population showed greater levels of balance ability [3]. One study [4] provided information's about differences in levels of balance ability among athletes of different sports. According to the reported results, highest balance ability level were found among gymnastics athletes, followed by soccer players,

swimmers and control subjects [4]. Basketball players tended to have the worst balance ability. To author's knowledge modest researching has been conducted on balance ability where characteristics of athletes were considered. Combat sports are classified by weight categories. It is important to know that height, body mass, body fat, muscle mass and water percentage as well as BMI can influence level of balance ability [5] for adults disregarding the fitness level. Dynamic balance is the ability to maintain center of posture (CoP) with maximal movement without losing stable body position. Dynamic balance is important for sports excellence. Tests of dynamic balance, unipedal or bipedal with eyes open or closed, are usually used for the assessment of the balance ability [4]. In combat sports like karate, or taekwondo it is important to adjust CoP position since the center of gravity is continuously moving according to situation in fight. To the authors knowledge, a modest researching has been conducted for determining differences between karate, taekwondo and boxing. Three relatively similar sports, in comparison of movement pattern, but different in terms of the technical and tactical demands [6]. Boxing athletes are using punches, taekwondo use mostly kicks and punches with spherical movement while karate athletes use various hitting combinations ending up without physical contact. Combat sports when compared to the other sports activities have proven to be dominant in balance abilities, specially judo athletes dominate in static and dynamic balance with eyes shut or open [7]. Why balance ability is important for this type of combat sports? Balance is mostly put in relation with precision, key component of fighting. This is especially important for boxers and karate athletes. In theory pattern movement, barefoot practicing, hitting control and rules could be responsible for deduction and higher level of the balance in karate athletes. Why is this important? If it is possible

to estimate which combat sport has the best training transfer to the balance ability, specific combat sport could be used to develop postural control maintenance in elderly since practicing of combat sports is very popular. Kata as form of karate could present an ideal way of practicing.

Aim of the research was to compare dynamic balance ability between different combat sports activity in relation to karate athletes. We hypothesized the fact that athletes of different combat sports might have different levels of balance ability. By reviewing literature it was noted that karate athletes might have better balance due to pattern developed by sport demands.

Material and Methods

Sample characteristics

Sample represents thirty (n = 30) healthy male athletes divided in three subgroups of ten (n = 10) Karatekas, Taekwondo and Boxing fighters. All athletes were international level competitors without injuries or condition that might affect study outcome. Each subject was verbally informed about testing protocol and signed written contest as for minor's team coach signed the same approval. The study was conducted according to declaration of Helsinki committee. Sample characteristics are displayed in Table 1.

Balance ability assessment protocol

Postural balance ability was assed using Biodex Balance System (BBS - Model 945-300, Biodex Medical Systems; Shirely, New York). System works by determining level of balance plate movement and quantifies it trough three stability indexes: overall stability index (OSI), anterior-posterior stability index (APSI) and medial-lateral stability index (MLSI) [8]. Testing procedure consisted of riding bicycle ergometar for 5 minutes on 35 W and 3 minutes on 70 W after which bare-foot subjects performed bilateral and unilateral stand tests [9, 10] at level 4 difficulty (moderate difficulty). Before measurement was taken standing position on balance board was entered and 3 trials of balancing for 20 sec. with 30 sec. pause in between were performed. Same procedure was undertaken for dominant and lesdominant leg. Participant's legs were slightly knee banded (15°-

20°) and arms were placed in front of center of posture (CoP) during the procedure.

Statistical analysis

All data have been recorded on spreadsheet to be adequate for the analysis. Basic measures of data dispersion and Shapiro – Wilk's test were used to evaluate normality of data distribution. One-way ANOVA was used to determine significant differences between groups of the athletes in stability indexes. LSD post – hoc test has been used to analyze significant differences among each group of sport subjects for all stability indexes. Significance level was set at $P < 0.05$.

Results

According to Shapiro – Wilk's test all data are normally distributed. According to results from Table 1 differ in height, age, body mass and BMI were not found. Results reveal insignificant differences ($p > 0.05$) for bilateral static balance ability between combat sports. Insignificant differences between subjects were reveled in unilateral (dominant and lesdominant leg) balance abilities as well.

Post-hoc test results have marked exact least significant differences between at least two groups. No significant differences were found in bilateral stance balance ability and in lesdodinant leg balance ability between subjects of different combat sports. Karate group showed significantly lower values for stability indexes of the dominant leg from boxing group, (OSId ($p = 0.040$), APSId ($p = 0.021$) and MLSId ($p = 0.024$)). Other differences were statistically insignificant.

Table 1. Sample characteristics

	Karate (n = 10)	Taekwondo (n = 10)	Boxing (n = 10)
	mean±SD	mean±SD	mean±SD
Height (cm)	184.3±6.96	181.3±9.43	181±4.62
Age (years)	19±2.45	20±3.56	19.8±4.26
Mass (kg)	77.78±11.49	74.89±12.85	77.65±14.12
BMI	22.81±2.45	22.6±1.96	23.6±3.45

Table 2. Results of ANOVA and LSD post - hoc tests

	Karate	Taekwondo	Boxing	p - value
OSI	5.42 ± 2.39	4.31±1.67	5.31±2.79	0.511
APSI	4.27±2.1	3.19±1.28	4.28±2.26	0.509
MLSI	3.42±1.51	3.11±1.1	3.42±1.7	0.861
OSId	2.77±0.88**	3.88±2.29	4.48±1.84	0.110
APSIId	2.25±0.8**	3.15±1.6	3.81±1.7	0.066
MLSId	1.79±0.44**	2.37±1.78	2.54±0.85	0.061
OSII	3.25±1.41	3.31±1.03	3.81±1.72	0.685
APSIId	2.74±1.3	3.39±2.24	3.24±1.76	0.780
MLSII	1.9±0.64	2.13±0.79	2.11±0.72	0.713

** significantly different from boxing group data are presented as mean±SD

Discussion

Results and outcomes of the study are confident and measuring devices used is reliable and very precise. Sample is representative and homogenous in relation to the age, height, weight, BMI and training experience. By inspecting the results, it is notable that in general no difference between balancing levels exists. Karate, taekwondo and boxing have similar balance abilities measured using BBS. Significant differences were observed in favor of karate subjects compared to boxers and taekwondo fighters for balance ability of dominant leg. Significantly higher differences were expected between three of this combat sports due to their specific demands. This results and study outcomes revile that combat sports do not differ in balance level abilities. Relatively small amount of time combat athletes spend in developing balance ability. Athletes of combat sports usually have better balance ability then non athletes due to developed strength of the ankle [11, 12]. Karate is practiced barefoot so this could represent a factor that improves stability and balance in karate athletes. Long term practicing of karate can result in improvement of postural control [13]. [14] revealed that number of karate hours can decrease postural sway. This explains that karate has the advantage when balance development is required. Furthermore one research [15] judged karate training effects during the 6 month period on subjects who practice karate in relation to group of similar characteristics playing other sports, it was confirmed that an improvement in a static body balance was noticeable for karate practising group. Based from the results of the study it is obvious that karate,

boxing and taekwondo do not differ in balance levels between. Karate athletes have better dominant leg balance compared to boxing athletes. Possible explanation of this result might be given in interpretation of the leg stance when fighting. Boxing, two legs stance presents much more stabile position for conducting the punch, avoiding attack. Most of the hits performed in fight is performed on two legs base support. On the other hand, karate athletes perform their kicks mostly single leg based on the ground. Practising kata karate athletes have better development of the static balance ability [16]. But why taekwondo fighters do not have better balance then boxers maintains the question for further investigation.

Potential limitation of the study might be small sample size, and researching on topics of the differences between combat sports. Every further explanation is on speculation level, not based on facts. Further analyzing is needed to gain maximum explanation why karate athletes have better balance ability for dominant leg.

Conclusion

Based on the facts and study outcomes, it is obvious that there is no significant difference in balance ability between karatekas, taekwondo and boxing fighters. This indicates that training adaptation has relatively same effect on the balance development in these combat sport athletes. Karate athletes achieved better results in balance test of the dominant supporting leg. However it is obvious that balance is important for competitive successes [17]. A further researching is must if balance abilities differ from combat sports athletes.

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Framework for 21st century chemistry instruction: A guide to teaching and learning of Qualitative Analysis

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Abstract

The purpose of this paper is to propose an instructional approach that may integrate the acquisition of knowledge and inculcation of 21st century skills in chemistry education. Many studies have found that digital game-based learning is an effective way to enhance academic achievement and promote 21st century skills. Effort has been done by many researchers and educators to develop digital games to be used in the classroom. However, there are many obstacles to implementing the students as game consumers approach in the educational settings. One alternative approach offered by some researchers is to allow students to take on the role of game designers, developing digital games during teaching and learning process. It is believed that this approach can create a platform that allows students to deepen subject content knowledge, and practice various 21st century skills in real situations. Based on this approach, MyKimDG Module has been developed. This paper presents conceptual framework of MyKimDG and demonstrates a brief lesson in MyKimDG to the teaching and learning of Qualitative Analysis.

Key words: chemistry learning, constructionism, constructivism, digital game-based learning, learning through designing, 21st century skills

1. Introduction

Malaysia is required to produce students who are capable of becoming the innovators in science and technology (S&T) in order to compete in the job market of the 21st century as well as to trigger the country's economic growth. To become innovators in S&T, students must be STEM (Science, Technology, Engineering and Mathematics) literate and have mastery of various new skills that are known as the 21st century skills. STEM literate students will

be capable of identifying, applying, and integrating the STEM concept to understand complex problems and generate innovation to solve the problems [1]. 21st century skills are needed to enable students to face challenges in the global economic market of the 21st century [2]. [3] and [4] have proposed that students' achievement in the 21st century should be expanded further and emphasis should be given simultaneously on improving academic achievements and the 21st century skills. In Malaysia, [5] has identified five important clusters of 21st century skills which need to be integrated in the Malaysian science curriculum, namely digital age literacy, inventive thinking, effective communication, high productivity, and spiritual values. These skills have also been applied in science education in Indonesia, for example [6].

In line with the current global changes as well as the national vision and mission, Malaysia has concentrated its efforts to increase the number of students enrolling in science streams and students' capability in STEM literacy. The 60:40 (Science/Technical: Arts) Policy has been launched and the Ministry of Education (MOE) has given emphasis on the strengthening of STEM education. In order to improve the STEM literacy ability, students need to have strong basic science (apart from mathematics) knowledge, especially chemistry. This is because chemistry knowledge is fundamental for innovation, scientific literacy and problem solving [7], and is really required to study many areas of science, technology and engineering [8]. Therefore, chemistry education in Malaysia in the 21st century should be shifted towards integration of knowledge acquisition and nurturing of 21st century skills to ensure that students are equipped with knowledge, skills and values that are relevant to the current needs so that they can adapt themselves to the 21st century work and social environments.

2. Contexts of Problem

2.1 Problems in Learning Chemistry

Chemistry has been identified as a difficult subject. Chemistry concepts which are abstract is one of the factors which cause difficulties in learning chemistry. Preliminary survey involving 28 chemistry teachers and 518 students in one district in Kedah revealed that the Salt chapter is considered the toughest chapter in the Form Four Chemistry Curriculum. Table 1 shows the mean score of the level of difficulty of each chapter. The findings of this needs analysis is consistent with the findings of [9].

The learning objectives of the Salt chapter include synthesising salts and synthesising qualitative analysis of salts [10]. During the practical of Qualitative Analysis (QA), students need to plan and carry out tests to identify anions and cations in the unknown salt sample. The problem which causes difficulty in QA is that students only have little understanding of the reactions occurred [11]. Lacking of understanding of the reactions involved, students tend to have difficulty understanding the procedures and observations involved meaningfully.

Learning of the Salt chapter becomes even harder if misconceptions occur. Based on the constructivist theory, students construct their own knowledge through personal interaction with natural phenomena and social interaction with adults and peers [12]. As a result, students already have their own ideas before attending the formal teaching of science in school. Students' ideas might be different from the idea or concept adopted by scientists and is known as misconception. In the chapter of Salt,

chemical reactions and physical changes involved include solubility, precipitation, displacement, thermal decomposition and acid-base reaction. Studies showed that students have misconceptions about those physical and chemical changes [13, 14].

This problem is critical because the failure of students in mastering the chapter of Salt (and any other chapters in the Chemistry Curriculum) will have an impact on mastery of advanced S&T knowledge. As an example, QA is one of the disciplines of Analytical Chemistry. Analyst will perform qualitative analysis before carrying out more difficult quantitative analysis. Analytical chemistry play an important role in almost all aspects of chemistry such as agriculture, clinical, environmental, forensics, manufacturing, metallurgical and pharmaceutical [15]. Hence, failure of students in mastering the chapter of Salt will reduce the competency of the students who will be the S&T human capital of the aspect which plays an important role in the nation's development.

2.2 Students' Achievement in 21st Century Skills

As discussed, students who are competent in the field of S&T need not only be required to be STEM literate, but also master the 21st century skills. 21st century skills enable a person to remain relevant in the living and working environments of the 21st century which is complex and competitive [4]. However, studies have reported that the level of 21st century skills for Malaysian students is not encouraging across all levels of education from the secondary to the undergraduate level. For example, the results

Table 1. Mean score of the level of difficulty of each chapter in the Form Four Chemistry Curriculum by students and teachers

Chapter	Student		Teacher	
	Mean	S.D.	Mean	S.D.
Introduction to Chemistry	1.61	0.71	1.36	0.62
The Structure of the Atom	2.15	0.77	2.14	0.65
Chemical Formulae and Equations	2.97	0.94	3.21	0.92
Periodic Table of Elements	2.92	0.89	2.64	0.62
Chemical Bonds	3.04	0.94	2.93	0.54
Electrochemistry	3.58	0.89	3.50	0.88
Acids and Bases	3.53	0.91	3.39	0.63
Salts	3.85	0.88	4.00	0.77
Manufactured Substances in Industry	3.28	0.96	2.75	0.80

of PISA 2012 problem-solving test showed that the achievement of Malaysian 15-year-olds in tackling real-life problems is ranked 39th out of 44 participating countries [16]. A study by [17] demonstrated that the 21st century skills of Form Four students is at the moderate level. In addition, the findings of the study by [18] involving 134 students revealed that the mean score in the *Malaysian 21st Century Chemistry Skills Test (CCST)* is low. If focus is placed on the information and communications technology (ICT) skills, the studies by [19] and [20] which involved Form Four and Pre-University (Form Six) students respectively showed that the level of students' ICT skills is low where students are only moderately skilled in word processing and weak in computer programming, spreadsheet and databases applications. In relation to communication and problem solving skills, [21] reported about evaluation from industry supervisors toward students who are undergoing industrial training. They found that the level of communication and problem solving skills for undergraduate students is also at the moderate level.

Overall, the problems in learning chemistry and the level of students achievement in the 21st century skills which are not satisfactory have raised concerns on the lack of S&T human capital for the country's economic need in the year 2020. Therefore, efforts need to be carried out to increase the level of 21st century skills among students in addition to improving students' achievement in the chapter of Salt (especially chemical and physical changes involved). Mastery of these chemical reactions and physical changes also helps students to deepen their understanding in other chapters, such as Acid and Bases, Thermochemistry, and etc. The purposes of this paper are to (1) propose conceptual framework for an innovative instructional strategy that may enhance conceptual understanding and develop the 21st century skills; and (2) demonstrate an application of the new instructional strategy to the teaching and learning of a specific chemistry unit in the chapter of Salt.

3. Digital Game-Based Learning

In order to help students improve their achievement in the topic of Salt and provide opportunities for students to apply the 21st century skills, changes

in teaching and learning (T&L) practices of chemistry is critical. This is especially more crucial when dealing with the present students who grew up in the digital world and are comfortable with digital technologies. The contemporary T&L practices of chemistry must be adapted to these digital natives and also their way of learning [22]. The starting point now lies in the creativity of the chemistry teachers to apply T&L approaches that are innovative to meet the needs of the digital generation students and subsequently achieve the desired aspiration.

One approach that is gaining popularity is digital game-based learning (DGBL). As the digital game is a medium favoured by students, hence DGBL is a good strategy to achieve the learning needs of students [23]. In Malaysia, [24] showed that the majority (92.1%) of students involved in the study were familiar with digital games. A survey conducted by the authors on 508 students from a district in the state of Kedah showed that 98.8% of students have played digital games. Table 2 shows the number and percentage of students who have and have never played digital games. The findings of the survey also found that 21.8% of respondents who have played digital games used more than 20 hours a week (i.e. at least 3 hours a day) for playing digital games (Table 3). Thus, the authors proposed a study that integrates DGBL in the T&L of the Salt chapter.

Table 2. Number of students who have played and never played digital games

Gender	Have played	Never played
Male	164	1
Female	338	5
Total	502	6
Percentage	98.8	1.2

Table 3. Number of hours (in a week) used by students to play digital games

Number of hours (in a week)	Number of students	%
Less than 1 hour	99	19.7
1 to 10 hours	209	41.6
11 to 20 hours	85	16.9
21 to 30 hours	44	8.8
31 to 40 hours	20	4.0
More than 40 hours	45	9.0
Total	502	100

The study on DGBL was carried out through two approaches, namely (1) learning through playing digital games, and (2) learning through designing digital games. Students played the role as the consumer in approach (1) while in approach (2) the students became the producer.

3.1 Learning through Playing Digital Games

In the learning approach through playing digital games, the students were involved as the consumer/player of digital games developed by educators or commercial digital games in the market. As commercial digital games were not designed for instruction, there are problems such as the contents are inaccurate or incomplete [25]. Hence, some educators choose to produce digital games for student use. Various suggestions have been given by researchers to develop effective digital games. For example, [26] has listed 16 learning principles that can be incorporated into digital games, such as interaction, challenge and consolidation, system thinking and so on. [27, 28] also highlighted the characteristics of digital games (such as rules, goals, outcomes and feedback, competition, interaction and representation) and the 'rules of engagement' (such as goals, decisions and discussion, cooperation and competition, fun and so on) that make digital games engaging for players. [29] also derived seven core elements of well-designed games based on literature review (such as interactive problem solving, specific goals/rules, adaptive challenges, control, ongoing feedback, etc.). Based on these recommendations, researchers integrate the subject content, teaching principles and characteristics of an effective digital game to create digital games which are usually known as serious games. Games that are used for serious purposes (other than entertainment) is known as serious games [30]. In theory, any digital game can be perceived as a serious game depending on the actual use of the digital game and players' perceptions of the game experience [31].

Various benefits have been reported after students play digital games which have been created. The most significant benefit is increasing the motivation to learn [32, 33, 34, 35, 36, 37, 38] and fostering 21st century skills such as collaboration and problem solving skills [34], [39, 40]. However,

there are many obstacles to implementing learning through playing digital games. Studies have shown that the effectiveness of educational digital games may not be significant if the digital games were developed without applying appropriate learning strategies [41]. Thus, the development of digital games in education needs to take into account learning theories and strategies. This results in the need to consider the development time of such educational digital games [42]. In addition, many digital game players do not play educational digital games as they do not find the game play in these games to be compelling [43]. This happens because educational digital games are designed by academics who do not really understand the art, science and culture of digital game design [25]. As a result, the product has failed dismally as a game. [28] also raised this issue and states '*... the students had no input into its creation, and the stuff came out cute to the adults, but boring to the kids*'. According to [28], a student even told straight forwardly: '*Don't try to use our technology, you'll only look stupid*'.

The approach which involved students as the consumer of digital games has induced debate about the students' ability to transfer the skills gained from the gameplay context to daily life. For example, [44] points out that learning of problem-solving skills in a virtual environment of gameplay is difficult to transfer to a new context that is different from digital games. For [45], this approach is a replication of existing traditional approach where the transmission of knowledge occurs in virtual environment. Students are not given the authority to make important decisions and take responsibility on their learning in such environment. It is only when students are given opportunities to be actively involved in the knowledge co-construction process, they are more likely to acquire deeper understanding of the knowledge as well as gain opportunity to develop the 21st century skills.

3.2 Learning through Designing Digital Games

Some researchers, such as [46, 47, 48, 49], proposed learning approach that allows students to use ICT to design their own game, that is the students become the producers of digital games. The approach of learning through designing of digital games (LDDG) is among the alternatives of DGBL.

Studies on LDDG have reported that the LDDG approach can contribute to environments that provide opportunities for students to explore ideas according to their own interests [50], become active participants and problem solvers, engage in social interaction by sharing their designs and helping each other, and take ownership of their own learning [51]. In addition, [52] has reported that LDDG approach is a better way to increase student motivation and deep learning compared to the approach of learning through playing digital games. With the LDDG approach, students also acquire knowledge of programming [53], develop ICT literacy to produce new things and develop new ways of thinking based on the use of ICT tools [54]. Digital game design activities also open the door for young digital game players to become producers of digital games [54]. In Malaysia, [55] also found that LDDG approach can enhance the students' knowledge in addition to creating a fun environment.

The potential of LDDG approach in improving student motivation and engagement has also been recognized by [28] and [45]. According to [45], when students are given the autonomy to take responsibility for their own learning and co-design learning experiences with teachers and other students, they are more inclined to engage in their own learning process. Hence, one way to do so is by allowing students to become designers of their own digital games based on their own interpretation of the school curriculum. For [28], students will be motivated if they are allowed to do something extraordinary in learning at school and gain recognition for producing digital games.

In brief, this LDDG approach can create a platform or learning environment that allows students to make decisions about the design of the desired digital game, apply ICT and collaborate in a social context to deepen subject content knowledge, and practice various 21st century skills.

4. Theoretical Foundations of Learning Through Designing Digital Games Approach

The LDDG approach is inspired by two important theories in learning and education which are constructivism and constructionism [56].

4.1 Constructivism

Constructivist theory focuses on the role of students as knowledge builders. Among the major theories that contribute to the growth of constructivism include Piaget, Vygotsky and Bruner's theories of learning.

Piaget's theory explains how humans organize information into the cognitive structure and explains how cognitive development occurs. According to Piaget, the new information is organized into existing cognitive structures (schemata) through two cognitive processes, namely assimilation and accommodation. Piaget asserted that the two processes of assimilation and accommodation which are complementary and must occur simultaneously [57]. Piaget's theory also explains the process of 'increasing equilibration' as a key mechanism in cognitive development. This process requires equilibrium between assimilation and accommodation [57, 58] to seek for better equilibrium through cycles of equilibrium, disequilibrium and re-equilibrium. Equilibration therefore is a dynamic process. According to [58], conflict situations can be created to attain the goal. This means that cognitive development can occur when disequilibrium or cognitive conflicts are resolved [59]. The process of equilibration aims to restore equilibrium or resolve conflicts through the processes of assimilation and accommodation which are complementary.

Other aspects in the constructivist theory include learning can be enhanced through social interaction and discovery. Vygotsky believed that learning is influenced by the social environment and emphasized on the role of social interaction in learning and cognitive development [60]. Collaboration between students with teachers or peers provides scaffolding to students in the Zone of Proximal Development to help them construct knowledge. Meanwhile Bruner believed that learning and problem solving are the result of the exploration of new knowledge [61]. If students discover knowledge and the relationships on their own, they will gain a deeper understanding [62].

Briefly, the constructivist theory states that students interpret new information based on existing knowledge and then reconstruct the knowledge in a form acceptable to him or her. Through social interaction, triggering of cognitive conflict and re-

structuring of ideas will occur when students share their ideas from their own perspective. However, no interaction would be beneficial if new information is presented to students traditionally. Instead, students should be given the opportunity to explore new knowledge.

4.2 Constructionism

The theory of constructionism is built on the theory of constructivism which defines learning as knowledge construction in the student's mind. In addition to the theory of constructivism, constructionism suggests that the construction of knowledge occurs felicitously in a context where students are consciously engaged in the construction of artefacts [63].

This theory emphasizes the role of designing (such as making, building or programming) [64] and external objects [44] in facilitating the learning process. Designer (student) creates external objects (artefacts) using a variety of materials and shares his or her artefacts as well as the artefacts' design process with others. In this process, the designer uses knowledge, ideas and skills as instrument of personal power [65]. This means that students apply concepts and skills learnt to construct more complex concepts, ideas or theories. This theory goes beyond the idea of learning-by-doing as indicated by Papert [66] that '*I have adapted the word constructionism to refer to everything that has to do with making things and especially to do with learning by making, an idea that includes but goes far beyond the idea of learning by doing*'. Apart from that, students will appreciate the results of his or her own design because the design is his or her personal intellectual statement or representation. Ownership would exist even though the result of the design is not perfect. This small success will in turn encourage students to continue to make exploration and eventually lead to greater intellectual development and engagement.

Computers play a role in the constructionist learning theory. Computers can be used as a building material [67]. According to [68], the use of computers as building material adds unique and powerful aspects to the learning process. The idea of using the computer as a construction material submitted by Papert is very different from the idea

of using the computer as a tutor, tool and tutee put forward by [69]. For [68], a computer is a 'material to be messed about with'. Learning occurs when students are 'messaging about' with the computer. The introduction of computers is also able to change the context of learning [63]. Computers can serve as a convivial tool [70]. The willingness of students to learn will increase because students can use the computer in building artefacts [63]. Papert has described that '*The computer is the Proteus of machines. Its essence is its universality, its power to simulate. Because it can take on a thousand forms and can serve a thousand functions, it can appeal to a thousand tastes*' [65]. However, he stressed that the main focus is not on the computer but on the minds of students [65].

Additionally, constructionist learning theory also appreciates the diversity among students. According to [64], this theory recognizes that students can build relationships with knowledge in various ways. Constructionist learning environment empowers diversity of learning styles and knowledge representations. Students can produce artefacts which are significant to themselves based on their interests, learning styles and their own experience using a variety of construction materials, including ICT. The theory of constructionism also recognizes the social aspects of learning and the role of communities in learning. Papert [65] has put forward the idea of the student community and the use of computers to support collaborative learning in his book titled *Mindstorms*. Community members act as collaborators, coaches, audiences and co-constructors of knowledge in the constructionist learning environment [64].

Constructionism proposed by Papert implies that learning can be enhanced if students are involved in collaborative artefact designing projects using ICT as a construction material. Educators should encourage students to create prototypes or artefacts from their own ideas. To support constructionist learning, environment that can stimulate intellectual development and encourage project implementation should be established. Besides, learning environment that is always bustling with activity and has a wide range of construction materials, equipment, books, ICT and so on that can be used throughout the artefact construction project should be set up. In addition, changes need to be carried out on peda-

gogy, assessment and curriculum [71]. Traditional curriculum model that involves the use of projects as a way to help students learn a particular skill or concept should be flipped to allow students to use their knowledge and skills to produce something that can be shared [71].

Both theories imply that learning really depends on the students themselves and learning can be enhanced through social interaction and discovery. Thus, learning environment that provides a variety ways of learning and collaborative learning activities should be developed so that the new knowledge construction process can be facilitated. LDDG approach is one of the approaches of learning based on both theories.

5. Conceptual Framework of MyKimDG

DGBL is a popular strategy in many countries around the world. In Malaysia, although the integration of digital games in T&L is increasingly emphasized by MOE, however, studies about DGBL, especially LDDG approach is limited in Malaysia. Indeed, even in the Handbook of ICT across the Curriculum by the Curriculum Development Division [72], examples of modules which involve the integration of digital games in T&L only focused on student as consumers of digital games and digital games serve as a medium to deliver knowledge and skills. This approach is inconsistent with Jonassen's [73] recommendations that ICT should not be programmed merely as a medium to deliver knowledge and skills. In the handbook, no module was developed to involve students as designers/producers of digital games. To fill this vacuum, this study was conducted to develop modules that show how LDDG approach can be applied to help students build knowledge about physical and chemical changes in the chapter of salt (i.e. solubility, precipitation, displacement, heat decomposition and acid-base reaction) and to provide opportunities for students to foster 21st century skills. The authors named the module as Malaysian *Kimia* Digital-Game (MyKimDG). This study is important to generate new knowledge regarding LDDG in the Malaysian context.

In MyKimDG, BSCS 5E instructional model [74] that is based on the constructivist theory was used to formulate the T&L steps. In addition, Cre-

ative Design Spiral [75] was applied to help students develop new ideas. Other instructional strategies considered include the development phases of helping students to design *PowerPoint* games successfully by [76] and *Qualitative Analysis Teaching Package* (QATP) [77, 78]. The conceptual framework of this study is presented in Figure 1.

While learning chemistry/science, mastery of concepts will be enhanced if students' misconceptions can be detected and changed. However, conceptual change truly depends on the students themselves. According to [79] conceptual changes involve the students recognizing their existing ideas, evaluating these ideas, and making their own decision on whether to reconstruct the existing ideas. Among the strategies to promote conceptual change is cognitive conflict strategy suggested by [58] and [80]. Thus, the instructional model used in MyKimDG is the BSCS 5E Instructional Model designed to facilitate conceptual change [74]. This model involves phases of Engagement, Exploration, Explanation, Elaboration and Evaluation. According to [81], this model includes student experiences that (1) engage existing knowledge, (2) motivates students to ask questions about discrepant event, (3) encourages students to explore the unknown, (4) ask students to explain their thinking and new understandings discovered, and (5) allow students time to extend their understandings to new situations of their own interests.

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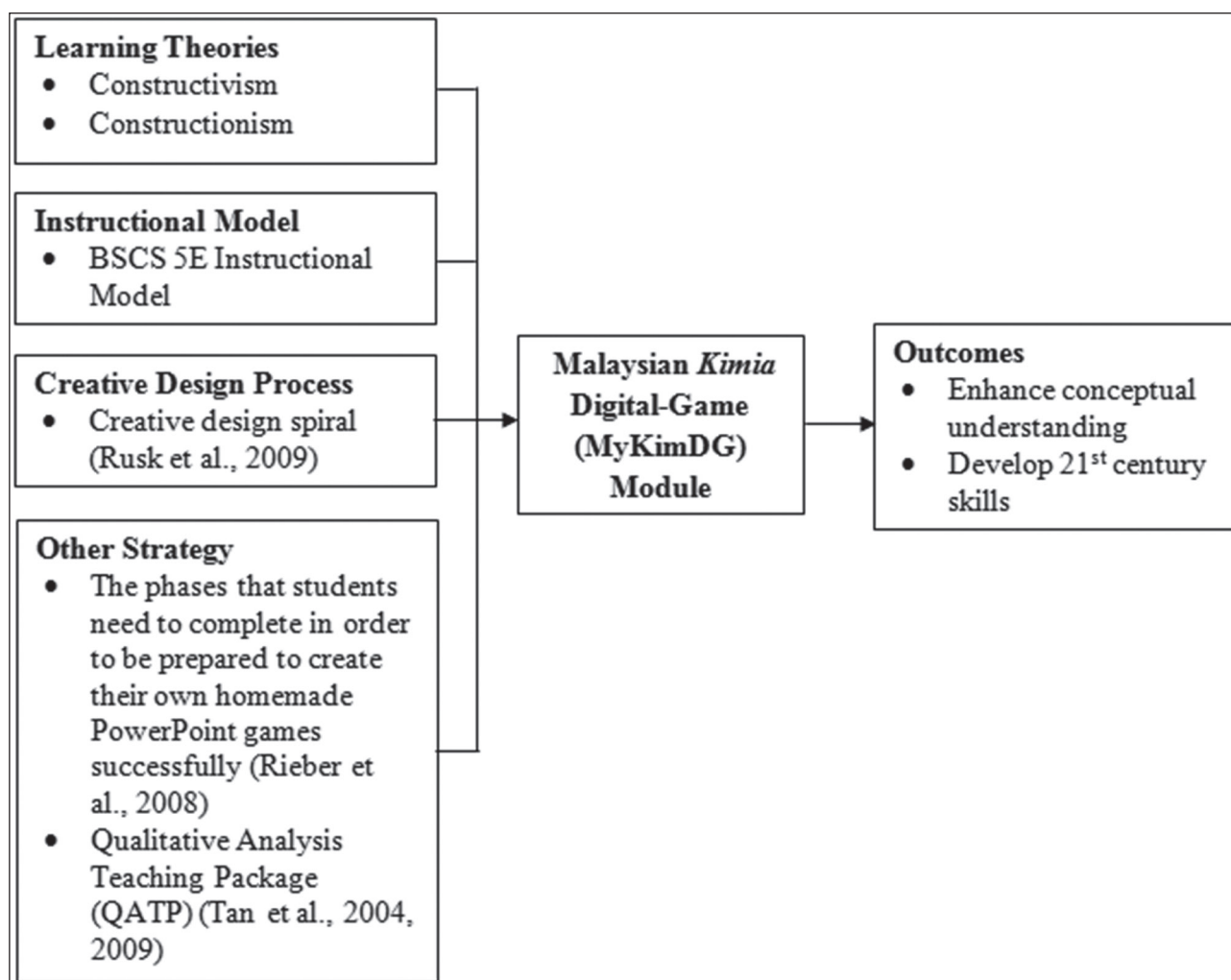


Figure 1. Conceptual framework of study

unknown, (4) ask students to explain their thinking and new understandings discovered, and (5) allow students time to extend their understandings to new situations of their own interests.

To help students understand the physical and chemical changes involved in the Salt chapter, students are guided to explain macroscopic experience at the sub-microscopic and symbolic levels. In this study, the authors have modified the activities in *Qualitative Analysis Teaching Package* (QATP) [77, 78] and integrated learning activities through designing of digital games in a phase that is suitable. With this strategy, students can observe the phenomenon at the macroscopic level, represent the phenomena at the sub-microscopic level via digital games, and explain the phenomenon at symbolic level using chemical equation. The triplet relationship is the key model in chemistry education [82].

Microsoft *PowerPoint* software is used to design digital games. This software was selected as

the software is available at all schools and the use of *MS PowerPoint* does not involve additional cost and complicated programming languages. Existing templates of digital games can be obtained with ease online and can be modified by the teacher. This will indirectly help teachers acquire skills to design digital games in stages. To help students master the skills to design *PowerPoint* games, the development phases of helping students design *PowerPoint* games proposed by [76] is used as a guide. In the early stages, students played existing games. Afterwards, they were asked to modify the existing games. In the end, students design games in groups. However, students are also encouraged to use other software like *Game Maker* and programming languages such as *Java*, *Logo* and *Scratch* if they are skilled in the software.

While students carry out the digital game designing project, they are guided to experience the creative design spiral by [75]. In this process, they

imagine the design of the game, create the game based on their ideas, experiment with alternatives, share their ideas and creations with others, and reflect on their experiences. If this process is experienced repeatedly, new ideas are always generated and developed. Students are expected to practice it continually and make it their daily culture.

6. Implementation of MyKimDG

In the following section, the authors present a brief lesson in MyKimDG to the teaching and learning of a specific unit (i.e. identification of anions) in the chapter of Salt which involved precipitation reaction.

Phase I: Engagement

1. Teacher shows discrepant events.
2. Students make observations and explain the phenomena at the microscopic and symbolic levels.
3. Students discuss in groups and compare their ideas with their peers.

Activity 1:

Aqueous Solution	Procedure	Observation	What happened?	Chemical Equation
Sodium nitrate	Pour 2 cm ³ of sodium nitrate solution into a test tube. Add 2 cm ³ of dilute hydrochloric acid.			
Sodium carbonate	Pour 2 cm ³ of sodium carbonate solution into a test tube. Add 2 cm ³ of dilute hydrochloric acid.			

Activity 2:

Aqueous Solution	Procedure	Observation	What happened?	Chemical Equation
Sodium nitrate	Pour 2 cm ³ of sodium nitrate solution into a test tube. Add 2 cm ³ of barium chloride solution. Add dilute hydrochloric acid until there is no further change.			
Sodium carbonate	Pour 2 cm ³ of sodium carbonate solution into a test tube. Add 2 cm ³ of barium chloride solution. Add dilute hydrochloric acid until there is no further change.			

Phase II: Exploration and Explanation

1. Students perform hands-on and minds-on activities in groups. (Note: At the same time, students practise the skills needed in the activities.)
2. Students are encouraged to engage in discussions and information seeking.
3. Students generate an explanation of each phenomenon.
4. Students are asked to report back with their findings.
5. Students also listen to the teacher's explanations. The key concepts involved are described with computer animation.
6. Students compare their ideas with the teacher's explanations.

Testing for carbonate ion

Activity 3: Repeat Activity 1 using dilute nitric acid.

Activity 4: Repeat Activity 2 using barium nitrate solution and dilute nitric acid.

Based on Activity 1 - 4, state the tests for carbonate ion.

Testing for sulphate ion

Activity 5:

Aqueous Solution	Procedure	Observation	What happened?	Chemical Equation
Sodium nitrate	Pour 2 cm ³ of sodium nitrate solution into a test tube. Add dilute hydrochloric acid until there is no further change. Add 2 cm ³ of barium chloride solution.			
Sodium sulphate	Pour 2 cm ³ of sodium sulphate solution into a test tube. Add dilute hydrochloric acid until there is no further change. Add 2 cm ³ of barium chloride solution.			

Activity 6: Repeat Activity 5 using dilute nitric acid and barium nitrate solution.

Activity 7:

Aqueous Solution	Procedure	Observation	What happened?	Chemical Equation
Potassium nitrate	Pour 2 cm ³ of potassium nitrate solution into a test tube. Add dilute hydrochloric acid until there is no further change. Add 2 cm ³ of barium chloride solution.			
Potassium sulphate	Pour 2 cm ³ of potassium sulphate solution into a test tube. Add dilute hydrochloric acid until there is no further change. Add 2 cm ³ of barium chloride solution.			

Activity 8: Repeat Activity 7 using dilute nitric acid and barium nitrate solution.

Based on Activity 5-8, what are the solutions that may be used to identify sulphate ion?

Testing for chloride ion

Activity 9:

Aqueous Solution	Procedure	Observation	What happened?	Chemical Equation
Sodium nitrate	Pour 2 cm ³ of sodium nitrate solution into a test tube. Add dilute nitric acid until there is no further change. Add 2 cm ³ of silver nitrate solution.			
Sodium chloride	Pour 2 cm ³ of sodium chloride solution into a test tube. Add dilute nitric acid until there is no further change. Add 2 cm ³ of silver nitrate solution.			

Activity 10: Repeat procedures in Activity 9.

Based on Activity 9 and 10, what are the solutions that may be used to identify chloride ion?

Testing for nitrate ion

Activity 11:

Aqueous Solution	Procedure	Observation	What happened?	Chemical Equation
Sodium nitrate	Pour 2 cm ³ of sodium nitrate into a test tube. Add 2 cm ³ of dilute sulphuric acid. Add 2 cm ³ of iron(II) sulphate solution. Shake to mix well. Carefully add concentrated sulphuric acid down the side of the test tube.			

Activity 12: Repeat procedures in Activity 11.

Based on Activity 11 and 12, what are the solutions that may be used to identify chloride ion?

Activity 13: Summarise the tests used to identify anions in aqueous salt solutions in the following table.

Anion	Procedure	Observation	Chemical Equation
Carbonate ion, CO_3^{2-}			
Sulphate ion, SO_4^{2-}			
Chloride ion, Cl^-			
Nitrate ion, NO_3^-			

In the test for sulphate ion, chloride ion and nitrate ion, why must the solution be acidified first before adding other reagents?

Activity 14:

- In the test for carbonate ion,
 - if barium chloride solution is added, it will be followed by dilute _____ acid.
 - if barium nitrate solution is added, it will be followed by dilute _____ acid.
- In the test for sulphate ion,
 - if dilute _____ acid is added, it will be followed by barium chloride solution.
 - if dilute _____ acid is added, it will be followed by barium nitrate solution.
- In the test for chloride ion, dilute _____ acid is added, followed by silver nitrate solution.

Do you see a trend in the dilute acid used? Does the trend matter? Plan your own experiments to find out the answer.

Phase III: Elaboration

- Students play a game related to the precipitation reactions involved in the testing for anions.
- Students are asked to differentiate between a good game and a bad game.
- Students are asked to improve the game they played to make it more educational and entertaining following steps of the creative design process, in order to help their peers or juniors who face difficulty in learning the concept.
 - Imagine:** Students brainstorm the design of the game in groups and select a favourite design from their brainstorming session and sketch their chosen design.
 - Create:** Students create their designs using *PowerPoint*.
 - Experiment:** Students are encouraged to test frequently and think critically about their designs, and rebuild as needed.
 - Share:** Students share their designs and digital games and get input from other groups.
 - Reflect:** Students describe the key strengths and weaknesses of their designs and digital games.
 - Improve:** Students are asked to create their own digital game in groups that incorporates the best aspects of all the designs, as well as improvements suggested through testing.

Phase IV: Evaluation

- Students are asked to plan experiments to identify anion in unknown salts.
- Students reflect upon the extent to which their understanding, abilities and competencies have changed

7. Conclusion

In MyKimDG, students are given tasks to design digital games using ICT to teach their peers who face problems in the Salt chapter. They collaborate in groups and apply chemistry knowledge learned to design *PowerPoint* digital games. Students are given the autonomy to choose their own digital game design ideas, plan and implement their plans based on the decisions achieved in the group. Group members help each other and act as co-constructors of knowledge. During the group discussion, the misconception that they have may be manifested. This approach gives students the opportunity to evaluate their knowledge and make their own decisions whether to reconstruct the existing knowledge. This strategy involves active learning, collaboration and discovery. Students will gain deeper understanding of Chemistry knowledge learnt.

The activities of MyKimDG involve higher order thinking skills but can be solved with reasonable diligence and if guidance is given to students. Success in completing a project will encourage students to continue making sophisticated explorations and ultimately lead to greater intellectual development. In addition, students will also gain knowledge from other fields because design projects often involve knowledge from various disciplines such as Science, Technology, Arts, Engineering and Mathematics (STEAM). Thus, MyKimDG can further enhance mastery of chemistry knowledge (and STEM knowledge in general) and at the same time providing opportunity for students to practice the 21st century skills in the real world. Knowledge and skills acquired are expected to be useful in life or future workplace.

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Effects of proprioceptive and strength training on improving precision in student population

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Abstract

The aim of this study was to determine effects of proprioceptive and strength training on improving precision in student population. A prospective randomised study with repeated measures design was conducted at the Faculty of Sport and Physical Education of the University of Sarajevo and consisted 39 units of training during a 15-week period. The study included a total of 44 male students aged 19-23 years, categorized in two groups. Group 1 ($n=22$) were students who had proprioceptive training (15 weeks, 3 times per week); Group 2 ($n=22$) were students who had a program that was primarily focused on the strength training (15 weeks, 3 times per week). Outcome measures were: hand aiming at the horizontal target, leg aiming at the vertical target and picado. The paired-samples t-test is used to determine whether the mean difference between paired observations is statistically significantly different from zero. Significance of intergroup differences was tested for the left or right limbs, using separate multivariate models (MANOVA). The proprioceptive training has beneficial effect on improving precision in picado for dominant side, compared with strength training ($\Lambda_{\text{Wilks}} = .796$; $F_{3,40} = 3.422$; $p = .026$; $\eta_p^2 = .204$), but not in the hand aiming at the horizontal target and leg aiming at the vertical target. There was not a statistically significant difference in improving precision of non-dominant side between two groups ($\Lambda_{\text{Wilks}} = .908$; $F_{3,40} = 1.349$; $p = .272$; $\eta_p^2 = .092$). A proprioceptive training is very important instrument for improving of physical performances in field of precision and it should become an integral part of the training of elite athletes.

Key words: proprioceptive training, strength training, precision, multivariate analysis

Introduction

The fundamental objectives of the transformation process in sport are quantitative changes

in abilities, characteristics and knowledge. The term „quantitative changes“ means any significant change in the level of development of particular skills or qualities and the level of acquired motor skills, regardless of the direction (positive or negative) of these changes. Transformation processes can be focused on the development of functional abilities (cardiorespiratory, anaerobic capacity etc.), but also on the development of neuromuscular efficiency in the field of measuring strength, speed, coordination, agility, balance and flexibility. Precision is the ability to perform properly dosed movements with important assessment in space and time. Also, it is defined as a motor ability to hit the target by a guided, thrown, struck or launched object [1]. Precision is manifested in hitting the target or conduct of an object to a destination which is located at some distance [2]. This motor ability depends greatly on inheritance with coefficient about .80. Two factors of precision were obtained after hierarchical structure of motor space [3]: precision with targeting or leading missiles to target and precision with shooting or throwing missiles to the target. For increase the accuracy of upper extremities it is necessary to practice precision with left or right hand. The same rule applies for the accuracy of the lower extremities, it is necessary to practice left and right foot [4]. Research in the field of precision is the least explored segment of the motor space [5]. Speed, strength, endurance and flexibility are the abilities studied more often and presented in earlier literature together with the methods for their improvement, while the study of precision was put aside [6].

In this study, we evaluated effects of proprioceptive and strength training on improving precision.

Materials and methods

A prospective randomised study with repeated measures design was conducted at the Faculty of

Sport and Physical Education of the University of Sarajevo and consisted 39 units of training during a 15-week period. The study included a total of 44 male students aged 19-23 years, categorized in two groups. Group 1 ($n=22$) were students who had proprioceptive training (15 weeks, 3 times per week); Group 2 ($n=22$) were students who had strength training that was primarily focused on the development of absolute muscle power (15 weeks, 3 times per week). Precision was assessed with following variables: hand aiming at the horizontal target, leg aiming at the vertical target and picado. Tests for the estimation of precision were taken from [7]. All tests of precision were administered both by the right and left hand (leg) and were assessed baseline and after 15-week exercise program. Results are expressed as mean value and standard deviation in case of normal distributed continuous variables, as median and IQR in case of non-normal distributed continuous variables. The Kolmogorov–Smirnov statistic with a Lilliefors significance level was used for testing normality. The paired-samples t-test is used to determine whether the mean difference between paired observations is statistically significantly different from zero. Significance of intergroup differences was tested for the left or right limbs, using separate multivariate models (MANOVA). A p-value <0.05 was considered as significant and Bonferroni correction was applied. Statistical analysis was performed by using the Statistical Package for the Social Sciences (SPSS Release 16.0; SPSS Inc., Chicago, Illinois, United States of America) software.

Results

For the non-dominant side, there was a statistically significant difference in mean of precision

in leg aiming at the vertical target measured baseline ($M = 1.29 \pm .71$) and after 15-week exercise program ($M = 1.98 \pm 1.11$), $t(21) = 2.788$, $p < 0.05$, $d = 0.594$ in group 1.

There was not a statistically significant difference in mean of precision in hand aiming at the horizontal target and picado in Group 1. There was a statistically significant difference in mean of precision in hand aiming at the horizontal target measured baseline ($M = 2.86 \pm .69$) and after 15-week exercise program ($M = 3.42 \pm .89$), $t(21) = 3.236$, $p < 0.01$, $d = 0.690$ and leg aiming at the vertical target measured baseline ($M = 1.36 \pm .99$) and after 15-week exercise program ($M = 2.11 \pm 1.29$), $t(21) = 2.2981$, $p < 0.01$, $d = 0.636$ in group 2. There was not a statistically significant difference in mean of precision in picado in group 2 (Table 1). There was not a statistically significant difference in improving precision of non-dominant side between two groups ($\Lambda_{\text{Wilks}} = .908$; $F_{3,40} = 1.349$; $p = .272$; $\eta^2_p = .092$).

For the dominant side, there was a statistically significant difference in mean of precision in hand aiming at the horizontal target measured baseline ($M = 3.12 \pm .94$) and after 15-week exercise program ($M = 3.82 \pm .78$), $t(21) = 3.004$, $p < 0.01$, $d = 0.640$; leg aiming at the vertical target measured baseline ($M = 1.48 \pm .81$) and after 15-week exercise program ($M = 2.15 \pm .99$), $t(21) = 3.240$, $p < 0.01$, $d = 0.691$ and picado measured baseline ($M = 5.23 \pm 1.37$) and after 15-week exercise program ($M = 6.02 \pm 1.49$), $t(21) = 3.371$, $p < 0.01$, $d = 0.719$ in group 1. Also, there was a statistically significant difference in mean of precision in hand aiming at the horizontal target measured baseline ($M = 2.95 \pm 1.14$) and after 15-week exercise program ($M = 3.77 \pm .89$), $t(21) = 2.999$, $p < 0.01$, $d = 0.639$; in group 2 (Table 2).

Table 1. Precision of non-dominant side of the body at start and after 15 weeks in two groups

	baseline		after 15 weeks		difference		t(21)	p	d
	M	SD	M	SD	M	SD			
<i>Group 1</i>									
hand aiming at the horizontal target	2.91	.95	3.03	1.02	.12	.95	.598	.557	.127
leg aiming at the vertical target	1.29	.71	1.98	1.11	.70	1.17	2.788	.011	.594
picado	4.85	1.90	4.95	1.59	.11	2.12	.234	.817	.050
<i>Group 2</i>									
hand aiming at the horizontal target	2.86	.69	3.42	.89	.56	0.81	3.236	.004	.690
leg aiming at the vertical target	1.36	.99	2.11	1.29	.74	1.17	2.981	.007	.636
picado	5.38	1.52	4.82	1.61	-.56	1.94	-1.358	.189	.289

Table 2. Precision of dominant side of the body at start and after 15 weeks in two groups

	baseline		after 15 weeks		difference		t(21)	p	d
	M	SD	M	SD	M	SD			
<i>Group 1</i>									
hand aiming at the horizontal target	3.12	.94	3.82	.78	.70	1.09	3.004	.007	.640
leg aiming at the vertical target	1.48	.81	2.15	.99	.67	.97	3.240	.004	.691
picado	5.23	1.37	6.02	1.49	.79	1.10	3.371	.003	.719
<i>Group 2</i>									
hand aiming at the horizontal target	2.95	1.14	3.77	.89	.82	1.28	2.999	.007	.639
leg aiming at the vertical target	1.77	1.01	2.26	.88	.48	1.33	1.712	.102	.365
picado	5.83	1.21	5.39	1.23	-.44	1.63	-1.264	.220	.269

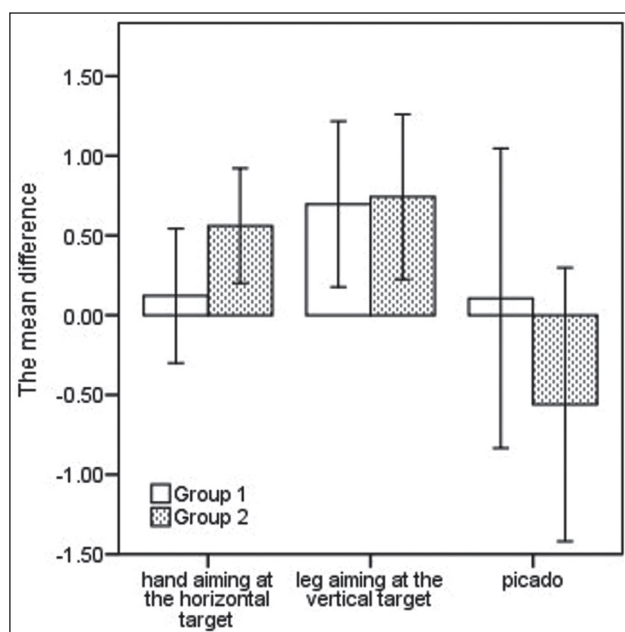


Figure 1. The mean difference of variables for precision for non-dominant side measured baseline and after 15-week exercise program in group 1 (proprioceptive training) and group 2 (strength training).

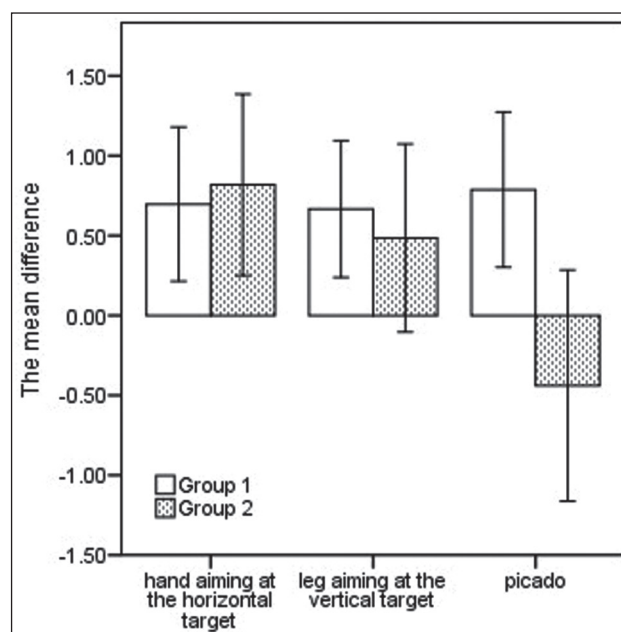


Figure 2. The mean difference of variables for precision for dominant side measured baseline and after 15-week exercise program in group 1 (proprioceptive training) and group 2 (strength training).

The proprioceptive training has beneficial effect on improving precision in picado for dominant side, compared with strength training ($\Lambda_{Wilks} = .796$; $F_{3,40} = 3.422$; $p = .026$; $\eta^2_p = .204$), but not in the hand aiming at the horizontal target and leg aiming at the vertical target (Table 3).

Discussion

In this prospective study we found that both programs, proprioceptive and strength training were effective in improving certain variables of precision. By multivariate analysis, we found that proprioceptive training has beneficial effect on improving precision in picado for dominant side compared with

Table 3. Effects of two programs on improving precision of dominant side

	SS	F _{1,42}	p	η^2_p
hand aiming at the horizontal target	.162	.115	.737	.003
leg aiming at the vertical target	.364	.270	.606	.006
picado	16.568	8.581	.005	.170

strength training. In the study of Joksimović et al. [8], there were investigated the relations and differences in cognitive abilities and precision in skiers and soccer players. Differences were observed in the tests: picado by the right hand, ($p = .001$), picado by the left hand ($p = .005$), right leg aiming at the vertical target ($p = .012$) and right hand aiming at the horizontal target ($p = .013$). In the remaining variables (left hand aiming at the horizontal target and left leg aiming at the vertical target) no statistically significant differences were found. In the study of Authors [9,7] pointed to precision in an effort to define the entire space of motor skills. The common conclusion on the basis of which precision was appointed as a factor is that it can be called so but only with caution, given the insufficient number. Fleishman 1954 [10] found two out of ten isolated factors which could explain the precise movements. One was related to the ability to control arms in the targeting and the author called it »hands« skills. The other factor is the »strength of arms and hands«, which was obtained from the task in which a safe hand movement, with the minimum power and minimum speed manifest is to be obtained. Ferrauti & Bastiaens 2007 [11] were investigate the acute effects of a complex throwing intervention set-up, with light or heavy loads, on the service velocity of elite junior tennis players. In a cross-over design, the players performed respectively 6, 4 and 2 maximum effort throws with a 200 g ball (LI, light intervention), 6, 4 and 2 maximum effort throws with a 600 g ball (HI, heavy intervention) and no throws (NI, no intervention) during the 2 min in between-set period. Service precision and service touch were unaffected by the interventions.

Conclusion

A proprioceptive training achieved a statistically significant increasing of the precision in picado of the dominant limb compared with strength training, but not in the hand aiming at the horizontal target and leg aiming at the vertical target. There was not a statistically significant difference in improving precision of non-dominant side between two groups. A proprioceptive training is very important instrument for improving of physical performances and it should become an integral part of the training of elite athletes.

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Cooperative learning in teaching

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Abstract

Collaborative learning is one of the modern ways of teaching and learning and it's getting more presented in the classroom. Modern school requires modern methods of teaching and learning, so we thought it was very useful for teaching practice to perform the research on the application of just this form of learning. We conducted research and we wanted to establish how collaborative learning are represented in teaching and what are the prospects of the practice as well as students interested in this form of learning and how much it facilitates the learning process. The teacher is able to present their work, to clearly express their views and opinions and thus becomes part of the active community. Each of us has a tendency toward further development and progress in order to build a complete personality, aspiring lifelong educational attainment. The task or intention of a teacher should be to better teach students and encourage them to connection. It is important for children to make clear that only when we work together, when we have each other on the available and when we strive for just such a positive direction in life, then we become richer for a couple of invaluable qualities that will be our guides to the creation of the entire personality.

Key words: collaborative learning, teaching, school, strategy, complete personality of students.

1. Introduction

Traditional teaching is still used in most of our schools. In such teaching teacher has a dominant role and the teaching itself is frontal and solid forms. The teacher teaches the students while they are sitting on chairs backs to each other. In this type of teaching, participation and activity of students is reduced to listening, recording and watching. What teacher intentionally or unintentionally works, serves as a model for the students, so-called. hidden curriculum [1]. One lesson is timed at 45 minutes with a strictly specified articulation lesson: preparation, presentation, exercising, revising and testing.

Modern society demands a school that is oriented towards a student but also his needs. In such a modern school of potential use and application of modern didactic strategies, by which students become independent and include teaching. Creating different methodological scenario teacher is possible just by choosing modern didactic strategy. We get this improved the quality of teaching, increased motivation and interest in students but is quite apparent research curiosity in students.

The student only after you gain some experience, we can say, that he teaches. In the center of the educational process we bring in our daily lives as well as students in this way do not learn passively, but they discover and observe the world around them. Collaborative learning involves learning where all students in the group equally important and it is this fact to them is a pleasure. The introduction of this form of work in classes encourage students to cooperate and assist in the everydaylife outside the classroom.

2. Theoretical part

2.1. Cooperative learning

The teaching process consists of the teacher and the students while they are connected to each other by preparing classes, work and evaluating the results obtained by this work.

Teacher and students are in constant interaction. Good organization of cooperative learning, the teacher can to create such conditions in which to develop cognitive, conative and psychomotor aspect of the personality of each child [2]. They try to make the teaching more interesting, richer in content, quality and age appropriate students with different forms and methods of work. The use of modern didactic strategies is possible in the teaching that is oriented towards students. Teaching oriented towards student tends independence of students in the teaching process. These are the active learning strategies.

Cooperative learning referred to as the set of strategies established to allow effective acquisition of academic knowledge and skills, and social skills [3]. In order to learn successfully, they say that first of all the whole group should be well motivated and have clearly defined task and rules by which to solve the problem. Each individual group is responsible for the success of the group, as well as for your own success within the group.

Cooperative learning is today identified with the team. These are two different things that can have common characteristics. In one group of students can work together, a collaborative group can function as teams. It is good to use cooperative learning when learning a complex skill that has more correct answers.

2.1.1 The elements of cooperative learning

Eric Jensen, in his book "Super-classes" lists five elements of cooperative learning [4]:

1. The positive interdependence - success requires that students be aware that depend on each other. They must realize that for their success or failure is responsible all the members of their group. This should mean to them, and be an incentive not to give up and to take as much effort in order to achieve better results.
2. Direct interaction – students always have to communicate, discuss the problem, to find possible ways of its solution, help each other and correct possible mistakes.
3. Individual and collective responsibility – when forming the group and its members determine the next step is to assign tasks to each of its members. It is important that each member of the group has its own task and responsibility. Successfully solved members lead to the achievement of a group.
4. The collaborative skills - skills that are selected for teaching depend on the age of students. Some of them are: the use of magical words in all situations, evaluating oneself and others, good behavior, conflict resolution, decision making, communication
5. Group processing - during group discussions students best assess the quality of work on the task and behavior within the group.

2.1.2 The advantages of cooperative learning

Collins, A. and Hardship and Peace reported two fundamental advantages of cooperative learning [5]:

- Helps to develop problem solving abilities and powers of deduction
- Improving relations between members of the group and their own self-esteem
- Cooperative learning improves learning outcomes. Meredih, HP, Steele, JL, Temple, C. reported the following results of participation in collaborative learning [6]:
 - Better success and prolonged memorizing,
 - Often higher order thinking, deeper understanding and critical thinking,
 - Focused work in the department and less indiscipline,
 - Greater motivation to better grades and learning,
 - Greater ability to consider the situation from someone else's perspective
 - Positive, tolerant and friendly relations with peers, teachers.
 - Greater social support,
 - Better adjustment and well-being,
 - Positive attitudes towards oneself,
 - Greater social competence,
 - Positive attitudes toward objects, learning and school.

3. Empirical part

3.1. The selection and formulation of research problem

Today, in literature is emphasized, with good reason, the issue of a cooperative, interactive and collaborative learning in general. Unfortunately, there is in most of our schools, the teaching educational process, practiced and carried out the traditional form of teaching in which is mainly used frontal form. In these schools apply a standard teaching resources and they do not striving towards the changes and development of the teaching process. From all this we can conclude that the teacher is largely the subject of the teaching process, and therefore has a dominant role in the teaching process, and the student is most object

of the teaching process and plays a role passive observer and listener. In this teaching, student activity that listens, observes and records. In this way, undermines the creativity of students and pushes his independence in every aspect of its development [7]. This problem is especially evident in primary school students. This is very bad because it is crucial that year and represent the first step towards the full development of the child in a comprehensive and built personality. Teaching should be filled with a variety of creative ideas and wisecracks, active participation and active learning students, and this is best achieved cooperative learning and teaching approach. Cooperative learning in class will serve as an “example of good practice” to overcome this problem. What really hidden behind this “example of good practice” is the question that we have set for ourselves after reading certain literature. A school that is not anthropocentric oriented, stiff and inflexible teaching that does not allow the student to develop the multiple, positive, free and independent personality on the one hand, and this “Example of good practice” on the other hand, have led to the problems that we have formulated in the following way: **Cooperative learning in the classroom.**

3.2. The research questions

1. Do teachers apply cooperative learning in the classroom and to what extent?
2. What are the most common methods of cooperative learning in their work?
3. What are the advantages of cooperative approaches to teaching that teachers have observed?
4. What difficulties do have in the application of cooperative learning in the classroom?
5. What are the changes in terms of motivation, communication and learning outcomes observed in students as a result of the application of cooperative learning?
6. In what extent the application of cooperative approaches to contributing to the increasing social and emotional competencies of students?
7. How does the application of cooperative learning impact on reducing the negative consequences in the classroom?

3.3. Defining the research problem

The wording referred to our work “Cooperative learning in the classroom” refer to the way of defining the research problem. Our research will take the form of case studies, because this problem is “example of good practice”. This would mean that we will study carried out only in the classroom and that we based on the results of observation of different situations and cases will be able to draw certain conclusions. The research topic would be: Cooperative learning in the classroom, and to our research problem could be the use of modern methodological approaches and procedures and their impact on the implementation of cooperative learning in the classroom.

3.4. The aim and objectives of research

The aim of this study was to examine the attitudes of teachers and students when it comes to cooperative learning in the classroom, and that access to and to what extent affects the growth of socio-emotional competencies students. We will also examine whether modern methodological procedures affecting the implementation and application of cooperative learning in the classroom.

To realize these objectives, it is necessary to perform the following research tasks:

1. Getting to the important data on the results of the application of cooperative learning in the classroom;
2. A brief overview of some important studies that are closely related to my topic;
3. A brief review of the socio-emotional climate and competencies in the classroom;
4. The design and selection of survey questions and studying pedagogical documentation means that I will solve the problem of the application of cooperative learning in the classroom, and observe the advantages and disadvantages of using these teaching strategies in the classroom;
5. Qualitatively analysis of data;
6. Extraction of research data;
7. Presentation of research results.

3.5. Setting hypothesis of the research

H1: Cooperative learning is most present in the classroom.

H2: Cooperative learning is achieved through application of modern methodological procedures.

H3: Cooperative learning in the classroom contributes to increasing socio-emotional competencies of students.

3.6. Methods of Research

As a basic research method we will use *empirical non-experimental method* or called *Servej method*. This method is most reliable for getting honest opinions, attitudes and reliable knowledge about a problem.

In the research we will use *the method of theoretical analysis* and *analytical-descriptive method*, which is a set of scientific research methods that describe the phenomenon in education. The essence of this method is to introduce pedagogical reality as it is in the current situation.

3.7. Techniques and instruments of research

In this work we will use the survey, scaling and work on the study of pedagogical documentation, as well as techniques of research. They will help us on the analysis of the available literature survey the problem of application of cooperative learning in the classroom, and that we see the advantages and disadvantages of using these teaching strategies in our schools. We will use anonymous questionnaires to avoid disingenuous answer, especially when it comes to some sensitive issues and questions that interviewers are afraid that their response to them could have negative consequences. In the research we used a survey for teachers, which contains questions in accordance with the objectives, requirements and research hypotheses. We have chosen the scale of attitudes for self-assessment activities for students. Students should to evaluate their activity in classes with the use of descriptive numerical scale of one to five (answers to questions: strongly agree, agree, and disagree, strongly disagree). It is impossible to directly monitor the experience and opinion, so I'll questionnaire to get to this information.

Example of survey questions for teachers:

1. Please indicate in which class and school subject most often apply cooperative learning?
2. In your opinion, if students demonstrate more interest and motivation to work in the classes when you apply cooperative learning?
3. How often do you apply cooperative learning in teaching the Bosnian Croatian and Serbian language?
4. Do you think that your students communicate freely and openly when you apply a cooperative approach to teaching languages the Bosnian Croatian and Serbian language?
5. How often do you apply cooperative learning in teaching process in Science?
6. Please, specify which methods of cooperative learning apply teaching process in Science.
7. In the Bosnian Croatian and Serbian language teaching is more often applied cooperative learning than in the teaching process other subjects.
8. Which Curriculum subjects do offer the most opportunities for the application of cooperative learning?
9. Please, indicate which difficulties have you in applying the cooperative approach in teaching mathematics.
10. Are cooperative learning and modern approaches to learning unnecessary in teaching and work?

Characteristics of the survey for teachers are following:

- The survey will be open or closed. This means that the respondents be asked and would respond with more choice, such as for example: “yes”, “no”; “Often,” “sometimes,” “rarely”, and on certain issues will be offered answers you will yourself to write your answer in the form of sentences.
- The survey will be anonymous - so answers will be honest and reliable.

3.8. The research sample

The only criterion for the selection of the sample will be “example of good practice” to help us overcome the traditional and stiff teaching that is not oriented to the child. Therefore, our sample

survey will be teachers and students as “example of good practice”. The survey involved 12 teachers from elementary school “Aleksa Santic” and 50 students III and IV grade.

4. Results of research

Results of the scale attitudes are the following (Table 1).

According to the semantic differential scales of attitudes we see that slightly less than half of the respondents completely agree with the statement that they learn faster and better when working in groups or pairs, than working alone. The same is and for the statement:

When we working in a group we always appreciate suggestions of his friends. From these answers students we can begin to understand the socio-emotional climate in their classroom and what is their

relationship to each other as well as the teacher. It was also shown that they prefer to work in groups or pairs and thus more teaching contents adopt in contrast to frontal work. The students did not agree with the statement when they work in a group, only one student works on the task while others talk about. This show an interest and desire to work in certain content but also a healthy competitive spirit when it comes to knowledge.

More than half of the students (54% of respondents) fully agreed with the statement that like to cooperate with friends on a task. So they feel freer in expressing their opinions and attitudes, especially students who are withdrawn and have a problem in communicating with others. They also agreed that they are more interesting to work in all groups than when the whole class works the same topic. Of course, as with everything, there is always the students who find some other way and

Table 1. Scale attitudes

Number	ASSERTION	I completely agree	I agree	I agree and disagree	I agree and disagree	Totally disagree
1	Faster and better learn when working in groups or pairs, than I do alone	42%	38%	8%	6%	6%
2	When I work in a group always appreciate suggestions your friends	46%	22%	28%	4%	0%
3	When we work in a group,only someone always doeswhile others talk	2%	2%	2%	18%	76%
4	I like working with partners in a task	54%	36%	8%	2%	0%
5	It's more interesting when all of us do in groups, than whole class does the same theme	42%	20%	14%	0%	24%
6	When we work in groups, all of us try that our group is the best	70%	18%	8%	0%	4%
7	Our group always makes the same students	6%	4%	12%	36%	42%
8	We are very united when we work in a group	48%	20%	20%	6%	6%
9	Colleagues from the group don't allow me to state my views	4%	8%	14%	22%	52%
10	In class of Science, we usually work in groups	12%	18%	50%	14%	6%
11	we adoptbetter the content of math when we work in groups	16%	8%	18%	22%	36%
12	I prefer working in groups and work in pairs than frontal work	40%	12%	30%	6%	12%

style of work of teachers. In this case, almost half totally agree with the above statement.

Working in groups and pairs usually as I have already stated, some form of competitive learning vision. This is confirmed by the statement: When we work in groups, we all try to be the best our group, with which it agreed 70% of students. The teacher should explain to students that the more important the quality of the performed tasks and not speed in solving as well as poor relations which may be produced by the desire to “victory “. if they want to compete and it is the best, then let it is for knowledge and quality of writing. The positive thing we can conclude from this scale of attitudes is that the students disagreed that their group always make the same students. That’s good, because students will so come in contact with each other and get to know, complement and correct each other.

With the statement: We are very united when we work in a group to completely agreed 48% of the students, and that their colleagues in the group do not allow to say does not agree. From this it is clear their relationship and how they see each other. Science is a subject in which, for half of the students, the easiest to accomplish this type of work, which shows the result of the scale of attitudes. As for mathematics, students disagreed that they acquire interesting content in mathematics, working in groups, as seen from the results of the scale. In education, the interdisciplinary approach is reflected in the linking of subjects common topics, or in the correlation and integration approach to lesson learning [8].

At the end of this test, we can see that students work in pairs and small groups interestingly than frontal work. A survey conducted in 12 teacher in third, fourth and fifth grade given the following results:

Question: Which of the subject most frequently used cooperative learning I received this answer: Science, Mathematics, Bosnian, Croatian and Serbian language. Teachers are the most emphasized Science. The reason may be the diversity of content and the possibility of better adoption of certain topics.

Do students show more interest and motivation to work at class when applied cooperative learning, all agreed that it depends on the topic and tasks. Teachers decide whether cooperative learning good vision

of work at the individual curricula and depending on him and used. Surely they have seen its benefits and therefore used this way of working learning [9].

Teachers often apply cooperative learning in the teaching of the Bosnian, Croatian and Serbian language and literature as reflected in their answers to the survey. They were also in agreement with that to their students freely and openly communicate when you apply cooperative learning in the teaching of the Bosnian, Croatian and Serbian languages and literature. In this way they all students have the opportunity to discuss the content, give their opinion and to express his position on this. The applicability of cooperative learning in the teaching of Science is large and is applied more often than the other subjects.

Methods of cooperative learning that teachers use in the teaching of Science are the following: the method of independent work, demonstration, dialogical method, experimental method, illustrations, work in pairs, mind map, and methods that include most of the children in active work. In teaching the Bosnian, Croatian and Serbian language and literature applies cooperative learning but not so much as to other subjects, it is the opinion of the surveyed teacher. They emphasized on that Science and Bosnian, Croatian and Serbian language and literature courses that offer the most opportunities for the application of cooperative learning.

Difficulties in the application of cooperative approaches in teaching mathematics are inattention students, indiscipline, procure adequate teaching resources, decreased concentration. Finally, they agreed that cooperative learning and modern approaches to learning aren’t useless approaches to teaching and work.

5. Conclusion

Through the survey that we conducted, we concluded that cooperative learning in the classroom is not very strongly represented in the classroom and that is not practiced to the extent to which the achievements and results in learning have been visible. Cooperative learning encourages us to learn how to learn, to act in a group as one and that each of our success, hard work and dedication to be a stimulus and others to behave like this and understand the point of cooperative learning.

Especially the little ones who practice cooperative learning, who do not have time for that or those to whom it is just a waste of time and no result is not achieved. It is unfortunate that our education can not be changed in some slightly more diverse framework, but we are used to it and what individuals do not consider themselves sufficient to start a new way of teaching generation that will certainly accept everything they the more unusual ways to collect new information.

We believe that the group work in any its form will be much used in the future than it is today.

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Participants academic distance education - Case study

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Abstract

Organization of academic e-learning requires a university to prepare both technological background (including an education portal) and human resources. In the article, the authors focus only on the latter aspect, namely on the participants of remote education, i.e. knowledge providers and recipients of the education process. The article presents such issues as: accessibility and speed of Internet links, Information and Communication Technologies (ICT) barriers in the process of preparing resources and teaching e-learning courses, the issue of division of responsibilities between teachers and Information technology (IT) specialists as well as training courses for knowledge providers.

The authors of the article conducted surveys among students and university teachers concerning access and use of Internet resources to review their competencies and experience necessary for teaching remote classes. The paper is further based on practical experience gained by the authors while teaching courses in remote education as well as preparing, creating and teaching e-learning courses at three universities in Poznań.

Key words: distance education; academic education; e-learning; ICT; LCMS; Internet access

Introduction

Remote education requires its participants to meet certain initial criteria, i.e. to have the right competencies specified for the given educational role and to prepare hardware and software environment for its implementation. Participants of remote education are divided into knowledge providers and recipients (students represent the group of recipients considered in the article). The providers are those individuals who prepare teaching

materials, but not necessarily teaching classes and creating courses [1, 2] class teachers and organizers of the educational process at the university.

Each student being a recipient of remote education should have a computer with fast Internet link in order to have 24h access to their account on the e-learning portal where all teaching materials are made available, student-teacher communication takes place, knowledge is evaluated, team work is implemented, etc. Providers of educational contents, particularly those in charge of remote groups, must also have devices with Internet access. An e-learning portal is the highlight of remote education and an optimized solution in terms of protection of sensitive data (personal data, study results, etc.) and copyrights of educational content providers. Such an important safety feature is not guaranteed by public networking sites [3].

Completed Learning Content Management System (LCMS) portal deployment projects, long-term experience in designing, creating and preparing remote courses, and a number of training courses for knowledge providers have allowed the authors to distinguish certain key problems concerning participants of remote learning that must be recognized and resolved accordingly. This concerns both colleges and universities that already offer remote learning and those which only begin its implementation. These issues concern:

1. Internet access among recipients (and providers) in the remote learning process.
2. ICT barriers related to preparation and development of materials as well as use of a LCMS portal.
3. Collaboration between authors of learning materials/course teachers and the school's IT specialists.
4. Regular training for educational content provider groups.

With an efficient solution for each of these issues, the indispensable criteria for achieving positive effect of remote learning implementation will be met, accounting for the unique characteristics of teaching at the given school. This is quite important because remote teaching may become an important source of building the school's competitive advantage [4] while affecting the quality of teaching [5, 6], as well as students' skills and IT competencies [7].

Methods

The authors conducted research on access to the Internet and use of the World Wide Web among medicine ($n=467$) and IT students ($n=130$). IT students were divided by term of study: full-time ($n=56$, 43%) and part-time studies ($n=74$, 57%), while medicine students were divided by course language: Polish ($n=330$, 71%) and English ($n=137$, 29%). The research took the form of a survey during Academic Year 2012-2013.

A survey was also carried out among teachers at Poznań universities ($n=60$)—concerning their use of learning content building applications and participation in online courses and e-tests. The research covered two Academic Years: 2011-2012 and 2012-2013.

Teachers were divided into two groups:

- group A - persons who teach remote courses or are studying as teachers, and have completed a course in the field ($n=28$, 47%),
- group B - persons who have not applied and have no experience with remote methods but intend to teach e-learning courses in the future ($n=32$, 53%).

The practical conclusions presented in the article are also the result of the authors' collaboration with medical university employees (medical doctors of various specializations), lecturers at humanities and administration faculties as well as representatives of science (mathematics, information technology) during deployments and teaching remote classes.

Statistical methods

Unpaired data for 2x2 or larger contingency tables were analyzed using the Chi-square test for independence, the Chi-square test with Yate's cor-

rection or the Fisher-Freeman-Halton test, depending on observed frequencies. All results were considered significant at $p < .05$. Statistical analysis was performed using statistical packages of Statistica v. 10.0 (StatSoft, Inc.) or StatXact v. 8.0 (CytelStudio).

Results

1. Internet access among remote learning recipients and providers

In an e-learning portal, a student can access all teaching materials: text, graphics, multimedia, interactive knowledge evaluation, etc. All communication with the teacher during the course is via the LCMS portal (forum, e-mail, electronic duty hours, etc.). A student can and should take e-learning classes at a convenient time and take online tests and exams. They should also be able to trace their results, use databases of self-tests drafted by teachers and other revision resources. All this requires uninterrupted Internet access.

The results of the authors' survey among students give a positive view of their commitment to accessibility of Internet resources (Figure 1, Table 1), which in most cases is determined by non-educational needs (Table 2).

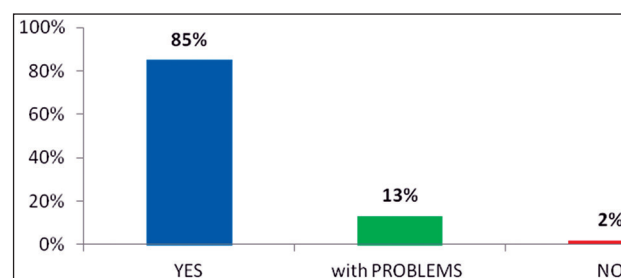


Figure 1. Permanent access to the Internet among students

Figure 2 presents the results concerning bandwidth of students' Internet connections. Figure 3 shows these results divided by field of study: IT, medicine.

Statistical analysis did not show significant differences in connection capacities between those IT and medicine students ($p=0.598$) who were aware of the bandwidth they had available. The number of persons who did not know their bandwidth parameters among medicine students (43%) differs significantly ($p<0.0001$) from the proportion of such

Table 1. Places of accessing the Internet by knowledge recipients

Where do you usually use the Internet?	Medicine students, language: Polish	Medicine students, language: English	IT students, language: Polish	p value
at home / in dormitory	98.5%	92.7%	99.2%	0.002
in library / at University	15.8%	40.9%	35.4%	< 0.000001
at an internet cafe	0.6%	7.3%	1.5%	0.0002
by mobile phone	32.7%	52.6%	62.3%	< 0.000001

Table 2. Types of information sought by students on the Internet

What kind of information do you look for on the Internet?	Medicine students, language: Polish	Medicine students, language: English	IT students, language: Polish	p value
advice websites	35.5%	72.9%	56.2%	< 0.000001
websites about your hobby	67.3%	72.3%	76.9%	0.109
political news	44.9%	53.3%	49.2%	0.233
sport news	25.8%	42.3%	32.3%	0.002
teaching aids	89.1%	56.9%	80.8%	< 0.000001
other	37.9%	59.1%	63.1%	< 0.000001

individuals among IT students (2%). No significant differences ($p=0.51$) were discovered in comparison of Internet connections available to IT students divided by term of study (full-time and part-time). Summing up, the surveyed students would emphasize they could not imagine learning without Internet access today (IT 88%, medicine 83%, $p=0.169$).

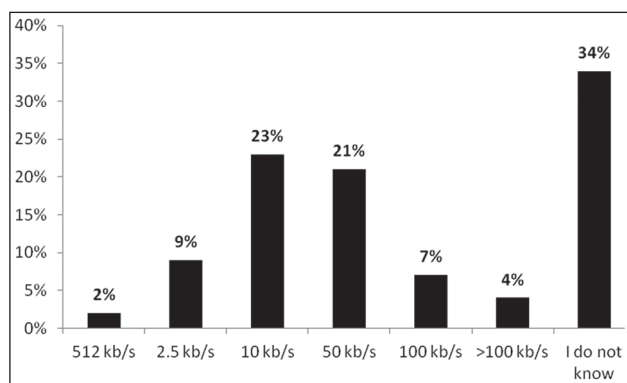


Figure 2. Knowledge recipients' Internet connection bandwidth

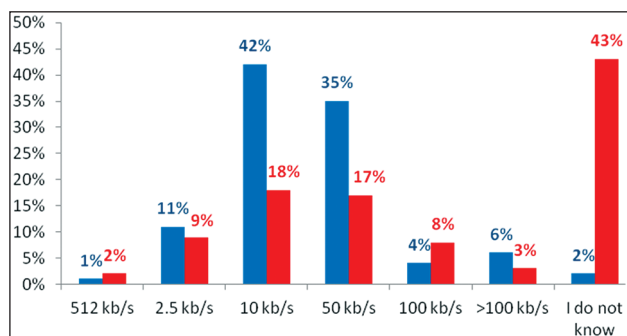


Figure 3. Knowledge recipients' Internet connection bandwidth, by field of study

Providers of educational contents, particularly those in charge of remote groups, must also have machines with permanent Internet access. Developed teaching materials must be uploaded to LCMS portal resources, and every modification involves repeated network transmission. This problem is extremely important for multimedia items, considering significant file sizes. Working with a remote group requires the course teacher to communicate with the learners' community on a regular basis. Students must rest assured they are not left alone with their problems [8]. They should be obliged to speak in public (e.g. on a forum) and required to verify their systematic work. Such verification usually takes place in an individual report left by the student in the portal resources. The course teacher must spend time on reading the reports and writing a review. This way of communication with every student takes 1-2 hours during each semester (4-8 x 15 minutes), yielding 20-40 hours per semester per one group of 20 students. This work is always done using a computer connected to the Internet.

2. ICT barriers

The process of preparing electronic learning materials typically comprises the following phases:

1. Editing text resources to be published online.
2. Editing educational graphics.
3. Preparing self-test contents.
4. Preparing subject-matter contents to be used in interactive items available for online publication.

5. Preparing lecture narratives to be processed with speech synthesizer or to be read by a reader.
6. Writing multimedia scripts and storyboards to be produced by a recording studio or by the author.

Each of the phases enumerated above requires medium or high level of ICT skills. The issue of online publication on the Internet should be emphasized. This concept involves customizing text formatting (using eg., Extensible Hypertext Markup Language (XHTML)) and all files dedicated to publication in LCMS portal resources so that they are correctly interpreted by Web browsers [9].

According to the authors of the paper, teaching e-learning courses requires certain experience as a remote course participant. Groups A and B under review showed significant differences ($p=0.009$) in terms of participation in e-courses and e-tests. Most teachers in group B (65.6%) never participated in electronic classes or took electronic tests, while the same percentage for group A was 32.1%. Table 3 presents the applications used by teachers to create and edit educational resources.

Table 3. Today's applications

Application	Group A % of users	Group B % of users	p value
Word	42.9%	37.5%	0.672
PowerPoint	78.6%	81.3%	0.795
Producer	39.3%	0%	0.00009
MoveMaker	35.7%	3.1%	0.001
Other free	60.7%	6.3%	0.00001

3. Collaboration in preparation of learning materials

Implementation of a learning portal at a school always involves the issue of division of tasks and determination of the terms of cooperation between the IT specialists working at the school, portal administrators, and course teachers. A division of tasks involves mandatory determination of ranges of responsibilities for individual participants of an online learning scheme. This refers in particular to the process of preparation and development of learning materials as well as electronic knowledge evaluation. Course content building is a time-consuming process [10,11] which may require appointment of a team of experts and IT special-

ists or persons able to help with the technology aspect of producing materials [12,13]. The authors believe that the concept of distinguishing the function of technical preparation of files for e-learning purposes from content preparation seems to be substantiated in terms of methodology, albeit very difficult to implement. The authors consider the main sources of problems to be [14]:

- frequent misunderstandings between the technical editor (IT specialist) - content developer (professional in the given field, e.g. a doctor or an academic in philology),
- the need to spend a lot of time on communication between them,
- the need for repeated professional verification of the outcomes of cooperation,
- high cost of an interdisciplinary team's work.

4. Training for knowledge providers

The authors of the paper believe that regular trainings should take place, particularly during the first years of e-learning implementation, covering the following three topical areas:

1. Preparing, creating and editing materials in publication versions.
2. Running the LCMS portal, including student work monitoring.
3. Teaching remote groups.

It seems reasonable to verify through a survey each employee's competences in the fields enumerated in the above three points. Information gathered in this way, such as that presented in Table 3, or a division of teachers into two groups A and B as applied by the authors of the paper, will allow to match the regular training courses to knowledge providers' current needs. With the traditional division of courses into basic, intermediate and advanced levels, syllabus can be prepared at once, and participants have the opportunity of starting with specific levels at different times. A single employee may take part in trainings repeatedly, at a level of their choice, to expand their knowledge in the field of ICT, and teach remote classes. The school will open such courses which are requested at the moment through surveys. Basic courses should be taught on a traditional stationary basis, allowing course participants to receive immediate responses from their coach.

During such training, employees must take active part in creating e-learning materials; the time of producing these materials is essential as well. A remote training requires the participant to commit more to individual work, which cannot be expected of persons with a basic level of skill.

Discussion

Internet access

Nowadays, it would be difficult to overestimate the possibilities offered by access to the Internet and its impact on the learning process [15], e-learning as well as conventional. The results of the authors' research only support this claim. Students usually have access to high-speed Internet and they use it frequently. Irrespective of their field of study, language or course, they perceive the need to use Internet resources in self-education as well as the advantages of common accessibility of current information. English-speaking medicine students, who usually live in student hostels, will more frequently use the Internet in a library, at schools or in Internet cafes than Polish-language students (Table 1). Computing students typically access the Internet from a computer or mobile phone, mainly seeking information related to their field of study or hobbies (Table 1, Table 2). For English-speaking medicine students, Internet resources are the source of all types of information (advice, news, hobbies, teaching aids, other), unlike their Polish peers who will focus mainly on the information they need for studying (Table 2).

The role of a recipient and provider.

Communication

After obtaining ICT competences of an e-learning recipient, including launching processes and applications, understanding the method of online communication and managing multimedia, one can switch to the role of an e-learning class teacher. Taking the role of a recipient not only helps you acquire the right skills and competences for the role of an e-learning provider [16] but also helps you understand the mechanisms of building learners' communities and get to know the methods of communicating within an LCMS portal. Communication with a group of participants (group mailing, discussion forum, and calendar) requires instruc-

tion and integration in the teacher's daily routine [17]. The authors again emphasize the importance of communication over the education portal only, considering participants' data protection and their achievements during the course.

The time devoted to teacher-student communication [18] is very often disregarded in workload calculation, to minimize the costs of teaching remote classes. As a consequence, Polish teachers are reluctant to teach e-learning classes, or there is no teacher-student communication, which in turn adversely affects the quality of e-learning [19] and prevents its further development at Polish universities. The authors point out that this is not the time of preparing, creating or editing materials but only the time for working with a group [20,21] using already complete courses.

Applications

The offering of e-courses in Poland is undergoing intensive growth. It is still not fully competitive to traditional course books. When reviewing the applications used by teachers, we can see that PowerPoint is the most commonly used software application for creating electronic materials, while it is not a typical tool for creating/editing e-learning materials. The authors were unable to determine whether multimedia narration was used in that application. The awareness of freeware applications for building educational contents among group B teachers is very low, compared to group A teachers, which supports the need to improve IT qualifications among future developers of e-learning courses (group B teachers). Work as author of educational materials requires significantly more advanced ICT competences than being a teacher or recipient of remote courses.

The authors' research output indicates the necessity to replace the tools currently used. It seems reasonable to recommend the applications which best meet the school's requirements on the school's information sites. Such recommendation should include data about access, installation process and tutorials. Such a small service will allow staff members to determine the level of their ICT competences and to decide to take part in more systematic training. A lot of foreign schools' websites publish such regular information [22].

Division of tasks in creating materials

A partial solution for the problems of separating the technical e-learning file edition functions from professional processing is to improve ICT competences of teaching staff and to involve staff members in both these tasks. Continuous and rapid growth of applications for comprehensive streamlining of the process of editing materials to be uploaded to LCMS portal will further minimize the problems with team work [23, 24].

Applications used to edit electronic resources are offered with continuously expanded sets of models for construction of educational materials. These include templates for: lectures to be read out, presentation materials with lecturer narration, repetition materials, and other items. Use of a template enables a text formatting engine which will also set up the place where information will be displayed on screen and save the output of automatic processing according to Internet standards (XHTML, Cascading Style Sheets (CSS)).

Training

Due to rapid progress in computer science, training courses for knowledge providers for e-learning should be implemented on an Lifelong Learning (Lifelong Learning Program) basis. This is consistent with the European Union directives [7] and sets an important direction for schools' development. Achievement of a basic level of ICT competences among teachers is extremely important, as it is not possible for a team of IT specialists employed by a university to carry out simple technology tasks. At the same time, the team of IT specialists will not take part in the teaching process and course teachers must work with their groups on the portal by themselves. They also have to choose the IT tools available in this online application, matching the topical area covered and the student group. Higher ICT competences gained by staff will allow improvement of university teaching level.

Conclusions

Internet accessibility and bandwidths have recently improved significantly in Poland. Nevertheless, we cannot yet speak of common broadband Internet access all over Poland. In this aspect, the position of larger schools is strongly privileged.

Results of the authors' research support the general tendency for more extensive use of Internet resources for educational purposes as well.

The position of e-learning, which requires the participants to be online all the time, is strengthening [25]. It requires schools to implement an informed long-term strategy for improving ICT knowledge and skills among staff members to create educational materials and teach remote courses. The competence development process is slow and generates costs related to the broad range of subjects covered by trainings. Knowledge providers for online learning should work with LCMS portal more efficiently, particularly in terms of group communication, or use of application tools to streamline the process of preparation and modification of materials. The authors' research shows that improvement of ICT competences is recommended in this field as well.

E-learning is a new and different way of working with students, not necessarily leading to an immediate reduction of costs of study [10, 4, 21, 13]. However becoming an important element of today's academic education [26, 27, 28, 2, 18, 29]. In order to ensure its efficient functioning and growth, qualified knowledge providers with relevant ICT consequences are necessary. They will determine the success of e-learning to a significant extent [12].

Acknowledgements

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The instruments of financial markets - review of options

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Abstract

The need for the application of products in order to meet their basic functions appeared in the chaos of the oil crisis in the world, exchange rate fluctuations and uneven conjuncture of economies around the world, especially after the abolition of pegged exchange rates. In such an environment derivatives should provide an improve in the market efficiency by diversifying and taking parts of risks, and safer investment planning, with a minimum cost. The sudden growth of the markets of financial derivatives in 80s of the 20th century should be mostly grateful to the interests of economic entities which are slowly beginning to realize the necessity of the application of derivatives in protection of their portfolio from the risks they are exposed to on daily basis and the benefits of derivatives for speculative profits on transactions and arbitration. The entrance to the 21st century has brought new challenges in trading derivatives, the market has become more demanding because of the need to constantly adapt to new needs of the participants in that particular market, so that the spectrum of derivatives traded every day is expanding, for example, to more complex variants of options and structured products.

A group of financial derivatives can be divided depending on the character of the basic instruments in the money market derivatives, foreign exchange derivatives markets and derivatives of the capital markets. Derivatives are being traded on organized markets and informal markets, depending on the properties of certain derivatives. [1]

Key words: derivatives, options, markets, banks.

Introduction

The derivatives of money markets or the interest rate derivatives are developed financial instruments which are primarily directed towards the

management of the interest rate risks. The noted instruments are mainly due within one year, they are of a short – term character and they are protected from the risk of the interest rate fluctuation. This group includes forward rate agreements, financial futures of the money market and interest rate swaps. The interest rate derivatives are present in the financial world for a long period of time and they are successfully being used by numerous financial and non – financial institutions. In the RS, however, the market has not yet been developed to the extent that is in accordance with the market needs considering the fact that the interest rate risk, together with the exposure to the foreign currency risk, abundantly influences the performance of different business entities. The exchange market derivatives, or the currency derivatives can be divided into the basic three groups:

- Currency swaps,
- Currency options,
- Foreign currency futures – futures and currency futures.

They are used for managing currency risks or the risks of changes in exchange rates which impacts the value of assets and liabilities of an entity denominated in foreign currencies. Capital market derivatives are derived financial instruments whose underlying assets are the instruments of the capital market, such as bonds, stocks and stock indices and other derived instruments which are based on the long – term financial instruments. Thus, this group includes stock options, stock indices options, financial futures options, caps, floors, replacement options, bond futures, stock indices futures, warrants, and convertibles, replacements on the capital market, joint – stock replacements and replacements of stock indices.

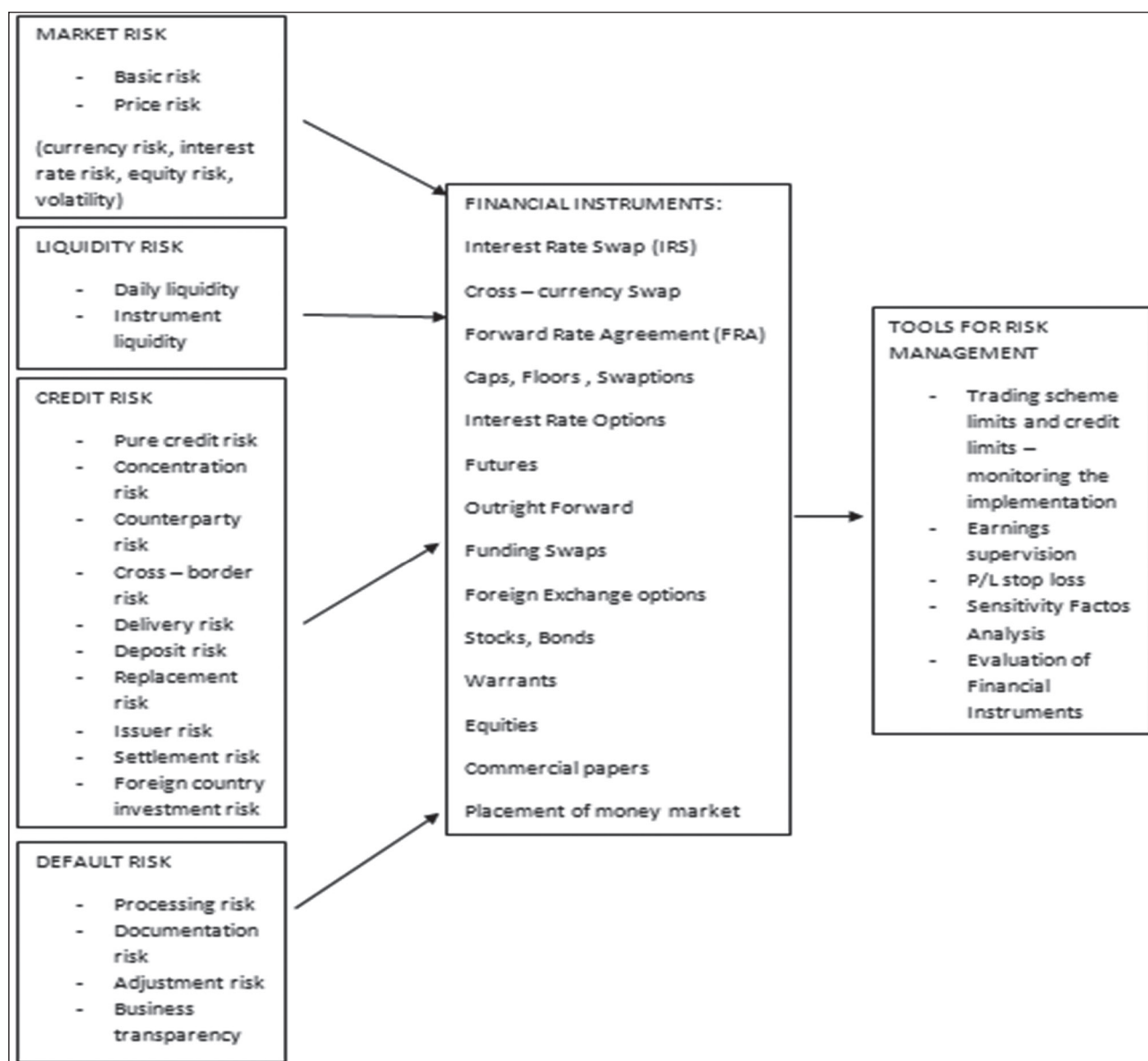


Illustration 1. Correlation of risk and financial instruments, Picture source: Katz, I.D. (1995.): “Financial Risk Manager”, Euromoney Publications PLC, London, p. 81.

1. The instruments of the financial market – review of options

Derivative securities or financial derivatives are very important forms of financial instruments which were developed together with the boom in financial innovations in the past 25 years. [1] Their appearance has given a new dimension to the stock exchange operations by leading to major changes in the financial markets of developed countries, but also in the international financial market. As has already been mentioned, derivative securities are created in a way that their value is derived from the value of some other underlying

asset which is located in their basis. But, as opposed to the basic securities, financial derivatives do not hold any of the two basic relations: credit and equity.

They, de facto, represent a specific type of contingent rights to other forms of financial assets (shares, for example, or other basic securities, interest rates, market indices, rates and so on).

The real reason for the existence of financial derivatives lies in the growth and importance of futures in financial markets. For the past 25 years they have experienced a real expansion, but their history is much longer. The root of their business can be found in 17th century on the territories of the

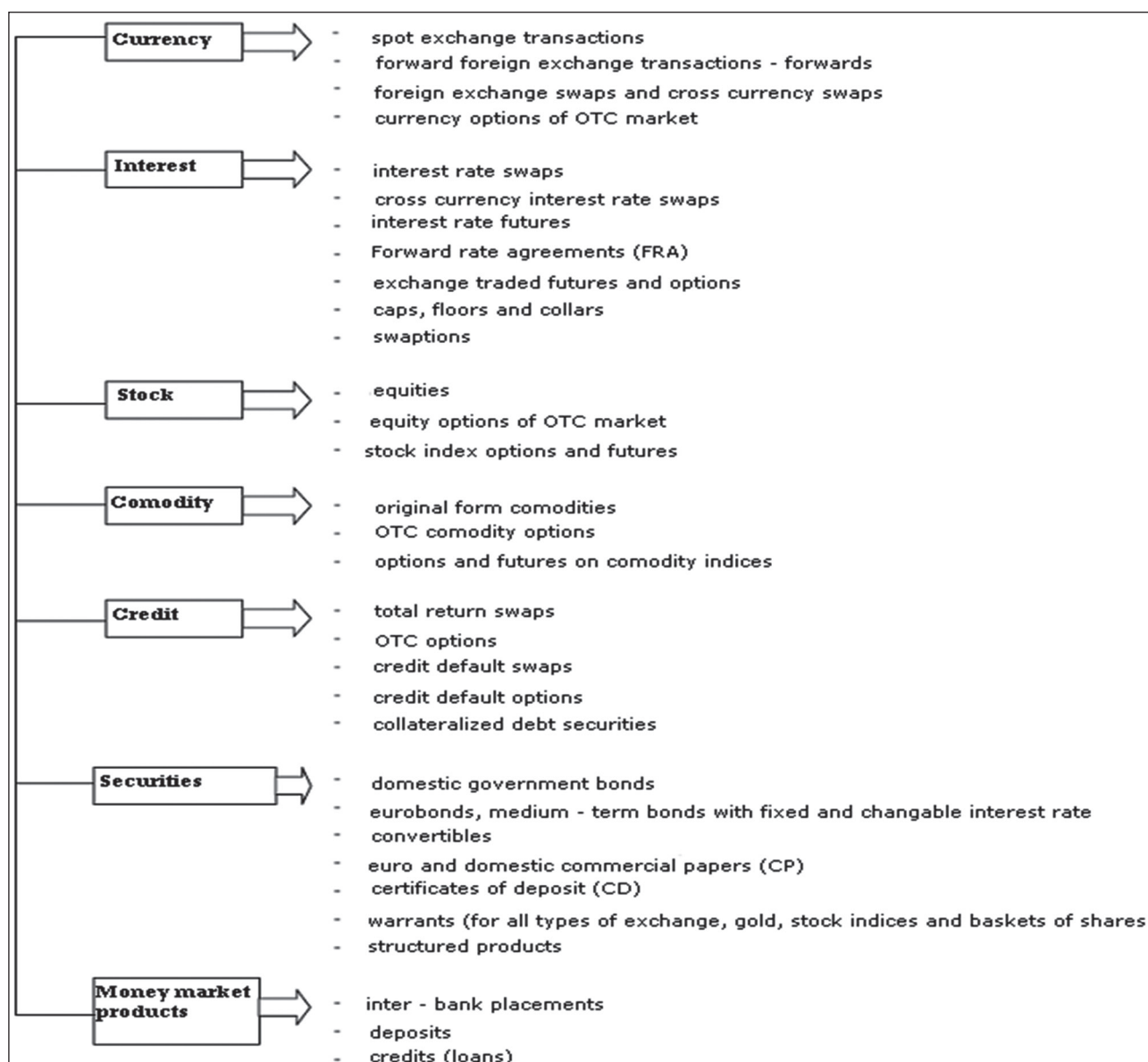


Illustration 2. Groups of products of financial market with similar risk characteristics, Source: Katz, I.D. (1995): "Financial Risk Manager", Euromoney Publications PLC, Nestor House, Playhouse Yard, London, p. 59 – 61.

Netherlands and Japan. The first conducts with the financial derivatives on the stock markets, such as the ones we can now see, took place on the London Metal Stock Market. There appeared the first forwards on different metals (copper and aluminum most commonly). These contracts were of a similar type to today's contracts when it comes to the relationship between buyers and sellers, the delivery and payment in the future. The only difference was that the price and the conditions of payment were agreed on much earlier, i.e. on the day of signing the contract. These contracts were based on a full autonomy of will of the contracting parties,

i.e. there was no institutional mechanism, nor were they standardized, which meant that behind them stood the clearing house which would guarantee the safety of delivery and payment. Modern futures on commodity stock markets appeared in the 19th century on the territory of American Midwest and the Stock Exchange of Chicago Board of Trade (CBOT) which was founded in 1848 [2], and which soon introduced improvements in the trade of forward contracts by introducing the standardization of quantity (e.g. for wheat 5, 000 bushels, as it is even today), and by introducing the standardized delivery during certain months. In 1874 the Chi-

Chicago Board of Trade has created the first clearing house as a guarantee of delivery and payment.

The options represent one of the most successful financial innovations although the most developed financial markets occasionally banned their use. That happened in England between 1931 and 1958, and in the USA between 1930 and 1973. The arguments for these prohibitions were based on the view that the options raise speculative character, or in case of commodity options, that they do not have rational economic function. [3]

Hence, the organized trade with options started in the USA in 1973, when within the Chicago Board of Trades, the option stock market was founded (Chicago Board Option Exchange). The formation and establishment of a special market for options allowed the operation of the secondary market that had, up to this moment, existed as a counter service market. [4] Today, the volume of trading with options on the Option Stock Market in Chicago has overcome the trading volume on the New York Stock Market. [5]

Over the last fifty years futures and options took their place in the international market. Originally, futures and options were used on the commodity stock markets, but in the early 70s begins their application onto the financial instruments. The currency futures experience an expansion with the fall of Bretton Woods system of fixed exchange rates. The fall of this system has announced the appearance of new financial instruments which will be used as means of reducing the risk in an increasingly unstable environment.

The term option is used in the economic literature which deals with finances, in the context of financial derivatives. [1] According to the literature, financial derivatives are “financial instruments, usually securities, whose value has been derived from the value of some other fundamental variable, which can be any commodity, financial instrument, even other financial derivative” [6], and they are called conditioned claims, because claims from derivatives are conditioned by claims from securities from which they are derived.

In other words, financial derivatives are financial instruments which are derived from primary financial instruments, or “those whose value is derived from some other asset or form some other financial instrument.” [4] They are divided, more

correctly classified, in four groups, namely on: forward contracts (futures and forwards), swaps, options and others. [4]

Options are perceived as “contracts for the purchase or sale of specific commodities or financial instruments on a specific date and at a specific price, provided that there is a possibility of using the right of withdrawal from the contract” [7], and “the contracts which give their owners the right to purchase or sell related property at the price given in the option for a specific time or on a specific date. Therefore, they represent contracts which are not bilaterally obligatory. [6]

Options represent the most important instrument of hedging, which helps the investors to protect themselves from different types of risks. [8] By using the options, it is possible to diminish, sometimes even eliminate, the risk of price changes, market indices, interest rates, exchange rates, and thus, increase the safety of investors in the market.

In finance, an option is a contract between the buyer and the seller which gives the buyer the right, but not the obligation, to buy or sell a particular good (a subjected good) at a later date at the agreed price. For giving the option, in return, upon concluding the contract, the seller gets a certain fee (premium) from the buyer. Call option gives the buyer the right to buy the subjected good; put option gives the buyer of the option the right to sell the subjected good. If the buyer decides to use the stated right, the seller is obliged to sell or buy the goods at the agreed price. The buyer can choose not to use the stated right and to let the option expire. The subjected good can be a real estate, land or any other property, shares of the share capital or other securities, such as, among others, futures. For example, the purchase of the call option gives the right to buy an outlined quantity of securities at the agreed price, which is known as a strike price, at any time until the date of expiry of the option, while the purchase of a put option gives the right to sell. When the owner of the option decides to use (carry out) the option, the party who sold or wrote the option, has to fulfill all the requirements of the contract.

From the given definitions we can notice that the term option, in its broadest sense, means the right of one person, by one – sided interpretation of the changes, to cause the emergence of a second con-

tract. This right is subjective and generally transferable and because of these characteristics it is suitable for an object of legal activities which can be concluded after it was formed and after the acquirer acquired the option. Most commonly, they are about the right to cause the formation of the sales contract for securities, currencies, interest rates and commodities which were included into the stock exchange quotation on the regulated market. In economic literature, this right is called the derivative, because it is the right which is derived, and its value is, also, derived from “other assets or from some other financial instrument”[4]. The trading of this right is, as well, common in the comparative stock exchange law and it is qualified as stock forward, but the option contract has the same qualification.

Therefore, options belong to a group of derivative securities, which means that they represent the derivative financial instruments. The basic role of derivatives in the financial market is the risk transfer. In their basis, there is some commodity or some financial instrument, or any asset that has marketability, and from whose price depends the price of derivative with which it trades on the derivative market, or forward market. [1]

Derivatives are mostly used to reduce risks, for example, for a farmer who is not certain what the price of corn will be in the time of harvest and sale. In order to reduce the uncertainty, he uses the derivative to protect himself from the future fall of prices of corn thus avoiding large losses. The main role of the derivative is the risk transfer onto those participants who are ready to accept that risk and achieve large profits or losses, because their forecasts about future price movements are opposite to those who want to protect themselves from the risks. Participants who want to protect themselves from the risk are called hedgers, and those who accept the risk, and make profit or loss, are called traders, or more popularly speculators. The forward markets, or derivative markets, could not possibly work if there was no speculators who are always ready to “gamble”.

Some financial institutions tend to use derivatives as a source of their income. Thus, there is a widely known incident related to the collapse of Barings Bank in February 1995. But this is not the only incident. Procter & Gamble, Orange County, Hammersmith and Fulham Local Authority, also

faced great financial difficulties. On the example of Barings Bank, Nick Leeson, apparently tried to take the advantage of the small price difference of financial instruments which he bought on the stock markets of the Far East and sold on the other stock markets trying to use the process known as the arbitrage. In January and February 1995, he bet on the Japanese stocks by buying a great amount of futures contracts on the Nikkei 225 index at the stock markets in Osaka and Tokyo. Then there was a difficult period in the Japanese stock market and this resulted in the disaster of the mentioned bank. [9]

As has already been stated, the option is the right to buy or sell a certain subject, such as shares or state bonds, at a predetermined price within a given deadline. This exact right to sell or buy a particular asset, and the possibility to give up this right, are the basic elements of an option, and precisely they make it different from the futures, in which there is no obligation to sell a certain asset, on a certain day, at a predetermined price, if you previously do not “come out” of the contract. The option represents a contract between the seller and the buyer which contains the right, but not the obligation, of the buyer to buy or sell a financial instrument at a certain period of time or on a specific date in the future, at a price specified at the time of the conclusion of the contract. [3]

The subject of the contract which is contained in the option is called the underlying asset. The subjects of the contract may be:

1. Commodities – agricultural products such as wheat, oil, wood, various metals
2. Currencies
3. Stocks or equities
4. Futures contracts
5. Stock indices.

The contract price, which is determined at the time of the conclusion of the contract, i.e. the price at which the asset, which is the subject of the optional contract, can be bought or sold, is called the strike price or the exercise price. The strike price or the exercise price of those options which are most actively traded with is usually very close to the current price of the asset which is the subject of the option contract, except in cases of exceptional growth or decline in prices. This happens precisely because the stock market determines the

strike prices on the basis of various analyses of the current market. The options available in several assets above or below the current price (spot price) are the underlying investments. For example, the prices of the shares which are under \$ 25 per share usually have strike price in the range 2 ½. The strike price of shares above \$ 50 is usually in range of \$ 5. As for stock options, they are not available for each share. There are about 2,200 companies whose options are available for trade.

The options are traded on the stock markets around the world such as: LIFFE (London International Financial Futures and Options Exchange) - London, CBOE - Chicago, EUA -European Stock Market Options, MONEP - France, DTB - Germany, SOFFEX - Switzerland and so on. Apart from the possibility to use the option until its maturity date, or not to do so, the buyer of the option has the right to annul the option (offset). Offsetting is a procedure reversed to the original transaction with a goal to leave the store. In case of the purchase of the call option, the call option needs to be sold at the same strike price and the same maturity date. If someone sells a call option, they buy a call at the same strike price and the same maturity date. The same goes for put options. In case of the purchase of the put option, the put option needs to be sold at the same strike price and the same maturity date. Analogously, if someone sells a put option, they buy a put option at the same strike price and the same maturity date. [6]

There is a division on the European, American and Asian options. Asian, American and European styles should not be related to the geographical locality, although majority of options on the US stock exchanges are the American options. In the European option, the right of the option can be used only on the maturity date of the option, and if the right of the option can be implemented throughout the whole period of maturity, then we are talking about the American option. The European options are rarely used in practice. The Asian options are, also, rarely used, but their trade began in 1994 at CBOE. The Asian options include the right, but not the obligation, of the buyer to buy or sell the contracted asset at the market price which is derived as the average of its spot prices at the agreed interval. The Asian options are related to oil, metals and a specific group of currencies. All

options of the same type (call or put) which have the same basic investment are called class options. For example, all call options on IBM constitute class options. All options that belong to the same class and have the same strike price are called option series. For example, all IBM call options with the strike price of 130 (and different maturity dates) consist a series.

There are two types of the option contracts. The contract which contains the right of the option buyer to buy the appropriate asset at the strike price until the expiration date is called the call option. Another type of the option is related to the contract that gives the right to the option buyer to sell the basic investment of the contract at the strike price until the expiration date. Such an option is called the put option. The rights that contain both the call and the put option imply the existence of the other contracting party which accepts to fulfill the obligation of the contract in order for the rights to be realized.

That other party of the contract is called option vendor or seller. If the seller of the call option is in question, or the seller of the right to buy “something”, then we can talk about the contract party who sells the right for a set premium, in order to buy the subject of the option contract at the execution cost. The seller commits to the request of the buyer of the right that it will be realized and that the subject of the contract will be delivered in a precisely defined period. If the seller of the put option is in question, or the seller of the right to sell “something”, then we talk about the contract party who sells the right for a set premium, who will be sold the subject of the contract at the execution cost and who commits to the request of the option buyer that the right will be realized and that the subject of the contract will be bought at the already – appointed date. [1]

1.1 Option elements – definitions and terminology

Strike price [10]:

Strike price – the specified price at which the option holder, whether the call option or the put option, can use his/her right of buying or selling the basic material which is the basis of the option, i.e. transition to the forward contract (the commo-

dity price at which the transaction will be executed if it comes to that).

Intrinsic value:

Intrinsic value – the actual value of the option is determined by the difference between the strike price of the option and the current market price of the material.

This means that the call option has the real value only if the strike price is lower than the current price on the futures market for the given material. For example, the call option of the corn lot with the price of 0,25 DIN/kg, in the case when the current price is 0,29 DIN/kg, means that the option has the real value of 0,04 DIN/kg. In accordance to this, the put option has the real value if the strike price of the option is higher than the current futures price for a given material.

The option – the option right – is not worth using if the option does not have the real value.

In the money option – in the market terminology this means that the option has the real value (*it makes sense to use the option right*).

Out of the money option – in the market terminology this means that the option does not have the real value (*it does not make sense to use the option right*).

At the money option – in the market terminology it means that the strike price of the option is equal to the price of the asset (*it does not make sense to use the option right*).

Time value:

Time value – it is expressed in the value – or the price which the buyers are ready to pay for a given option but which is over its real value – because they expect, within the period of the option validity, the corresponding forward price to fluctuate in the direction which will increase its real value. Since both the buyers and the sellers are present in the market, the premium, which consists of the

sum of the time and the real value, also determines the price at which the sellers are ready to accept the sale of the option right.

Option premium – is, actually, the price of the option. The height of the premium – the option price – is freely formed at the option market, by confronting the supply and demand. The reached premium is the one the buyer of the option will pay to the seller for the right which the first one acquires and the second one gives away.

Terminology[10]:

Bear – (literally means bear – an animal) – is the one who believes that the market prices are going to fall;

Bid – the desire to propose to buy the certain commodities at a certain price, opposite of “offer”;

Broker - the neutral or the legal person who executes the orders for futures and options in the name of the financial and trade institutions and/or public in general;

Bull - (literally means bull – an animal) – is the one who believes that the market prices are going to rise;

Call Option – the option which gives the buyer the right, but which does not oblige the buyer, to buy the underlying futures contract at the strike price, at the maturity date or before the expiry of the due date;

Clearing – the procedure according to which the clearing house performs the balancing and the alignment of the accounts of its members and takes care of all the obligations that come out of the futures and options contracts;

Closing price - the last price paid for a specific commodity in one work day;

Convergence - the mutual rapprochement between the price at the spot market and the futures price, in case when the futures is close to maturity;

Dealer - a neutral or a legal person who trades with securities more often as a principal rather than an agent, earning the difference in the price;

Table 1. Tabular spreadsheet on the example of corn

Forward price (DIN/kg)	Strike price (DIN/kg)	Classification	
		Call option	Put option
0,29	0,25	In the money	Out of the money
0,29	0,29	At the money	At the money
0,29	0,34	Out of the money	In the money

Delta - Index – the indicator of the change in the value of the option premium which is obtained by dividing the change per unit with the futures price;

Gamma - Index - the indicator of the speed of the change of Delta Index;

Hedger - the participant at the stock market who is interested solely in commodities, in terms of reducing the risk of possible changes in prices, more correctly commodities in the future;

Leverage – investing smaller amounts in the investments of much higher value;

Limit order – the order in which the order maker determines the upper or the lower level of prices and/or the time of maturity in which the transaction is to be executed;

Linkage – the ability to buy (sell) the futures on the one stock exchange, and later to buy (sell) the same futures on the other stock exchange;

Margin call - the call addressed to a member of a clearing by a clearing house to pay the deposit to the required minimum level;

Offer – the desire to sell certain commodities at a specified price, opposite of “bid”;

Option - the right to buy or sell a certain asset at a predetermined price at a fixed time limit;

Put option – the option which gives the buyer the right, but which does not oblige him, to sell the basic futures at the strike price at the maturity date or before the expiry of the due date;

Ring - the space for trading (usually a smaller place for the trading of certain commodities) within the stock market hall for trading;

Scalper – a short – term trader who wants to quickly invest in order to achieve a small profit;

Speculator – the participant on the stock exchange who trades exclusively for profit;

Spot - the way of trading at the stock exchange by paying the full price in cash – the spot trade;

Spread – the difference in the price between the two respective markets or commodities;

Strike price - the predetermined price which represents the amount to be paid or received if the transaction is executed;

Stock option is a contract which gives the owner the right to buy off a specific amount of stocks, or to sell them at a certain time for a certain price during the emission. That is a frequent method of stimulation, or rewarding the “top managers” for

“achievements”, as well as a way to motivate the “quality” of personnel.

Hedge fund is an investment fund which applies a hedging strategy. Hedging is a process which means the protection against the risk of the price movements in the future. Hedgers are people who want to protect themselves from the negative impact of the future prices (the exchange rate), and thus, they undertake certain activities. The classic hedging is the purchasing of a certain forward contract which indicates the delivery of commodities on a specified date in the future.

On the maturity date the difference between the spot price and the price of the contract is annulled in such a way that the buyer (seller) cannot be at loss. Hedging is carried out through the purchase of the futures, options, forwards and swaps. Hedging is used in foreign currencies, financial and commodity markets. An example of the foreign exchange market would be entering the counter positions because of the currency fluctuations (when it comes to dollars, the counter position would be taking a loan in dollars). In this way the interest rate affects both sides, so if the interest rate reflects badly on one side, the positive effect on the other side would neutralize the loss.

1.2 Option types

Options are classified according to several criteria [6]: according to the occupied investment position, the possibility of execution, the character of the underlying assets, the coverage of the underlying assets and the duration. From the point of view of the investment position, there are the call and the put options. The call option gives its buyer, in exchange for a premium, the right to buy from the seller, or the maker of the option, a contracted underlying assets at the strike price fixed on a specific date or over a certain period of time until the expiration of its return. Therefore, they are called the call options. The put option is the right of the maker of the option to sell the underlying assets at a guaranteed price on a date of its maturity, or through the time of its duration. Therefore, it is called the put option. Depending on which method can be used to implement the right from the option till the moment of its expiration, there are different types of options.

The basic types are the European and the American options. The European options can be executed solely on their maturity date. The American options can be executed any time up to their maturity date. As a special type of options there are the Asian options as well in which the time until the expiration return determines their strike price.

According to the character of the underlying assets, options are divided into commodity and financial options. In commodity options the subject is the commodity, real assets, while in financial options the subject is the financial assets, i.e. securities (shares and bonds), as well as other derivatives (e.g. options on futures of share indices, options on futures of interest rates, options on futures of currencies and so on) or indices of shares. According to the coverage, there are covered options and uncovered or naked options. Covered options are made when the underlying assets are owned, and uncovered options are made when there is no ownership over the underlying assets. According to the duration, there are short – term options, options are generally short – term financial instruments which expire within up to nine months, and long – term options such as the leaps options (Long – Term Equity Anticipation Securities), which expire in a period of two to five years.

1.3 Trading with options

The options are traded in the same way as the forward contracts, the futures, the only difference being the necessary insurance. The buyer of the option pays immediately the full amount of the premium to the seller of the option. He does not claim any insurance, nor is he subject to a call of the clearing house to provide security. The seller of the option, on the contrary, needs to put certain insurance and is constantly subjected to adjust the height of insurance at the call of the clearing house, at the same time as this mechanism functions at the futures market in accordance with the movements of the price of the basic materials. This means that the seller of the option is constantly exposed to the possibility that the option right will be activated against him, so that his margin account with the clearing house needs to cover the height of the possible loss per option. The adjustment is done on a daily basis.

1.4 Call option

Call option is a financial contract between two parties, i.e. the buyer and the seller of that option. The buyer of the option has the right to buy an agreed amount of the certain financial instrument up to a specific maturity date and at a predetermined strike price. The buyer has the right to buy, but he does not have to. On the other side, the seller is obliged to sell the financial instrument if and when the buyer requests him to. For the buyer to have this possibility he needs to pay the premium, so called option price, for that right. The buyer of the call option wants the price of the financial instrument to grow so that he can buy a specific instrument at a lower price, i.e. at the price he has contracted to buy. The seller of the call option, on the other side, receives the premium in advance, but he also risks the loss if the price of the option grows more than the premium he has received. There are differences between:

- The American call option, in which the buyer can buy the option any time until the expiration date of the option,
- The European call option, in which the buyer can buy the option solely on its expiration date.

One can use the call options to buy many financial instruments. The option price is the premium that the buyer needs to pay to have the right to buy a financial instrument until its maturity date when he considers that it is the best time to do so.

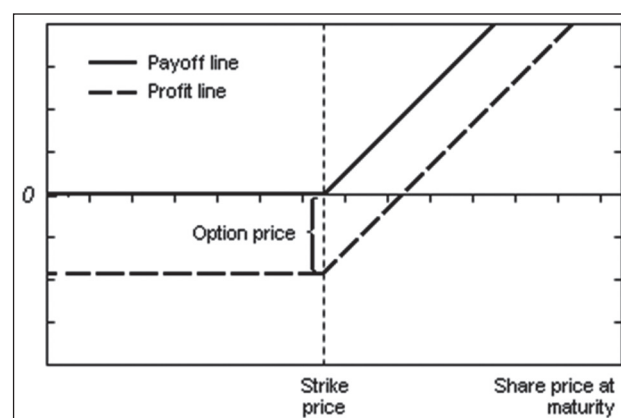


Illustration 3. Buying of the call option – this is a diagram interpretation of the gain and profit of the call option, the way it is understood by the buyer of the call option. The higher price means the higher profit. The final price can be sufficient to pay off the share price.

The examples of the call option:

The investor buys the call option at the price of 50 on September, 16th 2006 and pays the premium of 5 units for the purchase. The current price of the option is, for example, 40.

Suppose that the share price has grown to 60. The buyer can now decide to use the option and to buy the share at the strike price of 50. As soon as he buys the share, the buyer can sell it on the open market at 60 units and, thus, earn 10 units. Having paid the premium of 5 units, his net gain is 5 units.

If the share price never exceeds 50 until the maturity date, the buyer will not buy such a share, so the call option will expire as worthless and the buyer of the option will have a loss of 5 units.

The buyer of the option can lose the highest premium, 5 units, but he has the possibility of unlimited earning.

If the share price rises to 55, the buyer will buy the stock at the strike price of 50. His gain will be 5, but since he has paid the premium of 5, his net profit will be 0.

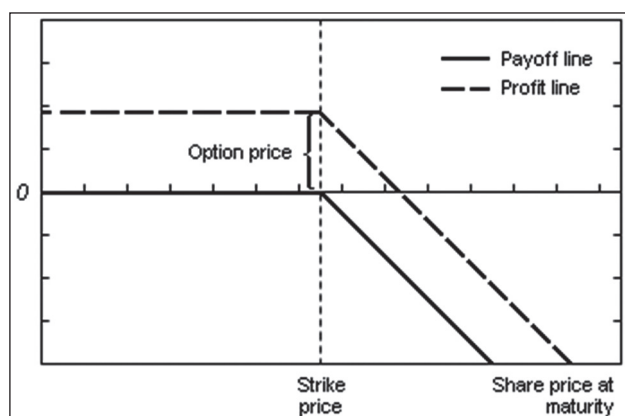


Illustration 4: Selling of the call option – this is a diagram interpretation of the gain and profit (net income) the way it is understood by the seller of the call option. The profit is maximized when the strike price is above the price of the corresponding financial instrument. Then the call option expires as worthless, so the seller of the option will keep the premium.

The picture shows the option price as the initial loss of the buyer if the share price is below the strike price. When the share price rises above the strike price, the buyer will buy the share at the strike price, which is then lower than the real share price. The buyer will have a certain profit, but his net in-

come is the income minus the price of the option. The buyer of the option will have net income only when the share price $>$ strike price + option price.

Conclusion

In the modern conditions, when choosing (using) a certain payment instrument, the risk factor makes an important impact. It is natural that business partners want the maximum safety when it comes to fulfilling their mutual contractual obligations. That safety is threatened by the distance of the parties and (in)ability of realistic assessment of the creditworthiness of the business partners. In the international trade there are more additional factors which have a hidden danger, namely: the diversity of the legal systems, diverging of the trade customs, pre unforeseeable state criterions, currency instability and so on. In such circumstances it is important to choose a payment method that provides the highest security to the business partners, thus minimizing the effects of the risk factors. That is the reason why today the payment instruments that, besides the payment function, also have the function of providing claims, are gaining even greater significance. Also, it is evident that there is the creation of the special funds which can secure the claims, highlighting the role of banks (bank guarantee). The lack of cash payments, as well as a number of other reasons of practical nature, stress the importance of non – cash payment and credit function of the payment instruments. Therefore, a check, a bill of exchange and a credit card are more and more in use today. Today a check has, in the international trade, become a security of a high circulation capacity and has as such largely suppressed cash.

It is, also, essential to emphasize the role of banks in the modern payment operations because the most payment takes place across the bank as a special subject of the international payment operations. The function of the bank as a guarantor is particularly important. The state intervention in the domain of the international payment operations is nowadays especially pronounced because the payment system on the international level is vital to the economy of every country. The economic policy measures of are all the more rigorous if the balance of payments of one country with the

foreign countries is more deficient and the foreign exchange reserves are fewer. The international payment operations are regulated by mandatory law, the norms that regulate not only the way, but also the extent of the payment. In addition, bilateral and multilateral international agreements are created between the contracting states and they deal with the modes of payment that are required for mutual payments between the legal subjects of these countries. The payments that our companies, as partners in contracts, carry out abroad are regulated on one side by the forced foreign exchange regulations and the international agreements, and on the other side they are determined by the banking payment techniques whose rules have the international character. It is this issue of the international payment and the instruments of the international payment system that are dealt with in this scientific paper. Considering the fact that this is a very interesting, but a very detailed legal and economic issue, the emphasis is put on the conceptual definition of the instruments of the payment system, their function, role and their importance in the international payments.

In the international payment operations, as opposed to the payment operations that take place within one country, there is no universal legal tender which is accepted in all countries. Performing, realization and the specificity of the international payment operations is aided by the payment instruments and the payment insurances. The International Chamber of Commerce has contributed to the unification of the payment instruments.

The performance of the international payment operations, due to the development of the world market, the international economic relations, different residences, participants in the international payment operations and many other factors, is characterized by volatility and uncertainty.

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The role of financial capital in the development of small and medium enterprises

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Abstract

Financial capital, through its large companies, influence the development of small and medium enterprises in two ways. Those small and medium enterprises, which are important competitors for them, are marginalized and eliminated from the market. The other companies, which integrate into its operation, receive support for their technological and market advances.

Key words: Financial capital, Small and medium enterprises, Development, Multinational corporations, Development impacts.

1. Introduction

In literature, and in practice, the long established view exists that entrepreneurial business, independent of volume - large, medium or small - cannot successfully develop without the support of financial capital. In order to start almost any business a bigger or smaller sum of money, or other resources, is needed. Certainly, different businesses need various amounts of capital in order to be successfully implemented. However, there is only a minority of businesses, whose successful start and successful execution, is not conditional on possession or support of a certain amount of financial capital. Needless to say that the biggest businesses are executed with the most financial capital given in the form of cash, material and / or any other form.

From the standpoint of our topic, it is interesting to consider what the role of financial capital is in the development of small and medium businesses in the context of the current economic and social situation in Serbia. This situation is characterized by a long and painful transition from an economic system of socialist self-management to the neoliberal capitalist economic system. The topic is even more interesting due to the fact that in all the plans and programs of transition countries, including Serbia, small and medium business should take a

key role in revitalizing the stalled economy. For a better understanding of the role of financial capital in the development of small and medium businesses, it is good to remind ourselves what financial capital is, how it has developed and how it increases. It is also important to analyse the goals of investors. In the context of the above information, it will be easier to understand what the chances are for developing small and medium businesses in all Balkan countries, including Serbia.

2. Financial capital - basic definitions

Economic literature that deals with finances clearly points out that financial capital represents the capital of manufacturing, trading, banking and other monopolistic corporations as well as other enterprises, which are interconnected through business and institutional interests. Connections that are established in this manner grow quantitatively greater into a qualitatively new and unique form of capital. When we look from the present position, it can be concluded that connections between the various types and forms of capital have initiated the process of forming mega multinational and transnational corporations, which act simultaneously in different business and on a global level and hold key economic, technological and financial powers in many key sectors of any economy. [1]

The whole process of the formation of financial capital is well known in the literature and is relatively simple. By purchasing shares of joint-stock companies, banks become their co-owners, and in the same way industrialists and traders co-owners of banks - this time buying their shares. After buying shares, equity owners participate in the management and control of banks, as well as industrial and commercial enterprises, which are connected in the context of a business - financial symbiosis. In this manner, a financial oligarchy develops, which in the further course of things establishes

new joint stock companies in which governments can retain control thanks to the possession of a controlling package or a golden share. Expanding the network of its influence, this oligarchy, in a wide network of different companies in different industries and in different countries, controls most of the global financial and other capital. The process of this expansion seems to be unstoppable and is manifested by the destruction of national economies and enormous social stratification of the population, which takes place in almost all countries of the world. [2]

It is financial capital, which is transformed into different forms, and which forms the basis of global economic power of the financial oligarchy that additionally to economic, completely monopolises political and every other type of power, both nationally and internationally. Needless to say how big the impact of the financial oligarchy and financial capital is to economic life and economic policies of governments, especially those that have a problem with high unemployment, and which also have problems with a lack of capital, technology and markets. In order to enter the markets of certain developing and transitional countries, the financial oligarchy demand various types of institutional concessions and financial benefits, which the governments of financially vulnerable countries willingly or unwillingly accept, in order to, at least partially, solve the economic, social and political problems they face. Thus, the global policy of the three major world financial police officers (World Bank, IMF and World Trade Organization), is fully adapted to the interests of financial capital. Regional mega financial institutions - such as the European Central Bank and other financial institutions of the European Union - also act in the same direction as the World Bank, IMF and WTO.

The financial oligarchy, that dominates the world's financial and other markets, knows very well that the available financial capital forms the basis of its economic, technological, market and political power, and the power of its impact on economic and social life of dependent countries. All attempts carried out so far in order to remove or at least to decrease significantly the monopoly of the global financial oligarchy have ended in failure up to now. Here we have to keep in mind that the financial oligarchy decreases in number, but ac-

ording to the available capital has become more powerful and dominant. Recently published data shows that the 100 richest families in the world own more capital the 3.5 billion poorest people on the planet, clearly indicating that things have become out of control and it clearly shows the direction to which humanity is going in its booming economic, social, demographic and every other development. [3]

We have to point out to the fact that the formation of financial capital is the result of high concentration and centralisation of different forms of capital, because large global and national projects cannot be carried out without much capital. This amount of capital was accumulated by governments via public finance in the past, but nowadays necessary huge amounts of financial capital is provided by private investors. Here, it is beneficial to separate between the capital of function and equity capital. This means that each (managers of different levels, usually in the status of well-paid professional wage workers) manage operational business processes, and that capital owners - who are usually behind the shadows (i.e. they are less known to the public), manage the strategic development of business entities through a variety of supervisory boards.[3]

We have already pointed out to the fact that the creation and functioning of financial capital deleted the duplication of capital into banking, industrial, commercial or other - which was the dominant feature of the economic structure of the world in the 18th and 19th century. The creation and accumulation of financial capital, the world has practically stepped into a new civilization, which is characterized by the domination of capital over all processes and subjects of power.

The rise and dominance of financial capital contributes directly to the intensive development of financial markets, where the turnover of securities of different types and character (stocks, bonds, various financial derivatives, etc.) transfer huge sums of money from one activity to another, from one country into another.

The economic life of every country is heavily influenced by large multinational and transnational companies, which in certain areas monopolise supply and demand, and also the available commercial space. In this area, next to them, business

has to be conducted by small and medium domestic enterprises. In fact, this relationship between large and small - superior and inferior, basically defines the conditions in which exist small and medium enterprises, both from strategic and operational aspects, as well as in the sense of fate. [4]

3. Various business conditions for small and medium enterprises

When it comes to the development of small and medium businesses in science, and also in the current policy, it is commonly argued that the development of this type of business is primarily affected by the inventiveness and ingenuity of entrepreneurs to discover certain prosperous niche areas whose skilful utilization can make a profitable business. In this sense, marketing theory, for example, has developed a number of sectoral disciplines to educate entrepreneurs: how to explore a particular market (subject: market research), in order to meet potential customers - consumers (subject: consumer research), how to interest customers - consumers in their offer (subject: promotion of the offer) and other disciplines, whose acquaintance and knowledge guarantee a successful entrepreneurial business.

The failure and bankruptcy of many small and medium enterprises in theory, and also in official policy, is explained by the argument that competitive entrepreneurs, who have experienced a business breakdown, have not well learned basic lessons of management and marketing. Although these theses are to some extent true, basic failures of many SMEs are caused by other factors. The question arises under which financial, technological and market conditions, and in what institutional framework the existing operating SMEs have operated before bankruptcy. So, we have to analyse whether these conditions - as seen from the above-mentioned aspects - were favourable for the development of SMEs. A large number of bankruptcies and difficulties for small and medium businesses - not only in developing countries but also in most developed countries - indicate that small and medium businesses are only formally promoted by media and official policy and they do not really receive any substantial institutional, financial and other support and practical help. A big surprise in the public has caused the data pre-

sented in the books of the popular theorists of small and medium businesses Robert Kiyosaki who noted that, in the American practice, of 10 newly established SMEs, only one company will survive until the fifth year of existence, while the other nine will go bankrupt. Then, of the 10 surviving companies, in the next five years again nine companies will go bankrupt, and only one will remain and survive on the market as winner. [5]

This data, and the data of our reality, point to the fact that despite all the political proclamations and sporadic financial assistance provided to small and medium-sized businesses through loans, still difficult things are occurring. The reasons for many failures and “stillbirths”, in the field of small and medium businesses are many - depending on the type of business and certainly depending on the context and environment in which a certain business is carried out. In some cases, the reason is lack of knowledge, or incompetence to manage a certain business. But there are also some more serious - systemic reasons. We do not claim to show all the limits and constraints under which operate many small and medium entrepreneurs, but we want to point out to some of them, which are specifically related to the established relations between small and medium businesses, on the one hand, and big business, on the other. Certainly, there are inevitable questions with regard to the above functional and financial links and flows, which are in practice established between the both types and forms of businesses. [6]

In the following we will show some external factors that directly affect the performance of a specific (concrete) small or medium business. Thus, we will set out the factors contributing to the success of small and medium enterprises and models of entrepreneurship.

4. Factors of success and failure of small and medium enterprises

Analysing the factors that contribute to the success and prosperity of certain small and medium enterprises - at the global and national level, we have concluded that there are three groups of factors, which are separate types, but which sometimes can manifest a synergy by multiplying the form of manifestation.

The first factor is a **monopoly** at disposal of a certain successful small or medium company. [4] This monopoly may be different in character and cover: the market, space, technology, institution, finance or other. Monopoly means that the company is concretely protected from unpleasant “intrusion” of other market participants, i.e. potential or actual competitors in its market area in which it operates. This space can be on the side of the procurement of necessary inputs for their business or at the sales side of output. The existence of certain monopolies is usually a sign that a concretely privileged monopoly company, collects through its an appropriate rent (part of income realized without adequate investment of labour and capital), which enables the company and its owners to successfully conduct a business and live comfortably.

Here are some examples of monopolies or rents, which in the practice of small and medium businesses appear and are manifested in numerous ways: [4]

- if a small hotel is located on the coast with a beautiful beach, with a good traffic access and a neighbourhood with rich social amenities, which attract tourists, who are willing to pay more to stay in it, it is quite sure that the hotel owners have a valuable and lucrative monopoly, which will enable them to achieve a certain tourist rent;
- if a small agricultural farm possesses exceptional fertile soil, where they manage a particularly valuable culture, with a convenient traffic access, and if it is still located near the centre of a large consumer, there is no doubt that the owners of the property, own a certain land monopoly, which puts them in certain superior position in relation to the land of inferior competitors;
- if a small store, based on franchising, has the exclusive license to sell products of a large and reputable company in a big city with a lot of interested buyers, it is clear that its business will be successful, as it has a certain type of monopoly. A similar monopoly has a well-stocked shop, which only operates in a large and rich village with a high purchasing power of villagers, who - whether they like it or not - can only buy products in this store.

Another factor that can ensure a successful business in the field of small and medium businesses are successful **innovations**. Innovations can be accomplished in the area of procurement, production, sales, promotion, finance and other areas of creative entrepreneurial business. [1]

The third factor is inclusion in **clusters** of large and well-known domestic and multinational companies, i.e. being part of a powerful system of organized financial capital. In this system, a small or medium-sized company, as an independent legal entity, performs part of delegated tasks, for a specific customer and market. [6]

Bearing in mind that the number of monopolies, which are at disposal for small and medium enterprises, is relatively limited, it is obvious that with this base, it is impossible to achieve a very large number of success stories. Furthermore, the number of imaginative innovations that small and medium entrepreneurs can discover and keep a monopoly at it, is very limited, because in every field of business - if a certain innovation proves to be successful - many competitors will imitate this innovation.

Practice has shown that successful and promising business achieved by SMEs, which are based on the third above factor, are associated in some way with some production, transport or service centres of the powerful financial capital. The shape of that connection can be of different types, i.e. small or medium companies can operate in a chain of franchising, clusters or other business cooperation. By operating under the “umbrella” of a large and powerful company, i.e. its branch office or a type of financial capital, entrepreneurs, small and medium businesses, which operate in such a system, will have stability and security for their business over the long term.

The factors of failure in small and medium-sized businesses are contrary to the mentioned factors of success. Small and medium entrepreneurs, who operate in the open market in the conditions of competition, and are not provided with any of the three factors of success, have little chance for a successful entrepreneurial business. If their job goes well, it will immediately draw attention of other market participants, who operate in the same field of business and want to achieve similar success. Increased supply of certain goods and

services, at the same level of demand, generates negative effects of business for all participants.

For small and medium enterprises, in all sectors, especially in the retail sector, a devastating situation exists if they are in close proximity where products and services are offered by large retail markets. It is well known that small and medium traders, whose stores are located close to major retailers such as: Tempo, Maxi, Metro and others in Serbia, or Wal-Mart, Lidl and similar abroad, are not able to withstand the bidding, pricing, service and other competition of these systems and quickly close their facilities, and then usually trying to achieve their personal income as employees at these retailers.

Conclusion

It is obvious that the time of successful, independent small and medium enterprises has been becoming a historical relic of the past. The above does not mean the end for small and medium businesses, but it is the beginning of the end of independent free small and medium businesses, which under conditions of free non-monopolistic competition try to find and to keep "their place under the sun".

Prosperous conditions of their business have mostly small and medium enterprises, which are protected by a kind of monopoly or are in symbiosis within some branch of the large financial capital. This symbiosis is in most cases achieved in the form of large and reputable multinational corporations, that have their business interests, more or less, in all countries.

To conclude; the future of small and medium enterprises lies in the form of license or business in the relationship with some form of the large financial capital. Independent business "uprisings" in the ambience of completely free competition will be less and less tolerated.

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Impact of top managers' leadership on occupational health and safety

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Abstract

The main aim of this study is therefore to establish the impact of the leadership on occupational health and safety and on top managements' attitudes towards occupational health and safety in large enterprises. To research this relationship and the critical factors that affect it, and consequently the impact of these factors on occupational health and safety, we implemented the self-assessment method by using self-assessment questionnaire. The questionnaires were sent to the census of 351 top managers of large Slovenian enterprises. 62 responses were received and analysed by employing a statistical software programme (SPSS). The results showed that leadership oriented towards occupational health and safety in large enterprises has a significant impact on the state of health in the organization and on the attitudes towards occupational health and safety. We can conclude that top management's leadership oriented towards occupational health and safety has a significant positive impact on occupational health and safety in enterprises. This study partially fills up the defined gap in the area of empirical data processing related to the safety leadership of top managers in ensuring occupational health and safety as well as to their attitude towards this issue.

Key words: executive managers, large enterprises, leadership, occupational health and safety

1. Introduction

In the past few decades organizations all over the world have been searching for the elements that constitute continuous organizational success in all fields of its activity [1]. Today safe and healthy working environment, as an essential element of work quality and therefore organizational success,

represents one of the most important advanced fields in organizations [2]. However, it is leadership that presents the crucial success element for the use of quality health and safety system in organizations [3, 4, 5]. The importance of leadership for effective safety management has been the focus of research attention in industry for a number of years, especially in energy and manufacturing sectors [6]. Senior management's commitment is crucial to a positive health and safety culture [7, 8]. Similar findings have been highlighted in other investigations across a range of industries [9, 10, 11, 12]. [13] established that the safety climate mediated the leadership-injury relationship in work groups. All these results indicate that the leadership commitment to safety is recognized as a fundamental component of an organization's safety culture [14] and safety performance [15]. Occupational health and safety-oriented leadership has become not merely a fashionable trend, but a necessary, integral part of the strategic planning for the sustained development and success of the organization.

2. Literature review

2.1. Defining the concepts of leadership and occupational health and safety

1. Leadership is defined as the activity of top executives who display high levels of persistence, overcome significant obstacles, attract dedicated people, influence groups of people towards the achievement of goals, and play key roles in guiding their companies through crucial episodes in their history [4]. Leadership is the ability to influence people to attain goals. According to [16], leadership is reciprocal as leaders are involved with other people in the achievement of goals. Leadership is the lifting of man's vision to high-

er sights, the raising of a man's performance to a higher standard, the building of a man's personality beyond its normal limitations [17]. Comparing leaders with managers, we can say that managers do things right while leaders do the right things. The clear implication is that "managing" is not only different from, but maybe even the opposite of "leading"; moreover, it is more useful to "lead" than to "manage" [18].

2. Occupational health and safety is a cross-disciplinary area concerned with protecting the safety, health and welfare of people engaged in work or employment [19]. Awareness of occupational health and safety grew in the early years of the 20th century, along with larger concerns about the wages and living conditions of workers [20]. The main focus in occupational health and safety is on three different objectives:

- the maintenance and promotion of workers' health and working capacity;
- the improvement of working environment and work to become conducive to safety and health and
- development of work organizations and working cultures in a direction which supports occupational health and safety and in doing so also promotes a positive social climate and smooth operation, and may enhance productivity of the undertakings [21].

There are numerous problems with the approach to developing a valid measure (indicators) of occupational health and safety [22].

What is needed to enhance safety in the long-term is a measurement approach that focuses on the proximal causes of safety incidents. For instance, measuring management practices that increase employees' levels of trust in management and perceived safety climate would be beneficial to the extent that these factors predict subsequent safety performance [23]. However, organizations need to be aware of what hazards or stressors may be present in the workplace of the future and to take preventive measures not only to protect employee well-being but also to cover themselves against any potential legal action from injured employees [24]. Dangerous and hazardous factors in general can be classified into six categories according to the direct cause of the incident and occupational

hazard: physical factors, chemical factors, biological factors, psychological and physiological factors, behavioral factors and other dangerous and hazardous factors [25]. Focusing on risks to health is key to preventing disease and injury. The most emotive and tangible images concerning health are of people suffering from disease. However, preventing disease and injury requires systematic assessment and reduction of their causes. Much scientific effort and most health resources are directed towards treating disease – the "rule of rescue" still dominates [26].

Given this limitation, regarding the defining valid indicators measuring occupational health and safety in organizations, we used an occupational injury and absence due to occupational diseases as indicators of a health and safety statement in enterprises. We used the indicator of occupational health and safety according to [27]. These indicators are numerous occupational injuries and lost days due to occupational diseases. [28, 29] described safety performance of organizations as well as occupational injuries. Below we offer a definition of the chosen indicators of occupational health and safety:

- Occupational injuries are defined as »all events that happen during the practice of work directly or indirectly causing physical lesion, functional disturbance or illness, and resulting in death or loss of the capacity to work, whether total or partial, temporary or permanent [30]. Occupational injuries are measured by total number of days lost due to occupational injuries [27].
- Absence due to occupational diseases is stated as time lost due to the employee's occupational diseases. The rate of absence is calculated as the number of registered days of absence due to occupational disease as a percentage of the total number of normal working days in one year, not including holidays [27].

In Section 2.2, we will discuss the relationship between senior leadership and occupational health and safety, and in Section 2.3, the leadership safety model will be examined.

2.2. Relationship between senior (top management) leadership and occupational health and safety

The quality of leadership may influence organizational climate, which can have a significant impact on organizational performance. Safety performance is considered to be a subsystem of organizational performance [31]. Senior managers have a prime influence on the organization's safety performance. They need to continuously demonstrate a visible commitment to safety, best indicated by the time they devote to safety matters [7].

Considering the fact that the principal mission of top management in for-profit organizations is to make profit, the knowledge of financial and other data related to occupational health and safety can positively influence the top management in terms of noticing occupational health and safety issues in organizations and influencing their decisions related to the management of organizations [32, 33]. Levels of management have distinct roles and are perceived differently by the workforce [34]. While senior managers undoubtedly set the tone and tempo for organizational atmosphere, establish priorities and allocate resources, there is very little evidence that unravels how this actually works in practice [35].

In general, leadership research has focused on outcomes such as productivity, profit, turnover and worker satisfaction as the criteria to measure leadership effectiveness, whilst few studies have considered occupational health and safety as an important criterion for measuring leadership effectiveness [36].

Although many studies purport to investigate leadership's relation to occupational health and safety, most of them actually focus on the supervisory level, and very few of them examine the impact of more senior level managers on occupational safety outcomes. With a few notable exceptions [31, 37, 38, 39, 40, 41, 42], there is very little research regarding the process by which senior level managers can achieve a strong safety culture in their organizations. The results of these studies in general showed that leadership behavior could affect the efficiency of safety performance. Therefore, leadership dimensions could be possible determinants for facilitating positive occupational health and safety environment.

In creating a quality health and safety environment, a leadership style is of utmost importance. [42] Showed that a leadership style had a significant impact on health and safety at work. The participative leadership style was the best practice for developing safety culture and safety policy in organizations. It also led workers to accept the responsibility and ownership for safety [36].

2.3. The leadership health and safety models

There are numerous business organization models for occupational health and safety leadership in the world. The largest differences among these models are in the number of factors (elements) influencing the state of occupational health and safety. [43] defined the Safety Excellence Model consisting of culture, elements of safety, organization and an individual. According to [44], safety excellence consists of seven elements: education, implementation, engineering, behavior, organization, leadership and culture. [45] designed a model called People-Based Safety, founded on the following elements: behavior, work methods and motivation management, a positive and systemic approach to improvements, information collection and communication. The Successful Health and Safety Model (by [46]) contains three groups/clusters of fundamental elements: governance and management (leadership and commitments, communication and documentation, assessment and reviews, and training and education), technical-operational / technical/operational elements (risk identification, assessment, supervision, engineering and operational safety and medical programs), and »soft« elements - culture and behavior (involving employees in decision-making in the field of health and safety, motivation, behavior, practices and employee education and training). [47] Proposed the Three dimensional Model for occupational health and safety management containing three dimensions operating simultaneously: self-confidence, credibility and developing organizational competences. The model is based on five steps: insight, direction, focus, ability and accountability. He established that lack of trust/confidence and credibility is the most common obstacle to enhancing safety culture. Another model - Leadership Diamond - the model designed by [48] is

founded on five basic dimensions or relationship clusters relating to leadership activities: greatness, courage, vision, ethics and reality.

Considering the above mentioned organizational models for occupational health and safety leadership and their dimensions or elements, we can conclude that no model contains equivalent elements. In some models, the so called »soft« factors (e. g. culture, organization, leadership, behavior, motivation, communication, trust/confidence, credibility, courage, vision, ethics, cooperation, responsibility) prevail, while with other models, the so called »hard« factors (e. g. engineering, supervision, systems approach, technics and technology) prevail. For the purpose of our research, we decided to focus on [49] model Leading with Safety, containing the leadership self-assessment, due to its elements which are exclusively »soft« and related to leadership, as well as due to the fact that the research results would enable us to compare and generalize the results directly with the studies conducted in other countries. In the discussed model, the author propagates the significance of occupational health and safety leadership. According to the author, the critical elements in human resource leadership in terms of ensuring health and safety are: vision, credibility, action orientation, cooperation, communication, recognition, feedback and accountability. *Vision, as the way of seeing a larger perspective in terms of occupational health and safety, means acting in a way to demonstrate a high personal standard in relation to health and safety at all times. The vision of occupational health and safety policy should be »no injuries, no health damages and no disabilities«* [50]. An important aspect or quality of visionary and effective safety leaders is possessing high levels of credibility. Visionary and effective safety leaders also need to be perceived as willing to take action on behalf of safety issues when it is appropriate. Another important quality of visionary and effective safety leaders and their leadership is collaboration, which is critical to effective safety leadership, at all levels [49]. Furthermore, communication is another vitally important aspect which contributes to effective safety leadership. The hazard communication standard of the Occupational Safety and Health Administration (OSHA) provides an excellent example of the value of a stand-alone implementation study [51].

And finally, the factor with the greatest positive perception by employees is management accountability to safety [52].

The main aim of this study is to examine whether leadership could be related to negative occupational health and safety events (injuries, absence due to occupational diseases). The study aims to establish the impact of the leadership of Slovene top managers on occupational health and safety and on top managements' attitudes towards occupational health and safety in large organizations.

We assume that top management should give occupational health and safety a high status within the organization's business objectives, and orientation towards good occupational health and safety should be prioritized in all situations.

The hypotheses formed on the basis of the reviewed literature and the questionnaire:

- H1: Leadership oriented towards occupational health and safety in large Slovene organizations has a statistically significant impact on the state of health in the enterprise (according to the number of the recorded occupational injuries).
- H2: Leadership oriented towards occupational health and safety in large Slovene enterprises has a statistically significant impact on the state of health in the enterprise (according to absences from work due to occupational diseases).
- H3: Leadership oriented towards occupational health and safety in large Slovene enterprises has a statistically significant impact on attitudes towards occupational health and safety (understanding of legislative requirements, attitudes towards investments and education in the field of occupational health and safety, OHSAS 18001 standard [53], occupational health and safety as an enterprises' priority field and risk management in enterprise).

3. Methodology

In our research, we included all large enterprises in the Republic of Slovenia, with more than 250 employees, listed in the public business register [54] as active business entities. We decided to include large enterprises due to their well-developed

occupational health and safety system, which also enabled us to acquire the necessary research data. The register contained 351 large enterprises (with more than 250 employees), in accordance with the Standard Classification of Activities, which were used as a sample for our research. The questionnaires answered by the top managers in Slovene large enterprises (we received 78 questionnaires out of 351 and used 62) enabled us to acquire and examine information on the situation in most branches of Slovenian industry. We could have employed a qualitative research method (interview), however, interviews usually last up to several hours; consequently it would be difficult for us to acquire information in such a way. Interviews also focus on the use of open-ended questions allowing the respondent to answer freely. It is the respondent's answer that leads the interview. As a result, the interview questions are not standardized [55].

For the above mentioned reasons we gathered the data and information by means of a questionnaire designed for Slovene top managers. The questionnaire measurement characteristics were verified. Reliability (internal consistency) was estimated via the split-half reliability index, the alpha coefficient [56]. The alpha coefficient reliable number was 0.76, which showed a good inter-rater reliability for the items. A face content validity examination indicated that the items included were adequate for the purpose of the assessment, and the time consumption for the assessment was acceptable [57].

The questionnaire was developed and designed on the basis of the reviewed literature and questionnaires used in similar studies conducted previously in an international affiliated group, and was divided into 5 parts. A pilot study (30 participants – managers and supervisors – were included) related to the strategic activities of the enterprise aimed at achieving quality results in the area of occupational health and safety, was conducted to test the questionnaire. According to the results of the testing, we applied several corrections targeting to eliminate inappropriate and ambiguous terminology. The testing also helped us to estimate the time required for the completion of the questionnaire.

In the first part of the questionnaire, which included the questions on the branch of industry and the length of the enterprise's existence, we aimed at acquiring the data which would enable us to

classify the enterprises according to their branch of industry (Standard Classification of Activities) and to determine the length of their existence. In the second part of the questionnaire, we acquired the demographic data of the participants: sex, age, total length of service, position in the enterprise and completed level of education. In the third part of the questionnaire, we investigated the state of health in the enterprise according to the number of the recorded occupational injuries and absences from work due to disease for the period between 2001 and 2006, which coincides with the last national programme on occupational health and safety in Slovenia. In the fourth part of the questionnaire, we acquired information on attitudes towards occupational health and safety. The questions were related to understanding of legislative requirements, attitudes towards investments and education, and the knowledge of the OHSAS 18001 standard and risk management. In the fifth part, we investigated the self-assessment of the Slovene managers in large enterprises concerning their leadership style in view of the selected evaluation criteria: vision, credibility, cooperation, feedback, accountability, communication and action orientation.

The questionnaire, therefore, focused mainly on the top management's interpretation of their role in the field of occupational health and safety, leadership and attitudes towards occupational health and safety and the state of health in the enterprise.

The questionnaires and the covering letters were sent to the participants in electronic form. We expected approximately the same response as if our questionnaires had been sent to the participants via ordinary mail.

In the covering letter, we expressed our awareness of the time constraints the participants were exposed to and highlighted the benefits of answering the questionnaire related to the reflection on their own leadership.

In the introductory part of the questionnaire, we thanked the participants for their involvement in the research. Furthermore, we provided brief instructions for the completion of the questionnaire, determined the approximate time required for the completion of the questionnaire, assured them that the results would not be presented individually and that there were no wrong answers. For any

questions regarding the questionnaire or research, the name of a contact person was included.

The empirical part of the research included 62 top managers from the enterprises that returned the completed questionnaires. By means of the equation for the finite population correction, we were able to acquire an accurate evaluation of the population characteristics [58].

Statistical data processing was carried out by the weighting of answers to the items in the questionnaire, namely by means of the Excel Software and SPSS (Statistical Package for the Social Sciences). Firstly, the general data was statistically processed. This was followed by processing the data by means of factor analysis, regression analysis and multiple regression analysis. All the hypotheses were tested at a significance level less than 5 % ($P=0.05$). The results are presented in a descriptive way and as tables.

4. Results

The studied sample included 62 large Slovene enterprises, each employing more than 250 people. In the first part of the questionnaire, we acquired basic information on the enterprises related to the branch of industry the enterprises operated in and the length of their existence on the market. The largest number of the completed questionnaires was received from the enterprises operating in the area of production activities. They are followed by health care, social security, public administration and defense, compulsory and social security, construction, electricity supply industry, gas supply industry, steam supply industry, catering, finance and insurance, transport and warehousing. The participating enterprises have been in operation for a longer period of time, most of them for over 40 years. Most of those enterprises which have been in operation from 10 to 20 years were established at the time of Slovenia's declaration of independence and are mostly state-owned. The data acquired through the questionnaires represent the operating systems, namely the enterprises that have tradition and are well-established in a competitive market.

On the basis of the reviewed literature and the sources used in the theoretical part of this paper, we designed three hypotheses related to the top management's leadership and occupational health

and safety state in Slovene large enterprises (measured by the number of the recorded occupational injuries, absences from work due to occupational diseases and attitudes towards occupational health and safety - understanding of legislative requirements, attitudes towards investments and education in the field of occupational health and safety, OHSAS 18001 standard, occupational health and safety as the enterprise's priority field and risk management in the enterprise).

Prior to verification of our research hypotheses, we tested the questionnaire's validity and reliability (if it contained a statistically significant cluster of items assessing or establishing occupational health and safety-oriented leadership performance). By means of the exploratory factor analysis it was established that there was a factor which could be labeled as the occupational health and safety-oriented leadership (items that indicate such leadership are shown in the table below – Table 1) by which we can explain 40.5 % variance of managers self-estimate of leadership in terms of critical factors defined according to Inc. BST^R and Leading with SafetyTM. Establishing the previously mentioned factor was important to proceed with the testing of the set hypotheses.

The first hypothesis tested is as follows: H1: Leadership oriented towards occupational health and safety in large Slovene enterprises has a statistically significant impact on the state of health in the enterprise (according to the number of the recorded occupational injuries). The hypothesis was tested by simple linear regression. The variable "occupational health and safety-oriented leadership" was used as an independent variable and "the state of health in the enterprise (according to the number of the recorded occupational injuries)" as a dependent variable. The basic hypothesis: The Pearson product-moment correlation coefficient, a measure of the linear dependence between two variables, equals 0. If the coefficient turns out to be different from 0, we reject the hypothesis and accept the hypothesis on the correlation of two variables. We normally do this at a 5 % significance level. To test the correlation between the variables, we used simple regression analysis model, which is shown in Table 2.

Table 1. Statistical analysis of the factor “occupational health and safety-oriented leadership”

Variable - number	Variable - description	F.L.	M	SD
F1: Occupational health and safety-oriented leadership (40.50 % var.; KMO = 0.82; α = 0.82)				
Vision - 1	I demonstrate a high personal standard in terms of H&S.	0.90	2.25	0.62
Vision - 2	I help others start thinking independently about their own standards in terms of H&S.	0.73	1.93	0.47
Vision - 6	I encourage other employees to take on challenges in the area of values relating to H&S.	0.86	1.89	1.06
Cooperation - 1	I promote cooperation in attitudes towards H&S.	0.71	2.16	0.82
Cooperation - 2	I discuss and encourage propositions for the improvement in the area of H&S.	0.80	1.88	0.91
Cooperation - 3	I help other employees solve their problems related to H&S independently.	0.62	2.05	0.25
Feedback - 2	I recognize and award those who contributed to H&S improvement.	0.76	2.02	0.51
Feedback - 6	We celebrate the achieved success in the area of H&S.	0.77	1.78	0.43
Responsibility - 3	I define responsibilities related to H&S tasks.	0.71	1.96	0.32
Responsibility - 5	I analyse the achieved results periodically, on the basis of the defined standards in H&S.	0.62	2.05	0.25
Communication - 1	I keep informing all employees about the activities in the area of H&S.	0.76	2.32	0.81
Action orientation - 1	I act uncompromisingly in responding to H&S challenges.	0.77	1.78	0.33
Action orientation - 2	I actively support resolving H&S challenges.	0.72	2.10	0.38
Action orientation - 3	I act creatively and innovatively in resolving H&S challenges.	0.79	2.50	0.49

Notes. KMO (Keiser-Meyer-Olkin Measure of Sampling Adequacy); α - alpha coefficient; var.-variance; F.L.- Factor Loadings; M- Mean; SD- standard deviation.

Table 2. Regression model

Model**			
Model	R	R Square	Adjusted R Square
1	0.36*	0.12	0.11

Notes. * Predictor: occupational health and safety-oriented leadership. ** Dependent variable: state of health in the enterprise (according to the number of the recorded occupational injuries).

Table 3. ANOVA

ANOVA**						
Model		Sum of Squares	Degrees of freedom	Mean Square	F	Sig.
1	Regression	18.07	1	18.07	19.98	0.000*
	Residual	132.91	61	0.90		
	Total	150.98	62			

R² represents the adjusted coefficient of the explained variance, which is, in our case, 11.4 %. The proportion of the explained variance in our model is 11 %, which means that the dependent variable is well explained with the selected independent variables.

By using F statistics, we tested the full regression model. We measured the purpose and mean-

ing of the overall model. This is shown in Table 3. We obtained F = 19.98. We assess this as a good model, which provides efficient data accommodation and is statistically significant.

Standard regression coefficient (Beta) for the factor “occupational health and safety-oriented leadership” is estimated to 0.35 and is statistically significant. This coefficient is shown in Table 4.

Table 4. Regression model

Coefficients*						
		Non-standard coefficients		Standard coefficients		
Model		Beta	Standard error	Beta	t	Sig.
1	Constant	1.09	0.41		2.67	0.009
	Occupational health and safety-oriented leadership	0.52	0.12	0.35	4.47	0.000

Notes. Constant – constant represents a parameter evaluation – value of the regression function constant equals the value of the regression function at the independent variable’s value 0. Beta – beta coefficient measures the amount of variation, i.e. the number of units the dependent variable is changed by on average if the independent variable increases by one unit, provided that all other variables remain unchanged. Sig. – sig. represents statistical significance or risk – the hypothesis is rejected at the statistical significance that is lower than 5 %.

Table 5. Regression model

Model**			
Model	R	R Square	Adjusted R Square
1	0.40*	0.16	0.16

Notes. * Predictor: occupational health and safety-oriented leadership. ** Dependent variable: state of health in the enterprise (according to absences from work due to occupational diseases).

Table 6. ANOVA

ANOVA**						
Model		Sum of Squares	Degrees of freedom	Mean Square	F	Sig.
1	Regression	24.16	1	24.16	28.05	0.000*
	Residual	126.78	61	0.86		
	Total	150.98	62			

Table 7. Regression model

Coefficients*						
		Non-standard coefficients		Standard coefficients		
Model		Beta	Standard error	Beta	t	Sig.
1	Constant	0.75	0.41		2.94	0.050
	Occupational health and safety-oriented leadership	0.59	0.11	0.40	5.30	0.000

Notes. Constant – constant represents a parameter evaluation; Beta – beta coefficient; Sig. – sig. represents statistical significance or risk.

This result shows that the factor “occupational health and safety-oriented leadership” has a statistically significant impact on the state of health in the enterprise (according to the number of the recorded occupational injuries). The hypothesis is thus supported.

The second hypothesis tested is as follows: H2: “Occupational health and safety-oriented leadership” in large Slovene enterprises has a statistically significant impact on the state of health in the enterprise (according to absences from work due to occupational diseases). The hypothesis was tested by simple linear regression, which is shown

in Table 5. The variable “occupational health and safety-oriented leadership” was used as an independent variable and “the state of health in the enterprise (according to absences from work due to occupational diseases)” as a dependent variable.

R² represents the adjusted coefficient of the explained variance, which is, in our case, 16.2 %. The proportion of the explained variance in our model is 16 %, which means that the dependent variable is well explained with the selected independent variables.

By using F statistics, we tested the full regression model. We measured the purpose and mean-

ing of the overall model. This is shown in Table 6. We obtained $F = 28.05$. We assess this as a good model, which provides efficient data accommodation and is statistically significant.

Standard regression coefficient (Beta) for this factor is shown in Table 7. The impact of the independent variable is statically significant.

We can conclude that occupational health and safety-oriented leadership in large Slovene enterprises has a statistically significant impact on the state of health in the enterprise (according to absences from work due to occupational diseases).

The third hypothesis tested is as follows: H3: Occupational health and safety-oriented leadership in large Slovene enterprises has a statistically significant impact on attitudes towards occupational health and safety (understanding of legislative requirements, attitudes towards investments and education in the field of occupational health

and safety, OHSAS 18001 standard, occupational health and safety as an enterprises' priority field and risk management in the enterprise). For testing this hypothesis we used the "enter" method as a method of multiple regression analysis, which are shown in Table 8, Table 9 and Table 10, and includes all the variables and evaluates the regression coefficients for all independent variables simultaneously [59].

The impact of all independent variables is statically significant, and the standardized regression coefficients reveal that attitudes towards occupational health and safety (understanding of legislative requirements, attitudes towards investments and education in the field of occupational health and safety, OHSAS 18001 standard, occupational health and safety as the enterprises' priority field and risk management in enterprise) are considerably affected by the occupational health and safety-oriented leadership.

Table 8. Regression model

Model**			
Model	R	R Square	Adjusted R Square
1	0.56*	0.31	0.29

Notes. * Predictor: occupational health and safety-oriented leadership. ** Dependent variables: top managers' attitudes towards occupational health and safety.

Table 9. ANOVA

ANOVA**						
Model		Sum of Squares	Degrees of freedom	Mean Square	F	Sig.
1	Regression	19.62	1	4.91	16.15	0.001*
	Residual	43.74	61	0.30		
	Total	63.36	62			

Table 10. Regression model

Coefficients*						
Model 1		Non-standard coefficients		Standard coefficients		Sig.
		Beta	Standard error	Beta	t	
	Constant	1.54	0.28		5.47	0.00
	Understanding of legislative requirements	0.53	0.10	0.55	5.22	0.00
	Attitudes towards investments and education	0.49	0.12	0.36	4.47	0.00
	OHSAS 18001 standard	0.39	0.08	0.41	5.28	0.00
	Occupational health and safety as the enterprises' priority field	0.38	0.08	0.40	5.17	0.00
	Risk management in the enterprise	0.36	0.07	0.38	5.12	0.00

Notes. Constant – constant represents a parameter evaluation; Beta – beta coefficient; Sig. – sig. represents statistical significance or risk.

5. Discussion and conclusion

Nowadays, sustainable development has become one of the most important issues in modern societies, and concern for employees' health and safety is closely related to it. According to [60], the top-down support of top managers is the key factor to achieve quality outcomes in the area of occupational health and safety in an organization.

Top managers' attitudes towards occupational health and safety in organizations and their willingness to improve the present situation and the style of leadership – in terms of critical factors defined according to Inc. BST^R and Leading with SafetyTM – are the key data by which we can influence the trends in the field of occupational health and safety. Managers are believed not to consider the care for occupational health and safety as a legal burden but as a great opportunity for boosting the competence and outcomes of their enterprises [48, 61]. The benefits that can arise from a good occupational health and safety practice can be reflected in lower costs, lower risk, lower rate of absences, fewer accidents, fewer lawsuits and penalties, better relationships between the participants in the business chain, better enterprise's reputation in their working environment and better reputation with their customers and investors as well as a higher level of employee satisfaction. Consequently, this results in a higher productivity and innovativeness as well as competitiveness and the pertaining business outcomes [49, 61, 62]. Each organization has its formal and informal side. Both of them are significant for achieving the required outcomes which are related to ensuring occupational health and safety, and, indirectly, also to achieving favorable business results [63]. The formal side of organizational structures refers to management systems or the use of mechanisms, while its informal side refers to leadership (leader's informal management practices) or the use of culture, i.e. the use of vision, credibility, cooperation, feedback, acknowledgement, accountability, communication and direction to action [64].

Occupational health and safety in enterprises is not exclusively regulated by the legislation and its requirements. This issue can be regulated also in other ways, especially by being aware of the fact that even by using state-of-the-art machin-

ery, appropriate amount of capital, developmental knowledge, available markets, etc., it is not possible to achieve sustainable business and other type of results without healthy, properly qualified and satisfied employees, »speaking the same language« and sharing the same goals. It is the top management's responsibility to adopt a proper attitude towards occupational health and safety and to implement safety leadership.

This study partially fills up the defined gap resulted from a lack of research dealing with the attitude of senior management towards occupational health and safety in the area of empirical data processing related to the safety leadership of top managers in ensuring occupational health and safety as well as to their attitude towards this issue. The research allows us to gain an insight into this issue by the self-assessment of the Slovene's managers' leadership towards occupational health and safety. As this is the first attempt in the Republic of Slovenia (according to the information we could obtain) that deals with this issue in such a way, the collected data will be helpful to other researchers in their studies of the top management and occupational health and safety in Slovenia. The empirical contribution of this study will be helpful to policy makers in the area of occupational health and safety in Slovenia (professionals, law makers and employers) as well as to top managers in their everyday work in Slovenia and outside its borders.

The research findings' contributions are theoretical as well as empirical. The theoretical contribution relates to gaining information on new findings related to top managers' leadership towards occupational health and safety.

The structure of our research enabled us to compare our research with a similar one conducted in other cultural environment. This comparison allows us to provide a clearer picture and understanding of top managers' behavior in a global competition and the issues related to managing occupational health and safety.

The research findings can be useful for top managers as well as for policy makers in the area of occupational health and safety, as we established that occupational health and safety-oriented leadership is related to occupational health and safety indicators (work injuries and absence due to occupational diseases). Other researchers [31, 37, 38, 39, 40,

42] also showed the relationship between leadership and safety performance, but for other health and safety indicators. We also established that the top management's awareness of the importance of occupational health and safety and their leadership oriented towards it has a positive impact on the systems approach and the established behavior or attitude towards occupational safety. Our results are in accordance with those of the previous studies, which also showed a positive relationship between leadership and attitudes towards occupational health and safety [31, 32, 62, 65, 66].

We should also emphasize that the results of this study are not definite or finite. They expose many relevant topics in terms of the relationship between occupational health and safety and leadership, however, the research leaves open several questions for future research. Such research could include an analysis of other indicators of occupational health and safety, taking into account psychological and physical working environment.

It would be also of great importance to identify the factors that create the need for and turn attention to occupational health and safety in top managers. Among external factors influencing the work of top managers, it would be essential to examine what form of legislation acts as an incentive for top managers in terms of occupational health and safety. Good results, related to occupational health and safety, cannot be achieved in a short term as ensuring occupational health and safety presents a long-term investment into an organization. It would be essential to establish how to motivate top managers to face the fact that only healthy and satisfied employees are able to contribute to a long-term business success.

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Correlation between sickness absence, job satisfaction, emotional exhaustion and fluctuation

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Abstract

The fundamental purpose of this article is to use theoretical and empirical results to show the different relationships between several concepts: sickness absence, job satisfaction, emotional exhaustion and fluctuation. We analysed the results of an extensive survey questionnaire developed as part of the INODEL project. The sample consisted of 942 respondents from the target population of employees of Slovenian businesses. Correlations between the concepts analysed are for the most part very weak, yet statistically significant. The correlation between sickness absence and job satisfaction is negligible and negative, while the correlation between emotional exhaustion and sickness absence is negligible and positive. Both correlations are statistically significant. There is no significant correlation between fluctuation and sickness absence. In terms of the overall impact of the above factors on the rate of sickness absence, ordinal regression only showed a significant impact in the case of job satisfaction.

Key words Absenteeism, sickness absence, job satisfaction, emotional exhaustion, fluctuation.

1. Introduction

In every working process a variety of activities are carried out every day whose performance is linked to a range of problems, the intensity of which can have various impacts on the working process. Organisations in the private and public sectors are not immune either to the problems of employees being absent from work or failing to perform previously agreed tasks. Employees can be absent from the workplace because of holidays, their own health problems, health problems of family members, education and training, etc. This shows that absence from work is a complex and multidimen-

sional area that needs to be dealt with carefully and correctly. Although there are different kinds of absence from work, practice shows that organisations devote most attention to the absence of employees due to sickness, either of employees themselves or of their family members. Such absence from work is referred to in the literature as absence from work or sickness absence. Sometimes the expression absenteeism is also used.

Løkke et al. [1] explain absenteeism as an individual's lack of physical presence at a given location and time when there is a social expectation for him or her to be there. Briner [2] on the other hand believes that absenteeism is simply non-attendance at work by an employee, although owing to its complexity this phenomenon is more difficult to explain. Briner's explanation of absenteeism suggests that it is a complex social and organisational phenomenon that has different dimensions.

The importance of distinguishing between different conceptions of absenteeism is explained by Van der Merwe and Miller [3], who divide the general concept of „absenteeism“ into three categories, which help us understand the multidimensional nature of absenteeism. They classify or divide absenteeism into three categories as follows [1]:

- sickness absence (absence of employees for health reasons);
- authorised absence/absence with permission (holiday, education and training, etc.);
- unexcused absence/absence without leave (arriving late for work, leaving work early).

Exact definitions of the concept of absenteeism are also important for understanding of absence from work in the present article. In this article we in fact only focus on those absences from work that are related to sickness, and ignore those related to education, holidays, etc. With this as our

starting point, we therefore place in the foreground *absence from work or sickness absence, which we define as a specific situation related to the non-attendance at work by employees at a time when work is available for them or they are expected to be performing agreed tasks. This therefore means those times when employees are not working or are unable to work because of sickness or injury or because they are caring for a family member, and such absence has a limited duration.*

In Slovenia between 38,000 and 40,000 employees are absent from work every day, meaning that approximately 4–5% of all workdays in the year are lost due to sickness absence. Slovenia has one of the highest levels of sickness absenteeism in the EU. Such figures point to a problem that is also evident in the financial consequences suffered by employers, the State and employees as a result of sickness absence. For this reason the State and employers undertake various activities through which they attempt to reduce sickness absence. In the working environment it can be seen that increasing attention is being devoted to improving working conditions, improving the health and well-being of employees in the working environment, etc. More and more studies [4, 5, 6] show that the causes of sickness absence are connected above all to factors that shape the working environment (working conditions, colleagues, managers, etc.). Løkke et al. [1] also believe that the principal causes of temporary sickness absence should be sought above all in the working environment, or in numerous factors of the working environment such as management style, the nature of the work, relations between colleagues, employee satisfaction and well-being, etc. Within the INODEL project we have also attempted to identify the correlation between employees' sickness absence and job satisfaction, fluctuation and emotional exhaustion.

This main aim of the article is to present the theoretical and empirical results of the INODEL project and show the relationship between employees' sickness absence and job satisfaction, emotional exhaustion and fluctuation.

The following hypotheses were developed from the aims of the study:

- H1: Employees who have changed employer in the past year are more frequently sickness absence than those who have not.

- H2: Job satisfaction is connected to sickness absence.
- H3: Among employees who have been absent from work in the last year and those who have not, there are differences in emotional exhaustion.
- H4: Fluctuation, job satisfaction and emotional exhaustion have an impact on sickness absence.

Analysis of the relationships between the concept is dealt with in this article can also be shown schematically by means of a diagram (Figure 1). This graphic representation clearly shows that we are testing for hypotheses, where the first three involve an analysis of the relationship between sickness absence and fluctuation (H_1), job satisfaction (H_2) and emotional exhaustion (H_3), while the fourth involves the overall impact of these variables on sickness absence (H_4).

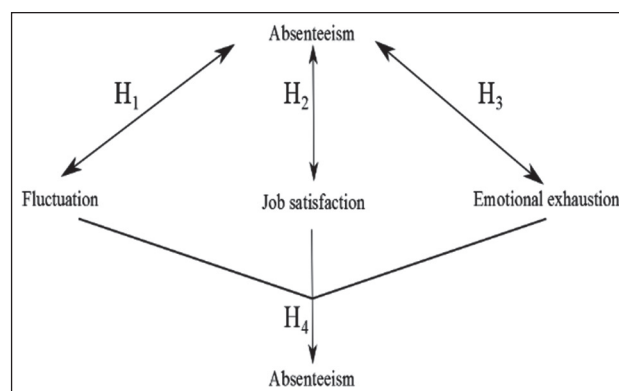


Figure 1. Relationships between concepts, which we analysed by testing four hypotheses

2. Sickness absence, emotional exhaustion, job satisfaction and fluctuation

2.1 Sickness absence and job satisfaction

The role of employees in an organisation is unquestionably important, and it is therefore logical to dedicate attention not only to the external public, but also to employees. Employees need to be treated with respect and a relationship needs to be established where employees perceive the importance of doing their job (in other words why performing tasks is important and what the result is). Job satisfaction can be defined as an employee's satisfaction with the individual factors that

make up the job, in other words: tasks, colleagues, managers, working conditions, opportunities for education/training and promotion, working hours, pay, bonuses and additional benefits, etc. Mathis and Jackson [7] explain that employees' job satisfaction is tied up with a positive emotional state that is the result of their experiences at work. Dissatisfaction at work occurs when employees' expectations are not met.

The literature includes studies that confirm a correlation between employee job satisfaction and absence from work, or the impact of the former on the latter, and also studies that do not confirm such a correlation. The latter group includes a study carried out by Goldberg and Waldman [8] among hospital employees in the United States of America, the results of which showed that no correlation exists between sickness absence and job satisfaction. On the other hand a study by Zabin (in Abu Sheikha and Younis, [9]) confirms that job dissatisfaction is one of the main reasons for sickness absence. The analyses of Dionne and Dostie [10] and Brown and Sessions [11] confirm that job dissatisfaction increases sickness absence.

A study carried out by Kristensen et al. [12] in the Danish banking sector shows that higher job satisfaction among bank employees has the effect reducing sickness absence. The factors identified by the authors of the study as having an influence on employee satisfaction included pay, benefits or bonuses, and participation in the organisation. The results of the survey showed that the most important factor influencing job satisfaction is participation in the organisation: the greater the satisfaction with participation in the organisation, the less absence from work. A study by Ybema et al. [13] shows that a correlation exists between employee satisfaction and temporary absence from work. This study took as its starting point the hypothesis that if employees are frequently absent or are absent for a long time, this will be manifested through an increase in job dissatisfaction. The results of their study confirm the hypothesis that the impact of employee job satisfaction and absence from work is reciprocal. Employees who are frequently absent from work will be less satisfied, and employees who are dissatisfied at work are more likely to be absent more frequently in the future. Tharenou [14] also demonstrates that

sickness absence (above all brief absences) affects job satisfaction in subsequent years, although the study was not able to confirm the reverse effect.

Not with standing the fact that many studies focus on the search for a correlation of the factors of job satisfaction and mental health at work with sickness absence, Ybema et al. [13] believe that it is still not entirely clear whether we can treat these factors as consequences or causes of sickness absence. The fact is, the majority of studies have shown that job satisfaction and sickness absence are negatively correlated. This means that (1) dissatisfaction in the workplace leads to an increase in absence from work and that (2) greater absence from work leads to the dissatisfaction of employees in the workplace.

2.2 Sickness absence and emotional exhaustion

Employees perceive numerous organisational factors in the working environment at the emotional level, and even in interpersonal relations the emotions play an important role. In the opinion of Musek [15] they can be defined as a complex mental phenomenon that has multiple aspects. In addition to observable behaviour, the emotions are also accompanied by numerous less noticeable and imperceptible physiological reactions, among the most common of which are physiological changes, changes in cardiac activity, in the functioning of the cardiovascular system, in respiration, etc. Also closely connected with the emotions is the aspect of emotional exhaustion, which appears in correlation with burnout syndrome. Emotional exhaustion is manifested above all as a lack of energy and through the feeling that one has drained one's emotional reserves. Such depersonalisation or dehumanisation is expressed above all in relations with other people and can be seen in the fact that the individual behaves towards people as though they were objects (cold attitude). In cases where burnout appears in employees, along with the related aspect of emotional exhaustion, the latter can also have the effect of rendering employees incapable of working, in other words it can lead to sickness absence. The results of a study by Karatepe and Choubtarash [16] also show that the emotional dissonance represented by the mismatch between emotion displayed and emotion felt can lead to emotional exhaustion,

which in turn exacerbates turnover intentions and absenteeism. Employees trying to manage their emotions by displaying controlled facial and physical expressions that are organisationally desired are emotionally exhausted. Such employees in turn exhibit negative job outcomes such as turnover intentions and sickness absence (Karatepe and Choubtash, 2014).

2.3 Sickness absence and fluctuation

Fluctuation occurs as the consequence of various processes taking place both inside and outside the organisation. We use this term to denote the dynamic movement of employees that is reflected in the outflow (i.e. departure) of employees from a company. We distinguish between various types of fluctuation – but in this article we focus on „undesired“ fluctuation, which relates to the departure of individuals who have a positive influence on the achievement of results. Such employees are necessary from the operational point of view and must therefore be replaced when they depart. This can have numerous consequences that have a significant impact on the future effectiveness and performance of the organisation [17]. Chiboiwa et al. [18] point out that studies have identified various causes affecting fluctuation, where those particularly highlighted include the reward system, the management style, poor working relations, a lack of recognition (praise), poor prospects of promotion, a lack of interesting work, etc.

3. Research

3.1 Methodology

The INODEL project included two studies that researched several areas (stress and burnout in the workplace, sickness absence, emotional exhaustion, fluctuation and coordination of professional and family life, and in this paper we present some of the results of the second study. The target group of the study consisted of employees of organisations in Slovenia.

Data were collected using a combination of CAWI (computer-assisted web interview) and pen and pencil methods. Data collection was carried out from March to April 2012. The final sample

consisted of $n = 942$ respondents. Employees from various companies and the public sector were invited to participate in the study. The criteria for selection of participants were their working status (they had to be employed) and their age (at least 18 years old).

The data were collected in two ways:

- T.I.M. randomly selected people included in their panel that met inclusion criteria and invited them to participate in the study ($n = 577$ responded to the invitation).
- Students of the Faculty of Administration at the University of Ljubljana were asked to give questionnaires to relatives or friends who met the inclusion criteria ($n = 365$ questionnaires were returned).

The paper covers the relationships between four concepts: sickness absence, fluctuation, job satisfaction and emotional exhaustion. The first two concepts are directly measurable, while for the other two we measured a number of aspects. In order to measure fluctuation we used the survey question „Have you ever changed jobs of your own volition?“, where the possible answers were Yes (fluctuation is present) and No (fluctuation not present).

We measured sickness absence using the survey question „How many DAYS (in total) were you absent from work in the last 12 months for health reasons (e.g. sickness, injury)?“, where respondents chose one of ten ranked possibilities. The coded value 1 meant that employees had not been absent from work in the past year, 2 meant that they had been absent less than three days, and so on. The greater the value, the longer the absence, while the highest value of 10 included all employees who had been absent from work for more than 30 days. We can already talk about absenteeism in cases where a respondent gives a reply that is greater than 1, but our further analysis will consider the original answers, since these offer more information about the rate of absenteeism.

To measure job satisfaction we used a set of eight questions, which measured agreement with specific statements on a 5-point scale (aspects of job satisfaction: communication between management and employees, clarity of tasks, pay, frequency of financial rewards, meaningfulness of work, enjoyment of the job, attitude of superiors, prospects of pro-

motion). Two questions in the basic questionnaire were for inverted test purposes, such that a value of 5 represented the lowest level of satisfaction and a value of 1 the highest. In our subsequent analysis we inverted the scale in these two cases and took the average of the eighth statements as the rate of satisfaction. The higher the average values, the greater the job satisfaction of employees. Emotional exhaustion is measured in a similar manner to job satisfaction, taking the average of 10 statements measured, in this case, on a 7-point scale where a value of 0 means that the respondent never encounters the given situation and a value of 6 means that the respondent encounters the situation every day. Individual situations are taken from the Maslach Burnout Inventory (MBI) and include exhaustion, feeling used up, fatigue, an unfeeling and impersonal response towards clients, finding work burdensome, burnout, insensitivity towards other people, impact on the lives of others, and effective discussion with clients.

3.2 Results

In this section we will begin by offering some basic data regarding our sample, i.e. descriptive statistics of demographic variables. We will then test all four hypotheses. In the case of the first three will present the analysed attitudes in graphic form, and then carry out the relevant statistical test.

Our study included 942 respondents, of whom 63% were women and 37% were men. The mean age was 38.7 years with a standard deviation of 10.5 years. The majority (55%) of employees had completed some form of tertiary education, 43% held a secondary qualification and 2% held an elementary qualification or lower. The majority of respondents were from the Central Slovenia region (48%), followed by the Gorenjska region (13%), the Pomurska region (8%) and the Podravska region (7%). The average length of employment of respondents was 16.1 years, with a standard deviation of 11.7 years.

H1: Employees who have changed employer in the past year are more frequently absent from work than those who have not.

Hypothesis H1 talks about a correlation between fluctuation and sickness absence and states

that the values of the variable that measures absenteeism, in the group of those employees who had already changed employer, are more displaced towards higher values. We will test it against the null hypothesis, which states that the distributions of absenteeism are the same in both groups. Since we are comparing two groups of units (two independent samples) with regard to the value of multiple variable, use of the Mann-Whitney statistical test is appropriate. Table 1 shows the picture in the sample. In the group of those who had already changed job (employer) in the past, the average rank of the variable "absenteeism" is in fact greater (315.22) than for those who had not changed job (employer) (297.61), but according to Table 2, this difference is not statistically significant at a 5% risk level (two-tail p-value Sig=0.208, one-tail 0.104). This means that in statistical terms we cannot claim that employees who have changed employer in the past year are more frequently absent from work than those who have not.

Table 1. Correlation of absenteeism with changing jobs (employer) in the past

	Fluctuation	N	Mean Rank	Sum of Ranks
Absenteeism	Fluctuation = Yes	291	315,22	91729,50
	Fluctuation = No	320	297,61	95236,50
	Total	611		

Table 2. Correlation of absenteeism with changing jobs (employer) in the past

	Absenteeism
Mann-Whitney U	43876,500
Wilcoxon W	95236,500
Z	-1,260
Asymp. Sig. (2-tailed)	,208

H2: Job satisfaction is connected to sickness absence (absenteeism)

In the second hypothesis we test whether a correlation exists between job satisfaction and absenteeism and how strong it is. In order to measure the strength of the correlation between the two variables, which are ordinal in nature, we will calculate the Spearman's rank correlation coefficient and test the hypothesis of whether its value is equal to or different from 0. In statistical terms we

Table 3. Correlation of absenteeism with job satisfaction

			AB	JB
Spearman's rho	Absenteeism (AB)	Correlation Coefficient	1.000	-.147**
		Sig. (2-tailed)	.	.000
		N	619	614
	Job satisfaction (JS)	Correlation Coefficient	-.147**	1.000
		Sig. (2-tailed)	.000	.
		N	614	843

** Correlation is significant at the 0.01 level (2-tailed).

Table 4. Correlation of absenteeism with emotional exhaustion

			AB	EE
Spearman's rho	Absenteeism (AB)	Correlation Coefficient	1.000	.109**
		Sig. (2-tailed)	.	.007
		N	619	600
	Emotional exhaustion (EE)	Correlation Coefficient	.109**	1.000
		Sig. (2-tailed)	.007	.
		N	600	815

** Correlation is significant at the 0.01 level (2-tailed).

Table 5. Correlation of absenteeism with fluctuation, job satisfaction and emotional exhaustion

Model Fitting Information				
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	2111.671			
Final	2095.541	16.130	3	.001

Link function: Logit.

will place the null hypothesis $H_0: \rho=0$ against the alternative $H_1: \rho \neq 0$. The calculated sample value of -0.147 implies a very weak negative correlation which, however, is statistically significant (Table 3: p-value Sig<0.001). At a 5% risk level we thus confirm our second hypothesis, namely that a very weak but significant negative correlation exists between job satisfaction and absenteeism.

H3: Among employees who have been absent from work in the last year and those who have not, there are differences in emotional exhaustion

From the statistical point of view hypothesis number 3 is similar to hypothesis number 2, except that in this case we analyse the relationship between another two variables. In order to measure the strength of the correlation between absenteeism and emotional exhaustion, we again use Spearman's rank correlation coefficient. The results are shown in Table 4. The calculated value of 0.109 again implies a negligible positive yet statistically significant (p=0.007) correlation. At a

5% risk level we thus confirm our third hypothesis, namely that a very weak but significant negative correlation exists between job satisfaction and absence from work.

H4: Fluctuation, job satisfaction and emotional exhaustion have an impact on sickness absence (absenteeism)

In our last hypothesis we analyse whether we can explain the values of the response variable „absenteeism“ with fluctuation, job satisfaction and emotional exhaustion. Given the ordinal nature of the response variable, the problem is suitable for ordinal regression, where in view of the type of variables we treat fluctuation as a factor and emotional exhaustion and job satisfaction as covariates.

The results of ordinal regression showed that its predictions are typically better (p=0.001) than the predictions that would be given by prediction using the free term alone (Table 5 „Model Fitting Information“), which means that independent variables have a significant impact on the values of

the dependent variable. Our results shows that at a 5% risk level there is a significant impact of job satisfaction (p-value Sig=0.013), while the influence of the other two variables is non-significant (emotional exhaustion: Sig=0.072, fluctuation Sig=0.298).

Table 6 („Goodness of Fit“) indicates that our data are suitable for the model (p-value Sig=0.601), although all the values of the pseudo R-square show that the impact is very weak (Table 7 „Pseudo R-Square“). We can therefore conclude that the analysed factors of fluctuation, job satisfaction and emotional exhaustion have a very weak impact on absenteeism, but that in the case of job satisfaction the latter is statistically significant.

Table 6. Correlation of absenteeism with fluctuation, job satisfaction and emotional exhaustion

Goodness of Fit			
	Chi-Square	df	Sig.
Pearson	4364.480	4389	.601
Deviance	1972.786	4389	1.000

Table 7. Correlation of absenteeism with fluctuation, job satisfaction and emotional exhaustion

Pseudo R-Square	
Cox and Snell	.027
Nagelkerke	.027
McFadden	.007

3. Discussion

Statistical analysis of the study showed that there is no significant correlation between fluctuation and absenteeism (Mann-Whitney test: p=0.208). This means that we cannot claim that those employees who have changed employers in the past have a greater propensity for absence from work than those who have not changed employers. The latter result shows that changing jobs in the past does not represent a cause, in the sense of being able to conclude that those employees who have changed jobs in the past have a greater propensity to be more or less absent from work in comparison with those who have not changed jobs.

Analysis of the correlation between absenteeism and job satisfaction revealed a very weak negative correlation (Spearman’s rho=-0.147) which, however, because of the large sample is statisti-

cally significant (p<0.001), while analysis of the correlation between emotional exhaustion and absenteeism showed a negligible positive but statistically significant impact (Spearman’s rho=-0.109, p=0.007). The weak correlation between absenteeism and job satisfaction in a way indicates and shows something that has already been established in numerous international studies, namely that the higher the level of job satisfaction, the lower the rate of absence from work.

In our analysis of the overall impact of fluctuation, job satisfaction and emotional exhaustion on absenteeism, we used ordinal regression to identify a negligible (low pseudo R-square values) but statistically significant overall impact (p=0.001). Of the individual factors within the model, the impacts of fluctuation and emotional exhaustion are non-significant (p=0.298 and p=0.072), while the effect of job satisfaction is significant (p=0.013). On the basis of these results, we can state that employees’ satisfaction with their job has the most marked impact on their absence from work, which is no surprise. We did however expect a greater impact on absence from work to also be shown in the case of emotional exhaustion. We expect the latter above all because of the numerous observed pressures in the working environment and other external circumstances which employees have to cope with and which have an impact on their emotional system.

4. Conclusion

Sickness absenteeism in organisations appears as the consequence of numerous factors and is also influenced by the interweaving of organisational factors that can then, as an interconnected whole, impact on employees in such a way that sickness absenteeism occurs. This phenomenon is increasingly becoming the object of study, because of the numerous negative consequences that it causes for employers, the State and also employees themselves. It clearly makes sense to view the occurrence of sickness absenteeism from the points of view of knowledge of the working environment of the organisation in which it occurs, the personality characteristics of employees and their related needs, and the moral and ethical norms of employees. At the same time it is essential not to overlook the normative regulation of sickness absenteeism in the country.

In the context of the INODEL project we verified the existence of correlations between sickness absenteeism and employee job satisfaction, emotional exhaustion and fluctuation. The results of the study showed that except in the case of one variable, we are unable to confirm a correlation with sickness absenteeism. Only in the case of the variable “job satisfaction” are we able to confirm, with a risk level of 5%, that a very weak but significant negative correlation exists between job satisfaction and absence from work. Following from this, we can state in principle that the satisfaction or dissatisfaction of employees in the workplace at those organisations in Slovenia included in the study is connected to absence of employees from work.

The emotional perception of some factors that are important to employees in the working environment is seen as a result of satisfaction or dissatisfaction of employees in the workplace. Also linked to emotions is the aspect of emotional exhaustion, which appears in correlation with employee burnout. Our study also aimed to establish whether a connection exists between emotional exhaustion and absence from work. The results showed that although such a statistical connection (negligible positive) does exist, the impact of emotional exhaustion is non-significant in the analysis of overall impact. The latter surprised us, since we expected that it would be possible to confirm its impact in the analysis of the overall impact of all three variables on absence from work. We expected this result above all because the study was carried out at a time of financial and economic crisis in Slovenia. We therefore expected a high incidence of stress, burnout, job security worries, etc. among employees. All these factors are closely linked to aspects of emotional exhaustion. We also failed to detect a correlation between absenteeism and fluctuation.

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A methodology to select the price criterion in public procurement

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Abstract

The construction sector is a key driver for economic growth in any nation and public procurement is one of its pillars – hence the importance of the study and investigation of its mechanisms, especially tendering criteria. Price is the main deciding factor for most tenders and projects must have an appropriate base price relative to market price to avoid problems during the execution of the project.

Most research on price criteria has been developed from the point of view of bidders and has discussed the development of tools and methodologies for determining the optimal bid price.

In this paper we propose a methodology for public procurement procedures from the point of view of the administration. The methodology enables setting all aspects of the price criterion based on the size of the project budget, the nature of the work, and the number of bidders.

Key words: public procurement, tendering, contracting authority, scoring system, public works, selecting contractors

1. Introduction

The construction sector is a key driver for economic growth in every nation [1] and public procurement is one of its pillars [2-4]. The public procurement of construction projects differs in practice from the private sector [2, 5] and is more complex [6-8]. Research on the characteristics of public procurement has focused on the selection of tendering criteria and the development of tools to assist bidders make decisions.

Research on tendering criteria has traditionally focused on developing optimal bidding price prediction models or bidding strategies [9-12] and less attention has been paid to the analysis of other criteria or attributes [13-18].

The decision about whether to participate in a tender is complex, and the decision factors and their relative importance vary between businesses [7, 19-24]. Models have been developed that assist decision making based on: neural networks [25-28]; AHP-ANP techniques [29-30]; game theory [31]; DEA techniques [32-33]; or a combination of several techniques [34].

Other researchers have developed mathematical models that assist in making decisions as to whether or not to tender, and if so, determine the optimum value based on several criteria including risks for bidders [18, 35-36]. Other researchers have taken into account only price criteria and have developed prediction models based on the historic time series of auctions and tenders in a given public body [3, 37].

Many of these investigations have been developed from the point of view of bidders, regardless of the fact that the state administrations and governing legislation evolve slowly, and that each public agency (national, regional or local) has certain preferences (sometimes non-explicit) when selecting criteria for public tenders [38].

The aim of this work is to develop a methodology that enables the contracting authority to set the price criterion during the preparation of a tender (i.e., select the weighting of price against other criteria such as abnormal pricing and scoring formulae) depending on the characteristics of the contract.

2. Background

Directive 2004/18/EC [39] regulates public procurement in the European Union. The directive describes two tendering procedures, the first of which is used when only the price criterion is applied. The second procedure is used when several criteria are applied – including price

The evaluation criteria used can be divided into two groups: criteria evaluated using formulae; and criteria evaluated by value judgments. For the first group, various predetermined formulae can be employed that include aspects such as price, delivery time, etc. However, scores for criteria evaluated using value judgment will always contain some subjective bias that reflects on the individual who performs the evaluation.

Directive 2004/18/EC requires that criteria assessable by value judgment are evaluated before the criteria for evaluation by formula are known – so lessening the possibility of fraud. Both best practice and the directive specify that criteria evaluated by formula must be given greater weight than criteria evaluated by value judgment.

Administrative and technical bid terms define the weight of each of the evaluation criteria and the scoring formula for each criterion (for the price criterion as known economic scoring formulae, ESF). Any abnormally low bid criteria (ALBC) must also be stated.

There are previous works on ESF [17, 38, 40-42] analyzing tender operation and offering guidelines or recommendations for use. Abnormally low bid criteria have been less studied, although interest has increased in recent years as these criteria provide the first filter for detecting inadequate bids or a bids that could endanger the project [4, 43-47].

3. Basic Definitions

This study will primarily use terms and concepts used in the European and Spanish construction industries. To help improve understanding some concepts as described below.

The economic value of the tender is the contract execution budget (CEB) plus value added tax (VAT). CEB reflects the investment required to implement a project and is composed of the material execution budget (MEB), overheads (OH) and profit (P).

MEB reflects the cost of implementing the various units that make up the project, while OH reflects a percentage of between 13% and 17% of the MEB that covers the structural, financial, tax, and other costs that fall on the contractor. The contractor's profit is seen as a percentage of MEB – and is usually 6%.

The cost or price of each of the project work units consists of direct costs (DC) and indirect costs (IC). DC includes the labour (LAB) directly involved in the execution of the work unit, materials on site (MAT), as well as the staff costs, fuel and energy used operating machinery and equipment, and depreciation and maintenance of equipment and facilities (MACH). These costs are reflected formally in the budget document known as the simple pricing table (labour, materials and equipment). Additionally, all units of work usually include a small percentage called supplementary direct costs (SDC) that includes small items of equipment or tools that are difficult to quantify.

Some work units may include other simple work units called ancillary prices: such as mortar and cement. These are defined in the budget document in the simple pricing tables and in the present study are termed AP.

IC includes installation costs for on-site offices, communications, construction of warehouses, workshops, temporary building for staff, laboratories, costs of technical and administrative staff assigned exclusively to the work, and contingencies. IC is usually computed as a constant percentage of DC for all project work units – depending on the nature of the work, the total budget, and the expected project completion time.

In short, we can calculate that the material execution budget (MEB) is equal to:

$$MEB = MACH + LAB + MAT + AP + SDC + IC \dots\dots\dots (1)$$

4. Proposed methodology

The proposed methodology represents a control and price justification tool for public contractors and helps officials make safer, more objective, and less arbitrary decisions regarding weighting criteria, possible cases of abnormal pricing and scoring formulae.

The methodology should be applied from the beginning of the tendering process and is divided into four phases:

- A. Economic study of the construction project
- B. Determination of the weighting of the price criterion
- C. Selection of abnormally low bid criteria

D. Selection scoring formula for price criteria

4.1. Phase A: Economic study of a construction project

The first phase involves an economic review of the project (Figure 1). From the project budget the following indices are calculated:

- Percentage of the amount of equipment used in the project compared to the material budget – here in after referred to as % MACH.
- Percentage of the amount of labour employed in the project compared to the material budget – here in after referred to as % LAB.
- Percentage of the amount of materials used in the project compared to the material budget – here in after referred to as % MAT.

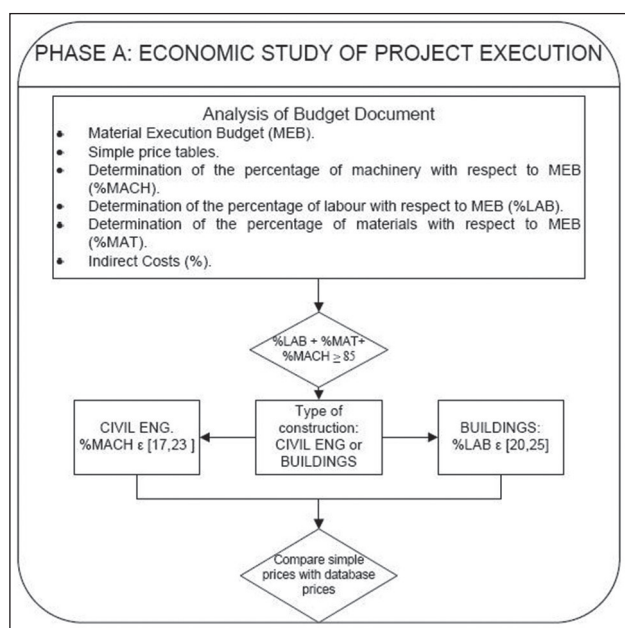


Figure 1. Phase A: Economic study of the project

The calculated values enable the following equation to be completed in terms of percentages (1):

$$MEB (100\%) = \%MACH + \%LAB + \%MAT + \%AP + \%SDC + \%IC \dots\dots\dots (2)$$

An analysis of a sample of 100 construction tenders [4, 38] showed the following equation to be fulfilled in 70% of the projects studied:

$$\%MACH + \%LAB + \%MAT \geq 85\% \dots\dots\dots (3)$$

If this requirement is not met then the project should be referred to the project oversight office of the contracting body (or a departmental specialist) for a review of the project and budget.

Secondly, after fulfilling (3) a distinction is made between civil engineering and buildings projects. According to the analysis of the sample, the following conclusions can be made for defining the parameters and ranges of each type of project (Table 1):

- Materials are generally the largest part of the budget both in civil engineering and building projects.
- The percentage of labour with respect to building project budgets is generally around 20% to 25%.
- The percentage of labour with respect to civil engineering budgets is generally between 10% and 20%.
- The percentage of the machinery budget in civil engineering budgets is usually between 5% and 25% with major fluctuations that can mean the machinery budget can sometimes exceed the materials budget.

Table 1. Labour and machinery ranges

Project Type	Parameter	Range
Buildings	Labour (%LAB)	20 – 25
Civil Eng.	Machinery (%MACH)	17 - 23

Certain types of civil engineering and building projects can produce changes in these percentages – for example, the construction of a tunnel using a boring machine would mean that the machinery component would have greater weight than is usually found in civil engineering projects. Another example is the construction of a precast structure in which the labour component would have exceptionally little weight. In any case, out of range values reflect the uniqueness of a construction process, or the project itself, and this information may help the contracting authority validate or reject the material execution budget for the project.

The last step of this first phase consists in verifying the total project price according to market prices – and this is achieved by checking the basic prices included in the project with the basic database prices for the geographical area.

The last step is divided into several tasks:

T1. Selection of basic prices of the materials, labour, and machinery with the greatest economic weight in the project.

Prices are selected from basic price tables using a total of ten units from each category (labour, machinery and materials).

T2. Check basic prices of materials, labour, and machinery on the reference database.

The sample of selected prices is considered valid when at least 20 basic prices (of the 30 selected) from the project are compared with 20 basic prices from the reference database.

The acceptance criterion for basic prices is that there is no more than a 15% difference above or below database prices.

T3. Project qualification from the price standpoint.

A project is considered valid from the price point of view when at least 70% of basic prices (namely, 14 items) have been accepted after comparison with the reference prices.

If a project is deemed valid, then the contracting authority will consider that the cost of the project matches market prices and so the project will be advanced to Phase B of the methodology. If a project is considered invalid, the project will be returned to the project team for an analysis of the proposed solution with respect to market prices (including materials used and construction process).

Projects involving implementation processes, organisational processes, technologies, materials, or locations that are unusual may be regarded as special projects and the contracting authority, having submitted the project to the corresponding economic analysis described above, must decide on the viability of the project. If the project is declared invalid economically but the contracting authority decides to make it viable because of its special characteristics, then this decision must be appropriately justified with an explanatory document placed in the project file.

4.2. Phase B: Determination of the weighting of the price criterion

In the second phase (Figure 2) the weighting of the price criterion is selected. Firstly, we must distinguish between an auction (where price is the

sole criterion) and tendering (various criteria employed). In auctions the price weighting is 100%.

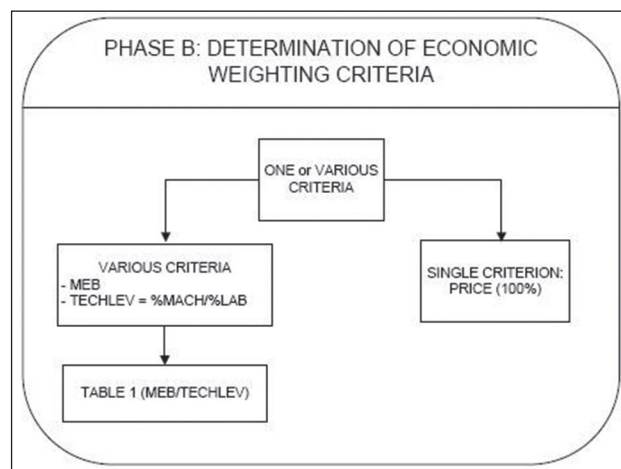


Figure 2. Phase B: Determination of price weighting

If the tendering process involves several criteria then the technological level (TECHLEV) of the project is now determined, meaning the need for machinery or equipment to execute the project is compared with the amount of labour needed. The technological level can be expressed as the ratio between the percentage of machinery (% MACH) and the amount of labour (% LAB) used in the project.

$$TECHLEV = \frac{\%MACH}{\%LAB} \dots\dots\dots (4)$$

The technology level is expressed as one, and the range of possible values is then defined:

- Construction, TECHLEV ∈ [4 - 0].

The maximum value of 4 corresponds to the assumption that the value of % MACH is equal to 80 and the value of %LAB is equal to 20, a situation that corresponds to the unlikely situation of a project that does not require any material (% MAT = 0).

The minimum value of 0 corresponds to the assumption that the value of % MACH equals 0 and that the value of % LAB equals 25 (or any mathematical value), a situation that corresponds to the unlikely situation of a project that does not need any machinery (% MACH = 0) and only requires labour and materials.

- Civil engineering TECHLEV ∈ [2.88 - 2.13].

The maximum value of 2.88 corresponds to the assumption that the value of %MACH equals 23%

(maximum range value of Phase A of verification) and the %LAB is 8% (10% is the average value obtained from the analysis of the sample of procurement specifications corrected with a 0.8 safety factor for possible deviations below this value).

The minimum value of 2.13 corresponds to the assumption that the value of %MACH equals 17% (minimum verification range value of Phase A) and the value of %LAB is equal to 8% (10% is the average value obtained from the analysis of the sample of procurement specifications corrected with a 0.8 safety factor for possible deviations below this value).

Once the technological level and the material execution budget are determined, a weighting table is used (Tables 2 and 3) to calculate the price criteria within a competitive tender.

The weighting table is applied in the following manner:

- A high level of technology (for example, a very high percentage of machinery in comparison with the labour force employed) together with a small execution budget (in this case, less than €500,000) characterises a simple project with little coordination needed. Accordingly, the weight of the price criteria within the set of objective criteria is high (meaning the procedure resembles an auction).

- A high level of technology and a large budget (in this case more than €5 million) characterises a highly complex project with specific technologies (such as dredgers, retaining walls, and tunnelling equipment) with a high level of organisation and coordination needed. This would result in a low price criterion weighting – given that the description and organisation of the construction process (which will eventually lead to quality results) means that quality, price, and delivery time are together more important than just the price.
- A low level of technology combined with a small budget supposes a relatively simple project with low or medium levels of organisation and coordination needed – resulting in a low price criterion weighting.
- A low level of technology with a large budget (in this case, more than €5 million) is a simple project with a high level of organisational and coordination needs – meaning a very low price criteria because the organisation and coordination of the process, labour force, and technical equipment is more important than the price and construction process.

The numerical ranges associated with each of the results in the weighting table are shown in Table 4.

Table 2. Weighting table for determining price weighting for building tenders

		TECH LEVEL			
		[4.00 – 3.01]	[3.00 – 2.01]	[2.00 – 1.01]	[1.00 – 0.00]
MATERIAL EXECUTION BUDGET (euros)	MEB < 500.000	VERY HIGH	HIGH	MEDIUM	LOW
	500.000 ≤ MEB < 2.000.000	HIGH	HIGH	MEDIUM	MEDIUM
	2.000.0000 ≤ MEB < 5.000.000	MEDIUM	MEDIUM	LOW	LOW
	MEB ≥ 5.000.000	LOW	MEDIUM	LOW	VERY LOW

Table 3. Weighting table for determining price weighting for civil engineering tenders

		TECH LEVEL			
		[2.88 – 2.74]	[2.73 – 2.53]	[2.52 – 2.32]	[2.31 – 2.13]
MATERIAL EXECUTION BUDGET (euros)	MEB < 500.000	VERY HIGH	HIGH	MEDIUM	LOW
	500.000 ≤ MEB < 2.000.000	HIGH	HIGH	MEDIUM	MEDIUM
	2.000.0000 ≤ MEB < 5.000.000	MEDIUM	MEDIUM	LOW	LOW
	MEB ≥ 5.000.000	LOW	MEDIUM	LOW	VERY LOW

Table 4. Summary of price weighting criteria

PRICE WEIGHTING		
Value	Numerical value (%)	Situation
VERY HIGH	66-70	High technological level Small budget
HIGH	61-65	High technological level Small/medium budget
MEDIUM	51-60	High technological level and medium/large budget. Medium technological level and medium budget
LOW	46-50	Low technological level and small budget. Medium/high technological level and medium/large budget Technological level medium/low and medium/large budget
VERY LOW	40-45	Low technological level Large budget

4.3. Phase C - Selection of abnormally low bid criteria

In this section the criteria to evaluate abnormally low offers are selected. These criteria should only be used with bids and not with rejected offers. The limits of abnormality should not be based on the tender price [4] and the contracting body should be aware of the possibility of price rigging by bidders [42].

This phase, regardless of the type of project, will depend on the number of bidders and the material execution budgets. We have set two tests for abnormality, the first is based on the calculation of the average of the bids submitted (B_m) and is to be used when the number of bidders (N) is less than or equal to 10; and the second test is based on the calculation of a reference base rate based (B_r) on the arithmetic average and standard deviation of the bids submitted. This second test is used when the number of bidders exceeds 10.

The first test considers an offer as abnormal when it is less than an 'X' percentage of the arithmetic average of the bids submitted; while the second test considers an offer abnormal when it is less than an 'X' percentage of the reference base rate. Both methods behave very similarly for a low number 'N' of bidders, so the first test is chosen in cases when there are fewer than 10 bidders because it is quicker and easier to apply. For a larger number 'N' of bidders, the calculation of the reference base rate enables a more precise evaluation.

It will not be known which method will be applied until the envelope containing the criteria for

evaluation by formulae is opened. However, the contracting authority will have determined the 'X' differential with respect to the bid average or reference base rate during the preparation of the administrative and technical bid terms and published this figure in the tender document. The value of 'X' is selected on the basis of the margin that bidders will have as determined by the material execution budget (Table 5).

Table 5. Table for selecting the 'X' percentage

		'X' (%)
MATERIAL EXECUTION BUDGET (euros)	MEB < 500.000	5
	500.000 ≤ MEB < 2.000.000	7
	2.000.000 ≤ MEB < 5.000.000	10
	MEB ≥ 5.000.000	15

The criteria selected to determine abnormal offers are further specified below:

For $N < 10$:

The average of the bids (B_m) is calculated according to:

$$B_m = \frac{\sum_{i=1}^n B_i}{n} \dots\dots\dots (5)$$

Depending on the 'X' differential selected, the price limit (P_L) that determines the initial feasibility

ity of the bids is calculated according to the following expression:

$$P_L = B_m \cdot (100 - X) \dots\dots\dots (6)$$

All of the bids are collated. Offers above the price limit calculated are considered acceptable, and those below the limit are considered abnormally low and the contracting body should seek an explanation from the bidder.

where:

B_i is the Bid (expressed in monetary values)

B_m is the Mean Bid (expressed in monetary value)

n is the Number of bidders

P_L is the price limit (expressed in monetary values)

X is the percentage according to Table 5

For $N > 10$:

The average of the bids (B_m) is calculated according to:

$$B_m = \frac{\sum_{i=1}^n B_i}{n} \dots\dots\dots (7)$$

The standard deviation of the bids is calculated according to:

$$\sigma = \left[\frac{\sum_{i=1}^n (B_i)^2 - n \cdot (B_m)^2}{n} \right]^{1/2} \dots\dots\dots (8)$$

To calculate the reference base rate (B_R), those bids n' that meet the following condition will be taken into account:

$$|B_i - B_m| \leq \sigma \dots\dots\dots (9)$$

The reference base rate is calculated using the following formula and taking account the bids that have met the previous condition.

$$B_R = \frac{\sum_{h=1}^{n'} B_h}{n'} \dots\dots\dots (10)$$

Depending on the 'X' differential selected, the price limit that determines the initial viability is calculated according to the following expression:

$$P_L = B_R \cdot (100 - X) \dots\dots\dots (11)$$

All of the bids are collated. Offers above the price limit calculated are considered acceptable, and those below the limit are considered abnormally low and the contracting body should seek an explanation from the bidder.

where:

B_i is the Bid (expressed in monetary values)

B_m is the Mean Bid (expressed in monetary value)

B_R is the base rate (expressed in monetary value)

B_h is the bid that satisfies condition (9) (expressed in monetary value)

n is the Number of bidders

n' is the number of bidders that satisfies condition (9)

P_L is the price limit (expressed in monetary values)

σ is the Standard deviation

4.4. Phase D - Selection scoring formula for price criteria

In this final phase, the scoring formula is selected according to the principle of proportionality of bids and with a moderate to high score gradient, so that the weighting of the price criteria is the target weight specified in the administrative and technical bid terms and not less [38, 48].

The price score formula is selected, both for civil engineering and construction projects, depending on the weighting of the price criteria (Table 6).

Table 6. Table for selecting the formula for price scoring

		SCORING FORMULA
PRICE CRITERIA WEIGHTING	VERY HIGH	I
	HIGH	I
	MEDIUM	I
	LOW	II
	VERY LOW	II

The scoring formula or criterion termed ‘I’ in this methodology consists of:

- The maximum score for the lowest normal bid.
- The minimum score (0 points) for all bids that have made an offer at base price, that is, bids that are not lower than the tender price.
- Bids between the lowest bid and the base price scored according to Figure 3.

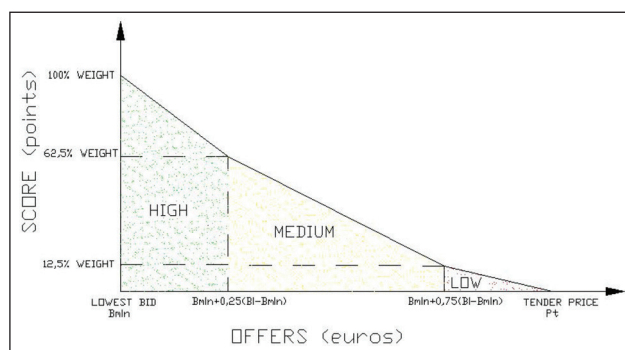


Figure 3. Chart for scoring offers according to scoring Formula I.

The first section of the curve is between the maximum score and 62.5% of the weighting of price criteria (determined in phase B of the methodology) and corresponds to bids between the lowest bid (B_{min}) and the lowest bid plus 25% of the difference between the tender price (P_t) and the lowest bid [$B_{min} + 0.25 \cdot (B_t - B_{min})$]. This zone is defined as the HIGH scoring zone (i.e. those bids with the largest reductions in the base price are scored highest).

The second section of curve is between 12.5% and 62.5% of the weighting of the price criteria and corresponds to bids between the lowest bid plus 25% of the difference between the tender price and the lowest bid [$B_{min} + 0.25 \cdot (B_t - B_{min})$] and the lowest bid plus 75% of the difference between

the tender price and the lowest bid [$B_{min} + 0.75 \cdot (B_t - B_{min})$]. This section is defined as the MEDIUM scoring zone (i.e. those bids that deviate from the base price are given lower scores).

The final section is between 12.5% of the weighting of the price criteria and a zero score corresponding to bids between the lowest bid plus 75% of the difference between the tender price and lowest bid: i.e. [$B_t + 0.75 \cdot (B_t - B_{min})$] and the tender price (P_t). This section is defined as the LOW scoring zone (i.e. those bids that are near to the base price are valued with a low score).

Scoring criteria under Formula II in this methodology can be summarised as:

- The maximum score is for the lowest normal bid.
- The minimum score (0 points) is awarded to all bids that have made an offer at base price.
- The bids between the lowest bid and base price, are awarded a proportional score according to the following formula:

$$S_i = W \cdot \frac{P_t - B_i}{P_t - B_{min}} \dots\dots\dots (12)$$

where:

B_i is the bid (expressed in monetary values)

B_{min} is the minimum bid (expressed in monetary value)

P_t is the Tender price (expressed in monetary values)

S_i is the scoring of the bidder i (expressed in points)

W is the weighting given to price criteria, as determined in phase B

5. Results and discussion

The proposed methodology was applied to a sample of 39 projects in which data was available regarding bids. These 39 projects were part of an initial sample of 100 projects that were the subject of a study on criteria for scoring formulae and abnormally low bids [4, 38].

In the study sample (39 projects), only 21 (or 53.85%) showed a breakdown in the budget for the basic prices of materials, labour, and machinery.

Of the projects with a breakdown in the material budget, only 12 satisfied the condition $\%MACH + \%LAB + \%MAT \geq 85\%$ (3), meaning 57.14% of the projects with a financial breakdown, or 30.77% of the overall sample.

Of the 12 projects that satisfy (3) a comparison was made of ten main prices of machinery, labour, and materials. In only 8 of the 12 projects (66.67%) was the sample of compared prices considered valid (20.5% of the overall sample). There were two main factors explaining the result: firstly, these projects include some very specialist works (such as improving the outer harbour and docks at a port in Malaga, whose prices were not reflected in traditional construction databases); and secondly, the non-use of building material databases that were developed and checked by local agencies – so that comparison became difficult and sometimes impossible because of differences in coding, measurement units, and concept description.

Of the eight samples of valid prices we then checked those basic prices that differed from the basic database price (above or below) by 15% or less. We needed to find at least 14 prices to validate the project from the price standpoint. Only one sample satisfied this condition, representing 12.5% of the valid samples and 2.56% of the overall sample – meaning just one of the 39 submitted projects complied with Phase A. The remaining projects should be returned to the bidders and, where appropriate, to the offices of the administration supervising the projects for a formal review, and if necessary, a review of the solutions adopted in order to make the project financially viable according to market prices.

One of the conditions for applying Phase B is that is that the project achieved validation in Phase A. In this case, Phase B could only be applied to one sample project. To further validate the methodology and study the overall behaviour of abnormally low bidding criteria and scoring formulae, we selected all the projects that were not given a low price weighting in Phase A, in accordance with Table 4 (with a score of 50 out of a total of 100). For the single project that satisfied Phase A, a high weighting criteria was applied with a score of 65 points.

In Phase C, the most frequently selected X differential was 7% (18 of 39) followed by a 15%

differential (12 of 39) and a 10% differential (8 of 39). The X differential = 5% was only selected once. Finally, in phase D, and in accordance with the weighting of the price criteria, the single offer that satisfied Phase A was evaluated using Formula I and the remaining projects were evaluated using Formula II.

Once bids are available, the contracting authority should initially assess for abnormally low offers and then score the bids in accordance with the formulae previously selected. In the study sample, the 'B' criterion of abnormality was used in 37 of the 39 cases because there were more than ten bidders. In the present study, all the bids considered abnormal according to the criteria applied were excluded from the scoring phase.

Performing an overall economic balance with the proposed methodology produced a positive balance of €274,775.85 for the contracting administrations. When an analysis was made according to project size: for projects with budgets above €2 million the positive balance for the administration was €1,158,004.61; while for smaller projects under €2 million, the negative balance for the administration was €883,228.75.

A comparison was made of the positions held by the bidders with the highest score on price criterion when applying the methodology – with the positions these same bidders held under the original administrative and technical bid terms. There are three possible results: winning bids that were previously deemed abnormal; winning bids that were previously also winning bids; and finally, winning bids that did not win under the previous terms. The percentage of winning bids that were not previously winners (41%) is greater than the other two possible results: some 31% were in the same position as previously; while 28% were previously deemed abnormally low.

In projects with budgets above €2 million euros, the proposed methodology produced the highest score for 40% of bids that previously were previously deemed abnormal; and for 35% of the previously winning bids. In projects below €2 million euros: the proposed methodology produced the highest score for 26% of bids that were previously successful and 58% of bids that were previously ranked in lower positions.

6. Conclusions

The presented methodology has been defined for application in public procurement procedures by administrations and enables the determination of all aspects of price criterion.

A project budget should be appropriate for market prices. It can be concluded from the sample that more care should be given to budget by both bidders and the supervisory offices of the contracting administrations.

Tenders below market prices generate problems during implementation, such as delays, claims, contradictory pricings, complementary projects, and even paralysis and non-completion of projects.

The weighting of price criteria depends on both the project budget and the level of technology, which means the relationship between machinery and labour provides a qualitative index of the technological difficulty and organisational needs for project implementation.

The abnormally low bid differential criteria were selected on the basis of the economic cost of the project. By using abnormality criteria and scoring formulae, the suggested methodology enables riskier bids to be presented for projects with budgets over €2 million. However, the methodology behaves more conservatively for projects with smaller budgets.

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