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A Study on the Authority Perception of School Administrators

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Abstract

This study aims to investigate school administrators’ perception of authority and explore their perception in relation to various variables. The participants included primary and secondary school directors and vice-directors. The findings showed that school administrators perceived authority arising from expertise as the most effective authority type in terms of teachers’ fulfilling directives from administrators, and it was followed by Charismatic, Legal, Traditional and Coercive authority. It was also found that there were significant differences for Traditional authority in relation to seniority and duty (director or vice director), Legal authority in relation to duty, Charismatic authority in relation to seniority in terms of the perceived effectiveness. These findings were discussed in the light of various studies and some suggestions were made.

Key words: Authority, Perception, School Administrators

1. Introduction

The chance of an organization to survive and fulfill its aims depends on its effective management in the hands of skillful administrators. Being able to make employees perform certain tasks constitutes a considerable portion of administrative activities in schools. When we take into consideration that one of the most basic definitions of management is that it is the art of being able to make employees fulfill the tasks in a desired way, the question of what constitutes the basic source of making employees perform in this manner gains importance. Even if all the social organizations tend to control its members, the problem of control becomes vital in formal organizations and the authority constitutes the base of the control mechanism in such organizations [1]. Authority is the legitimate form of power which emanates from written or unwritten norms and rules and the personal characteristics of the person who exerts power in an organization [2]. At this point it can be said that authority must be used appropriately to channel behaviors of the employees in accordance with the goals of the organizations. Moreover, the findings which shed light on the relationship of authority with effectiveness related variables such as job satisfaction, involvement, organizational culture etc. testify the importance of studying authority thoroughly. Assessing the perception of administrative staff in schools about authority and the relation of with various variables would help us understand the concept deeper.

2. Conceptual Framework

Authority comes originates from the Latin word “Auctoritas” and it referred to the prestige, influence and being able to gain support from the people around. More modern definitions of the term seem to be related with the original term more or less. [3] defines the term as having the right and power to command and obtain obedience. According to [4] authority can be defined as having power and right to command and obtain obedience. According to [4] authority can be defined as having power and right to command, initiate and end a task. In her work called Between Past and Future, [5] compares authority to a pyramid. Authority is embodied in a form of layers which are connected with each other from top to the bottom, widens as you go down and in this construct lower layers carry the ones on the top. According to [6], while management fulfils its functions, fourteen principles should guide administrators. [6] mentions about authority as the second principle and defines it as the right to command and power to ensure obedience. Although these definitions give us an understanding of the concept, one of the most comprehensive analysis on authority was
made by [2]. He evaluated the concept in relation to legitimacy and explained it in terms of the basic beliefs of people who are managed about authority. In order to have authority, the related person should have some sources. One of these sources is comprised of the personal effect of the person who exerts authority such as charisma or expertise. The other source originates from the formal organization or the societal norms.

2.1. Types of Authority

The administrators in formal organizations make use of different kinds of authority and each of them has different sources. These authority types can be numbered as Charismatic, Legal, Traditional, Coercive and Expert authority.

*Traditional:* This type of authority gets its source from the attribution of authority to a certain position by the society in general and employees in an organization in particular. This type of authority is not related with the person who occupies a position. Rather, the source of the authority is the traditional respect and acceptance of a position in an organization by the society and members of an organization [7]. An example of this situation can be seen in school organizations. Students can fulfill the demands of teachers or administrators because of the fact that their parents have done so. This is not related with the administrator holding the position. It is about the respect of the traditional roles in that organization [1].

*Legal:* This authority type depends on the contract between an organization and its employees. In this contract, employees’ duties and responsibilities, and who is responsible to whom is specified openly in the chain of authority. As a natural result of this situation, superiors get right to control the behaviors of subordinates [8]. People have legal authority as a result of the fact that they have been appointed to a particular position. In this context, subordinates have an obligation to obey the demands of their superiors [9].

*Charismatic:* A person may attain authority as a result of his/her personal characteristics and behavioral patterns. If the members of an organization envy a person, their behavior may be affected by that person. People who have charisma can obtain loyalty of others and direct them [7]. The power of the Charismatic authority depends on the followers’ perception that the only way to achieve their goals is to follow the person who has charisma [10].

*Expert:* Expert authority refers to a person’s ability to control and direct the behaviors of the followers as a result of her knowledge, skills and experience in an area. The basic rule which determines the effectiveness of such authority is that the followers shouldn’t have the related knowledge, skill and experience [11]. The studies about the variables which have a force on people’s behavior have shown that one of the most important of them is an individual’s degree of knowledge, experience and skills in an area [12]. The rationale behind the ability to convince followers to behave in a particular way with this kind of knowledge is that followers tend to believe in the accuracy of the ideas from expert individuals more easily [13]. This is an indication of the perceived reliability of expert people [14].

*Coercive:* This authority stems from the fact that certain behaviors may bring about negative outcomes. If a superior can fire her subordinate, degrade her position and give her undesirable tasks, we can say that the superior has coercive authority over her subordinate [15]. The fact that this authority rests on the fear of punishment brings some problems with itself. Some of these are employee disappointment, job dissatisfaction, high turn-over rates and low performance levels [16].

When we examine the related literature, we can observe that the authority types mentioned above are categorized into two as formal and informal. Formal authority depends on a person’s position in the hierarchical system of an organization. Legal, Traditional and Coercive authority can be put under this category. On the other hand, informal authority gets its source from the person herself. Charismatic and Expert authority is examined under this category.

School administrators should develop a deep awareness of these authority types and know how to use them in the appropriate place and time [1]. Effective administrators shouldn’t rely on only their formal authority, they should also make use of informal authority types as well [17]. The administrators who utilize their formal authority in excess can only expect superficial commitment from his subordinates. However, the use of informal authority can make a reverse effect [18].
When the related literature is examined, it can be seen that although there are a number of studies about the perception of teachers about the authority types made use of by school administrators, the research on the perception of administrators about their authority is much more limited. The current study was undertaken to assess the perception of school administrators in terms of the effectiveness of various authority types to make teachers obey the directives from them.

3. Methodology

Descriptive research design was utilized to assess school administrators’ authority perception and its relation to various variables.

3.1. Sample

The sample of the study consists of 101 school administrators working as director or vice director in various primary and secondary schools in Gaziantep/Turkey. The data was collected in 2013-2014 academic year.

Table 1. Distribution of the participants according to demographic variables

<table>
<thead>
<tr>
<th>Gender</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>90</td>
<td>89.1</td>
</tr>
<tr>
<td>Female</td>
<td>11</td>
<td>10.9</td>
</tr>
<tr>
<td>Seniority</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-4 years</td>
<td>34</td>
<td>33.7</td>
</tr>
<tr>
<td>5-8 years</td>
<td>37</td>
<td>36.6</td>
</tr>
<tr>
<td>9 or more years</td>
<td>30</td>
<td>29.7</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27-35</td>
<td>34</td>
<td>33.7</td>
</tr>
<tr>
<td>36-40</td>
<td>31</td>
<td>30.7</td>
</tr>
<tr>
<td>41 or more</td>
<td>36</td>
<td>35.6</td>
</tr>
<tr>
<td>Position</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Director</td>
<td>23</td>
<td>22.8</td>
</tr>
<tr>
<td>Vice-director</td>
<td>78</td>
<td>77.2</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Associate Degree</td>
<td>9</td>
<td>8.9</td>
</tr>
<tr>
<td>Bachelor’s Degree</td>
<td>79</td>
<td>78.2</td>
</tr>
<tr>
<td>Master’s Degree</td>
<td>13</td>
<td>12.9</td>
</tr>
<tr>
<td>Total</td>
<td>101</td>
<td>100</td>
</tr>
</tbody>
</table>

3.2. Data Gathering Instrument

In order to collect data a likert type scale questionnaire was used. The original questionnaire was developed by [19]. In the adaptation process of the questionnaire to Turkish language, two different translators were asked to translate the questionnaire into Turkish. After that a consensus was attained between the translators on differences. There were five options in the questionnaire to choose ranging from never to always. Because of the cultural differences, statistical analyses were done to assess the reliability and validity of the questionnaire. In order to make deductions based on mean scores, means were labeled in the following manner: Always ($\bar{x}=5.00-4.20$), Generally ($\bar{x}=4.19-3.40$), Sometimes ($\bar{x}=3.39-2.60$), Seldom ($\bar{x}=2.59-1.80$), Never ($\bar{x}=1.79-1$).

4. The Findings of the Study

Firstly, factor analysis was done with varimax rotation method. After that reliability analysis was done by calculating Cronbach’s alpha coefficient for each of the factor and then, all off the factors.

Table 2. Factor and Reliability Analysis

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item number</th>
<th>Factor loading</th>
<th>Explained variance</th>
<th>Reliability coefficient (C. Alpha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coercive</td>
<td></td>
<td></td>
<td>%17.3</td>
<td>.852</td>
</tr>
<tr>
<td></td>
<td>20 880</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>24 819</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16 794</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12 725</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legal</td>
<td></td>
<td></td>
<td>%12.5</td>
<td>.655</td>
</tr>
<tr>
<td></td>
<td>23 759</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>17 714</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 661</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charismatic</td>
<td></td>
<td></td>
<td>%12.2</td>
<td>.683</td>
</tr>
<tr>
<td></td>
<td>27 829</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8 694</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19 683</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional</td>
<td></td>
<td></td>
<td>%12</td>
<td>.679</td>
</tr>
<tr>
<td></td>
<td>9 784</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15 760</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7 724</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expert</td>
<td></td>
<td></td>
<td>%11.8</td>
<td>.632</td>
</tr>
<tr>
<td></td>
<td>11 819</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>22 697</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 580</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>%65.7</td>
<td></td>
<td>.786</td>
<td></td>
</tr>
</tbody>
</table>

As can be observed in Table 2, as a result of the factor analysis five factors emerged, and these five factors explain 65.7% of the total variance. Coercive authority contributed most to the total variance (17.3%). It was followed by Legal (12.5%), Charis-
matic (12.2), Traditional (12%) and Expert (11.8%) authority. Another finding is that the Cronbach’s alpha coefficients altered between 0.632 and 0.852, and the coefficient for all the factors is 0.786. These findings show that these values are at an acceptable level and the scale is reliable.

The mean scores for the authority perception of school administrators about each subscale were at different levels.

**Table 3. Means, Standard Errors and Standard Deviations for Authority Types**

<table>
<thead>
<tr>
<th>Authority Type</th>
<th>( \bar{x} )</th>
<th>SE</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert</td>
<td>4.04</td>
<td>0.53</td>
<td>0.53</td>
</tr>
<tr>
<td>Charismatic</td>
<td>3.98</td>
<td>0.64</td>
<td>0.64</td>
</tr>
<tr>
<td>Legal</td>
<td>3.21</td>
<td>0.76</td>
<td>0.77</td>
</tr>
<tr>
<td>Traditional</td>
<td>3.13</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>Coercive</td>
<td>2.55</td>
<td>0.92</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Schools administrators perceived that Expert authority was the most effective authority type in terms of getting teachers to do the tasks given by them (\( \bar{x} = 4.04 \), Generally). It was followed by Charismatic (\( \bar{x} = 3.98 \), Generally), Legal (\( \bar{x} = 3.21 \), Sometimes), Traditional (\( \bar{x} = 3.13 \), Sometimes) and Coercive (\( \bar{x} = 2.55 \), Seldom) authority.

The analyses showed that the perceived effectiveness of Traditional authority differed significantly according to the seniority of the administrators, \( F(2.98) = 5.91, p < .05 \).

**Table 4. One-Way Anova Tests Results for Administrators’ Perception of Traditional Authority according to Seniority**

<table>
<thead>
<tr>
<th>Seniority</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>7.826</td>
<td>2</td>
<td>3.913</td>
<td>5.912</td>
<td>.004</td>
</tr>
<tr>
<td>Within Groups</td>
<td>64,858</td>
<td>98</td>
<td>.662</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>72,684</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Multiple comparisons with Scheffe test put forward that the administrators who had nine or more years of experience (\( \bar{x} = 3.56, SD = 0.8 \)) perceived that Traditional authority was significantly more effective than administrators with 1-4 (\( \bar{x} = 2.9, SD = 0.84 \)) and 5-8 (\( \bar{x} = 3, SD = 0.79 \)) years of experience.

Because the data about the perception of directors and vice directors’ with regards to Traditional authority didn’t show normal distribution with Shapiro-Wilk test (\( p > .05 \)), non-parametric Mann-Whitney U-test was carried out to compare the groups.

**Table 5. Mann-Whitney U-Test results for Administrators’ Perception of Traditional Authority according to Position**

<table>
<thead>
<tr>
<th>Position</th>
<th>n</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
<th>U</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Director</td>
<td>23</td>
<td>65.63</td>
<td>1509.5</td>
<td>560.5</td>
<td>.006</td>
</tr>
<tr>
<td>Vice-director</td>
<td>78</td>
<td>46.69</td>
<td>3641.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to the results, directors perceived that Traditional authority was significantly more important when compared with vice directors (\( U = 560.5, p < .01 \)). Administrators’ perception of legal authority was also significantly different with regards to their position, \( t(99) = 2.88, p < .01 \).

**Table 6. T-Test Results for Administrators’ Perception of Legal Power according to Position**

<table>
<thead>
<tr>
<th>Position</th>
<th>n</th>
<th>( x )</th>
<th>SD</th>
<th>df</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Director</td>
<td>23</td>
<td>3.6</td>
<td>0.68</td>
<td>99</td>
<td>2.88</td>
<td>.005</td>
</tr>
<tr>
<td>Vice-director</td>
<td>28</td>
<td>3.1</td>
<td>0.76</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Directors perceived that legal authority was significantly more effective in comparison with vice-directors. This finding shows that the position of the administrators is an important factor which determines the perceived effectiveness of legal authority.

The analysis of the data with Shapiro-Wilk test about Charismatic authority in terms of seniority didn’t put forward normal distribution, (\( p > .05 \)). Accordingly, non-parametric Kruskal-Wallis test was carried out. The test put forward that there were significant differences between groups, \( \chi^2 (sd=2, n=101) = 7.95, p < .05 \).

**Table 7. Kruskal-Wallis Test Results for Administrators’ Perception of Charismatic Authority according to Seniority**

<table>
<thead>
<tr>
<th>Seniority</th>
<th>n</th>
<th>Mean Rank</th>
<th>df</th>
<th>( \chi^2 )</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>34</td>
<td>44.81</td>
<td>2</td>
<td>7.95</td>
<td>.019</td>
</tr>
<tr>
<td>5-8</td>
<td>37</td>
<td>46.62</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 or more</td>
<td>30</td>
<td>63.42</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To find out which groups differed significantly, Mann-Whitney U-test was run. The results pointed out that administrators who had nine or more
years of experience perceived Charismatic authority to be significantly more effective than those with 5-8 and 1-4 years of experience (p<.05). Another finding was that perceived effectiveness of Charismatic authority was significantly higher for administrators with 5-8 years of experience than those with 1-4 years of experience, (p<.05).

The comparison of authority types according to age, gender and education level variables didn’t put forward significant results. Accordingly, it can be claimed that school administrators’ perception of authority types didn’t varied significantly with regards to these variables.

5. Conclusion

The current study puts forward that school administrators perceived Expert authority as the most effective authority type in terms of getting teachers to carry out directions given by them. This authority type was followed by Charismatic, Legal, Traditional and Coercive authority. A study carried out by [20] on teachers about the application of authority in school settings put forward that administrators used legal and coercive authority more than other authority types. This finding puts forward that there may be discrepancies between the practice and the perception of authority in schools. In other words, administrators may not make use of certain types of authority as much as they perceive them to be effective. However, there are also studies which suggest a reverse relationship. In our study Expert and Charismatic authority were the most effective authority types according to administrator’s perception. These authority types take their source from personal characteristics [9]. The study by [21] has put forward that this type of authority was the most often used one by administrators according to the perception of teachers. The study by [22] also gave similar findings. Their study on teachers found that informal authority types such as Charismatic and Expert was the most often used authority types by administrators. This finding can be interpreted as positive if we take into consideration that administrators shouldn’t get by only with their formal authority [17]. The findings which show stronger positive relations between informal authority and organizational involvement in the study by [22] testify this idea.

Another finding of the current study was that school administrators perceived effectiveness of certain authority types differed significantly according to their position and seniority. Administrators with nine or more years of experience perceived Traditional authority as a significantly more effective authority than those with 5-8 and 1-4 years of experience. The analysis on the data about Charismatic authority also pointed out seniority was an important factor which determines the perceived effectiveness of the related authority. For administrators with more than nine years of experience, Charismatic authority was significantly more effective than for those with 5-8 and 1-4 years of experience.

The last significant finding of the study was that the position of the administrators as director or vice-director is a determinant factor in terms of the perceived effectiveness of Legal and Traditional authority. Directors perceived these authority types to be significantly more effective than vice-directors. The significant differences for Traditional and Legal authority according to seniority and position can be explained by the age factor. Administrators who are more experienced and hold the position of directorship tend to be older and these people may attribute more importance to Traditional and Legal aspects of authority because they were grown more traditionally than their younger colleagues.

References

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Abstract

Soft lithography encompasses a collection of inexpensive low-expertise methods to fabricate complex micro- and nano-structured topographies. The most forms of soft lithography use a patterned elastomeric stamp having inverse relief features, which can transfer the desired patterns on almost any, flat or curved, surface. The short “turn-around” time from an idea to prototype, coupled with its suitability for a broad range of soft materials and a good control over surface chemistries, has made soft lithography one of the top most versatile fabrication tools in many research laboratories.

In this work, soft lithographic replica molding method was used to fabricate anti-fouling and self-cleaning engineered topographies. Anti-fouling patterned surfaces developed have shown increased inhibition toward bacterial attachment and biofilm formation compared to control surfaces, all made of the same material. Self-cleaning hydrophobic engineered topographies have shown the “Lotus-leaf-effect”. In both types of topographies fabricated in this work, the surface features’ size and periodicity seem to play the major role in the surface final performance.

Key words: soft lithography, replica molding, antifouling, self-cleaning.

1. Introduction

Traditionally, surface patterning in microelectronics has been done with photolithography. However, photolithography has some limitations, such as: it cannot be easily applied to non-planar (curved) surfaces and tolerates a very narrow range of materials with no control over the chemistry of patterned surfaces. The size of features produced by photolithography are dictated by the optical diffraction, while the high-energy radiation needed for small features requires complex facilities and technologies. Photolithography is an expensive technique, often not accessible to non-specialists. From the other hand, soft lithography overcomes the limitations of conventional photolithography and further extends its possibilities. Soft lithography is inexpensive and applicable to three-dimensional and curved structures, well-suited for a wide range of elastomeric (soft) materials, which cannot be used in the conventional photolithography. Moreover, soft lithography enables patterning large areas and has a potential for large specific surface area molds without expensive capital equipment. Thus, soft lithography opens possibilities for novel applications in biotechnology, flexible electronics, microfluidics, etc [1-12].

Soft lithography is a process in which a soft polymer (elastomer) is cast onto mold that has the desired surface pattern. The elastomeric “soft” mold or stamp in soft lithography is made from a master, which is most often fabricated on a silicon wafer by conventional lithography. Figure 1a below is a schematic presentation of a master, which is used to make an elastomeric stamp by solidifying the liquid prepolymer material with heat or UV light.

The elastomeric stamp is made usually of a soft material, very often polydimethylsiloxane (PDMS). PDMS has been the most widely used material as stamp material in soft lithography due to its outstanding properties, such as low cost, transparency, biocompatibility, low toxicity, chemical inertness, diverse surface chemistry, mechanical flexibility and durability. Various acrylates, mostly photo-curable, have been also used as stamp materials in soft lithography. The soft and rubbery backbone of PDMS and other elastomers enables conformal contact that is crucial for a good reproduction of desired patterns in soft lithography.
According to Whitesides et al. the terminology soft lithography refer to “a collection of techniques based on printing, molding, and embossing with an elastomeric stamp [1-5]. Some of the soft lithographic fabrication methods, which use a patterned elastomeric stamp are: replica molding, micro-contact printing, micro-transfer molding, micro-molding in capillaries, solvent-assisted micro-molding, micro-particle fabrication, and many variations of the above methods.

Figure 1. (a) Elastomeric stamp fabrication from a rigid master and (b) replica patterning

In replica molding (Figure 1b), a patterned elastomeric stamp is used as a soft mold and filled with a liquid prepolymer. Upon curing the prepolymer by heat or UV light, the cured polymer is easily separated from the stamp due to low surface energy of the stamp. The inverse patterns of the stamp are imprinted in the surface of the polymer, known also as replica. Replica molding allows replicas to be made in a wide spectrum of materials and the stamps to be reused many times.

In this study, novel types of engineered surfaces, fabricated by soft lithography, are presented. Among many patterned topographies fabricated, two categories of engineered surfaces will be disclosed. The first category of patterned engineering surfaces reported in this study are anti-fouling topographies, i.e. surfaces with topographic features that reduce bacterial colonization and biofilm formation. The second category of disclosed engineered topographies are related to self-cleaning hydrophobic surfaces.

2. Experimental

Micro-patterned topographies were prepared by soft lithographic method replica molding (Figure 1b) using micro-patterned acrylic-based stamps. The photo-curable acrylate/ methacrylate formulations used for making the stamps were designed in such way to provide certain degree of flexibility for a good conformal contact and release from the replicas, but also some rigidity for easy handling, especially when large area stamps were needed. The micro-patterned replicas were made in different photo-curable liquid prepolymer based on acrylate-urethane- and fluoro-acrylate polymer formulations, cured with UV-A light supplied by a lamp with intensity of 4 W/cm² at total fluence in the range 0.5 – 1.0 J/cm². A fluoro-acrylate and an acrylate-urethane formulation were used for the fabrication of anti-fouling topographies, while several fluoro-acrylate formulations were used for making non-wetting hydrophobic surfaces. The actual chemical compositions of the stamp polymer formulations used in this study, as well as the actual chemistry of the replica polymeric materials will be not disclosed here due to proprietary reasons.

Some of the patterned surfaces made by soft lithography were further subjected to reactive ion etching (reactive ion etcher, Trion Technology Phantom II) in order to impose dual structure topographies, i.e. random nano-structures embedded on top of the micro-structures. For comparative purposes, reactive ion etching was applied on smooth surfaces made from the tested materials resulting in random nano-structured topographies only. Topographic characterization of micro-patterned stamps and patterned surfaces (replicas) was done with scanning electron microscopy, SEM (FEI XL30 SEM-FEG).

The anti-fouling engineered surfaces were further characterized in terms of monitoring the bacterial growth on them over certain time period (1-60 days) and conditions (temperature, humidity, flow and static conditions) and were compared to smooth surfaces made of the same materials as control surfaces. The surface energy of smooth surfaces was determined by commercially-available ACCU DYNE TEST™ marker pens. The anti-fouling character of the surfaces developed in this study was tested against two strains of bac-
bacteria, *Escherichia coli* as gram-negative bacteria and *Staphylococcus aureus* as gram-positive bacteria, in static and flow conditions. The static conditions were improvised in large plastic containers \( (\text{length} \times \text{width} \times \text{depth} = 0.5 \times 0.5 \times 0.5 \text{ m}) \), coated and patterned with the studied materials and topographies, and filled with stagnant water. The dynamic conditions were improvised on plastic plates containers \( (\text{length} \times \text{width} = 0.5 \times 0.5 \text{ m}) \), coated and patterned with the studied materials and topographic features, over which water was allowed to pass with velocities of 0.1 - 1 m/min.

The self-cleaning hydrophobic surfaces were characterized for their self-cleaning and repelling performance of water drops. The wettability of the replicas was characterized by contact angle measurements (Drop Shape Analyzer – DSA100S, KRUSS). Water droplets (5 µl) were applied to the studied surfaces with a syringe. The sliding angles were measured by tilting the engineered surfaces with applied droplets on them. Particularly, the minimum angle at which the droplets rolled-off the surface without wetting it (i.e. without spreading on the surface) was recorded as a sliding angle for the particular surface. For this purpose, the tested surfaces \( (\text{length} \times \text{width} = 0.5 \times 0.5 \text{ m}) \) were covered with sand comprising micron-sized particles in amount of 0.02 g sand/cm² surface and were microscopically inspected before and after water drops roll over them for qualitative observation of the washed/non-washed sand particles. The water droplets were supplied at the top edge of the tested surface in amount of 10 ml/cm² surface.

![Figure 2. SEM images of (a) micro-patterned replica produced by soft lithography and (b) elastomeric stamp used to make the replica (a).](image)

### 3. Results and Discussion

#### 3.1. Anti-fouling micro-structure based topographies

Bacterial surface fouling (bacterial attachment) and biofilm formation are big problems in many applications and industries, including but not limited to: medical devices (implants, replacement joints, stents, pacemakers, catheters), municipal infrastructure (drinking water pipes, wastewater treatment), food production (food processing surfaces, processing equipment), hospitals, water transportation vehicles (ships), etc. Biofilm exists wherever surfaces are in contact with water or body fluids. Biofilms are considered to be a collection of microorganisms surrounded by the slime they secrete, attached to a surface. Biofilm is defined as “structured, co-operative microbial community embedded in an extracellular usually polysaccharide matrix, attached to a surface.” [13-25]

To avoid the danger of biofilm formation, several solutions have been proposed to prevent bacterial attachment and biofilm formation on various surfaces, [26-34] In this study, micro-engineered topographies were fabricated as non-toxic strategy against the biofilm formation on plastic surfaces. This approach seems to be the best in fighting bacterial contamination on surfaces of interest without any toxic anti-microbial chemicals and antibiotics, and thus, without any harmful consequences for the life species in contact with those surfaces. For this purpose, surface patterns that were antici-
pated to disrupt the ability of bacteria to adhere, colonize, and develop into biofilms were fabricated by soft lithographic technique replica molding. An example of a fabricated topography by replica molding is given in Figure 2. Particularly, SEM image of an engineered surface with square posts is given in Figure 2a, while the SEM of the elastomeric stamp used to make such surface is presented in Figure 2b.

It is known that the bacterial adhesion to surfaces is greatly affected by the physical and chemical properties of the surface, as well as the characteristics of the bacteria. Our initial results of the kinetic study have shown that the topographical features developed in this study reduced cell-surface interactions, and thus, reduced surface colonization and biofilm formation compared to smooth surfaces made of the same materials. Furthermore, the kinetics results of bacterial attachment to the tested surfaces was slightly affected by the surface energy of these materials, when smooth surfaces were tested. Particularly, two types of materials were tested: smooth surfaces made of acrylate-urethane material and fluoro-acrylate materials with surface tension values of 45 mN/m and 25 mN/m, respectively. In both cases the biofilm was formed; however, fluoro-acrylate surfaces had less amount of biofilm formation than the acrylate-urethane-based smooth surfaces for a given time period. Therefore, surface material nature has little or no effect on biofilm formation rate; the lower surface energy material inhibits only the initial phase of bacterial attachment compared to the higher surface energy material. The patterned surfaces demonstrated the highest degree of controllable inhibition over bacterial attachment, when compared to control smooth surfaces. Among different well-defined topographic features tested in this study, the best results were observed for surfaces with square- and cylindrical- micron-sized posts.

To assess the effect of the surface patterns’ size and shape on kinetics of bacterial attachment, various topographic features were fabricated and tested. For this purpose, the pitch \( p \) (or period), width \( w \) and height \( h \) of square- and cylindrical posts were systematically changed and easily prototyped by soft lithography.

For patterned topographies with square posts (Figure 2), the pitch \( p \), was changed as a function of the post width \( w \) (equation 1), in the range given below:

\[
\frac{w}{4} \leq p \leq 2w \quad \text{(1)}
\]

while the post height \( h \) was varied in the range given with the equation 2:

\[
\frac{w}{4} \leq h \leq \frac{w}{2} \quad \text{(2)}
\]

For cylindrical surface posts, the same equations given above were used with \( w \) equal to the post diameter.

Preliminary results on kinetics of biofilm formation showed that the size, spacing, and shape of surface features play a significant role in cell-surface attachment. A mathematical correlation between the surface parameters, such as specific surface area and initial biofilm formation is envisioned, which will be published additionally.

The surface patterns were tested against two different strains of bacteria, *Escherichia coli* as gram-negative and *Staphylococcus aureus* as gram-positive bacteria. No statistical difference in the rate of surface attachment between gram-positive and gram-negative bacteria on tested topographies was observed.

In regard to the flow conditions, biofilm was formed in both, static and dynamic conditions. The initial observation was that even a high flow rate did not prevent bacterial attachment nor completely remove the existing biofilm, but it limited the total biofilm thickness only. The reason for this is believed to be that even in turbulent flow conditions, there is always a laminar sublayer close to the surface, which allows the bacteria to attach to the surface and progress into biofilm. In turbulent conditions, it is expected that the biofilm fragmentation and detachment would happen more often, resulting in lower total biofilm thickness compared to laminar flow conditions.

The key observations from the initial biofilm studies are as follows:

- **Material surface energy**: surface material nature has little or no effect on biofilm formation rate;
- **Specific surface area**: well-defined engineered topographical have demonstrated
the highest degree of controllable inhibition over bacterial surface attachment when compared to smooth surfaces. The specific surface area of surface patterns (i.e. their period and size) plays the major role in the kinetics of biofilm formation;

– **Bacteria type**: no statistical difference in the bacterial growth rate on tested surfaces was observed for *Escherichia coli* and *Staphylococcus aureus*;

– **Flow conditions**: biofilms were formed in both, static and dynamic conditions, with only difference in the final biofilm thickness, which appeared to be thicker in static and laminar conditions.

### 3.2. Self-cleaning hydrophobic engineered surfaces

Self-cleaning surfaces that repel various liquids without wetting the surface can find use in a wide range of technological and consumer applications, including self-cleaning windows, windshields, sun rooms, glass roofs, repellent fabrics, anti-icing surfaces, drag-reducing surfaces, solar panels, utensils, etc. One of the most studied examples in Nature is the *Lotus leaf* (*Nelumbo Nucifera*), known for its superhydrophobicity and self-cleaning effect. Due to its extreme water repellency and self-cleaning performance, lotus leaves always remain clean in muddy ponds; such effect is often known as the ‘Lotus-Leaf-Effect’ in literature [35-41].

Repellent superhydrophobic surfaces can be designed either by selecting low surface energy materials, or by introducing surface patterns, or both [42-53]. With an objective to fabricate non-wetting engineered topographies in an easy and inexpensive way, replica molding was utilized to produce micro-structure-based patterned surfaces. The cross-sections of soft-lithographic patterned surfaces developed in this work are given in Figure 3. These surfaces were developed to provide different specific surface areas, and thus, different contact areas between the liquid drop and the surface.

The sizes of surface features in this work were systematically varied. Particularly, the pitch or period *p*, and the height *h* of micro-structures were varied as functions of the features’ width *w*, as given with equations 3-13.

$$w \leq p \leq 2w \quad (3)$$

$$0 \leq h' \leq \frac{w}{2} \quad (4)$$

$$\frac{w}{4} \leq h'' \leq \frac{w}{2} \quad (5)$$

$$h' + h'' = h_1 \quad (6)$$

$$\frac{w}{4} \leq h_1 \leq w \quad (7)$$

$$\frac{w}{2} \leq h_2 \leq 2w \quad (8)$$

$$\frac{w}{2} \leq h_3 \leq w \quad (9)$$

$$0 \leq h' \leq \frac{w}{2} \quad (10)$$

$$\frac{w}{4} \leq h'' \leq \frac{w}{2} \quad (11)$$

$$h' + h'' = h_4 \quad (12)$$

$$\frac{w}{4} \leq h_4 \leq w \quad (13)$$

Figure 3. Schematic of cross-sections of different topographies developed and tested for their self-cleaning hydrophobic performance

The materials used for fabrication of self-cleaning superhydrophobic topographies were different photo-curable fluoro-acrylate formulations due to
their intrinsic lower surface energy. The surface energy measured on smooth surfaces of these materials was in the range 20-25 mN/m. The contact angle measurements yielded that all tested surfaces have shown water contact angles of 140° or greater. In some cases, the soft lithographic fabrication of micro-structured surfaces was followed by reactive ion etching post-fabrication step with CFx/O2 gasses for different time periods in order to create dual-structure topographies, i.e. random nano-structures imposed on top of micro-structured surfaces.

In Figure 4 are given SEM images of surfaces of petals of *Dahlia* and *Rosa montana* (Figures 4a, 4c) [43] and artificial engineered topographies made by soft lithography followed by reactive ion etching in the present study (Figures 4b, 4d). By adjusting the conditions of both steps in the fabrication process, viz. the surface chemical formulation and its photo-curing, the etching gas type and the etching time, one can produce tailored surfaces in terms of their patterns and performances. The close resemblance of the artificial surface structures made in our laboratory, to the surface structures found in Nature confirms the main goal of the study: a relatively inexpensive soft lithographic step followed by reactive ion-etching step yielded the intended dual structure topography.

![Figure 4. SEM images of plant surfaces found in nature (left column) and surfaces produced in this study by soft lithography (right column). (a) Dahlia petal and (c) Rosa montana, adapted from Ref. [86]; (b) and (d) artificial surfaces developed in this study by soft lithography followed by reactive ion etching.](image-url)
The various surface micro-patterns, which cross-sections are schematically given in Figure 3 were easily prototyped by replica molding. The replicas, which SEM images are given in Figure 4b and 4d are just two examples of topographies made in our laboratory by replica molding followed by reactive ion etching. Many more topographies were fabricated by soft lithography with an objective to study the effect of patterns’ pitch and size on surface self-cleaning and hydrophobic character. For instance, the replicated surfaces given in Figure 4 have pitch \( p \) equal to the pattern’s width \( w \) (\( p = w \)). Among all studied topographies, where \( p \) was chosen to be in the range between \( w \) and \( 2w \), the topographies with \( p \) equals or closer to \( w \), have shown the best results in terms of self-cleaning performance. A trend towards improved non-wetting and self-cleaning behavior was observed, when the feature size and period were compared relative to the water drop size. These results will be published additionally.

Micro-structured and hierarchical micro-/nano-structured topographies developed in this study were subjected to measurement of their non-wetting character towards water. Besides the qualitative observation of the repellency and assessment of the contact angles on different surfaces, the engineered surfaces were assessed for their self-cleaning character, as well. Upon being covered with sand comprising micron-sized particles (0.02 g sand/cm² surface), the tested surfaces were tilted at given angles and subjected to water droplets, supplied at the top edge of the tested surface (10 ml/cm² surface). Figure 5a presents a schematic of this assessment: drops of water were supplied on the top edge of each tested surface containing sand particles. The tested surfaces were observed under microscope before and after the water washing step. For superhydrophobic surfaces, the water drops rolled down the surface as spherical drops, which collect the sand particles from the surfaces (Figure 5b). On the surfaces with lower hydrophobicity, the water drops were not spherical, i.e. they spread out and their “cleaning performance” was not as good as in the case of superhydrophobic surfaces (Figure 5c). The minimum angle \( \alpha \) (Figure 5a), at which the water still rolls-off from the surface without spreading on the surface was registered for each surface. This angle \( \alpha \) was reported as a sliding angle for each of the developed engineered topographies. All tested topographies have shown sliding angles in the range 3°-8°.

It is believed that the self-cleaning property is due to the stronger adhesion between the water droplet and the particles than the adhesion between the particles and the surface, hence the spherical water drops pick up the particles while rolling-off. On micro-structured and dual micro-/nano-structured surfaces, water drops are “tip-toeing” over the tops of the surface patterns and maintaining their droplet shapes, because there isn’t enough surface area for the adhesive forces of the surface to overcome the cohesion forces in the water. Therefore, the sand particles “sitting” on top of the surface features are most likely to be attracted more by the water (as a polar molecule) than to the low energy surface. Actually, the experimental results confirmed that the water drop wets or does not wet the flat surface of a given material as dictated by the material surface energy. By introducing surface structures, the wetting character of the surface of the given material can be further modified. The combination of micro- and nano-structures (dual-scale surface structures), made in the given fluoro-acrylate material, has shown the highest value for the water contact angle (160°). It is believed that such dual structures allowed the most air to be trapped under the water drops, which contributed to both, the superhydrophobic and the self-cleaning behavior [42-44].

The main observations regarding self-cleaning topographies, fabricated and tested in this part of the study, can be recapitulated as follows:

The water contact angle was found to increase by incorporation of micron-size features on a sur-
face compared to a smooth surface of the same material. Further increase in the water contact angle was observed by introduction of hierarchical dual-structure topographies. All tested topographies have shown water contact angles above 140°.

The *sliding angle* was found to decrease by introducing micro-structured topography and was further decreased by incorporation of nano-structures on top of the existing surface micro-structures. All tested surfaces have exhibited sliding angles in the range 3°-8°.

The combination of dual-scale surface structures and low surface energy materials minimize the contact points between the drops and the surface, which is responsible for both, the superhydrophobic and the self-cleaning behavior.

4. Conclusion

Soft lithography provides a low-expertise and quick route towards fabrication of micro- and nano-patterned engineered topographies, making it as one of the top listed and most versatile tool without major capital equipment investment.

Surface patterns in this work were successfully developed and fabricated by soft lithographic replica molding technique using an acrylate stamp. The first category of surface patterns developed in this study were anti-fouling topographies, which have shown increased inhibition of bacterial attachment and biofilm formation compared to smooth surfaces. The second category of topographies developed and tested in this work were hydrophobic topographies, which showed improved non-wetting and self-cleaning behavior compared to control surfaces. The surface patterns’ size and pitch, i.e. the specific surface area seem to play the major role in the surface final performance. The quantitative results of the anti-fouling and self-cleaning surface assessment will be published additionally.

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Abstract

BIM (Building Information Modeling), or modeling based on object data, is a process that involves the creation and management of digital representations of physical and functional characteristics of objects. The BIM system, therefore, is used to create a model using relevant information, respectively a relevant database. BIM is applicable throughout the entire life cycle of a building, from the design phase, where the BIM concept predicts the construction of an object virtually and prior to its actual physical construction, and is then also applicable in the phases of construction as well as management and maintenance. There is even a tendency to use BIM systems with older, previously built structures. Today, there are many software packages based on the BIM concept. Those are digital software packages used to create 3D object representations with layers of additional project information, which are sometimes referred to as 5D representations of objects, with time and price as the 4th and 5th dimensions. BIM management covers all IT processes in design based on the BIM system, from data storage and employee collaboration, to modeling to the project design and preparing final documents. Basically, the BIM system parameters are ‘intelligent’ objects that are not only visual displays, but also contain other information required in the design process and the preparation of project documentation. All quantities of materials and components to be used in the project are promptly followed. BIM software allows various kinds of analysis of objects. It has wide application in the theory of structures and static load analysis, because it allows a variety of analyses and 3D simulations as well as a range of calculations and the dimensioning of structural parts.

Key words: BIM, virtual information model, static analysis, BIM management

1. Introduction

BIM (Building Information Modeling), or modeling based on object data, is a process that involves the creation and management of digital representations of physical and functional characteristics of structures. Models obtained on the basis of information about a structure become a common source of information needed to support decision-making from the preliminary stages, to design and construction, through the rest of its life cycle, to its potential demolition. Building information modeling has been the most significant change in the construction industry since the creation of CAD tools BIM was developed as a way of managing the entire life cycle of a building, from initial design ideas to using the building. Using BIM technology improves the effectiveness of communication between the contractor and the design team and ensures a significant reduction in costs and increased general efficiency, from developing 3D design documents to construction works to effective use, maintenance, renovation and adaptive reuse. [1]

The concept of BIM involves the construction of an object virtually, primarily by building it physically, in order to solve problems and simulate and analyze potential impacts. [2] Building Information Modeling combines geometry, spatial relations, lighting analysis, geographical parameters, quantity and technical description of elements (for example, details of the manufacturers of individual elements or parts of a building). BIM can represent the entire life of an object, from the building process to the use scenario, namely, its maintenance. BIM allows easy access to all necessary information about quantities (for example, when doing a cost analysis). Individual elements may be extracted from the project and their variables separately determined. The systems, assembly or parts of an object can be shown to scale in relation to the entire object or group of objects.
This concept allows lower costs, faster construction, higher quality, fewer conflicts and greater satisfaction. [3] The concept of BIM has been around since the 1970s. The term Building Information Model appeared in a paper by G.A. van Nederveen. The phrase Building Information Modeling was coined by Charles M. Eastman, although he originally used a slightly different term, Building Product Model. This term often appears in his published works from the late seventies. [2] In any case, both this term and Building Information Modeling, abbreviated to BIM, only became popular when Autodesk began using the concept. [4] Phillip G. Bernstein, an FAIA architect and industrial strategist, first used the acronym “BIM” for building information modeling. The person to be thanked for popularizing and standardizing it is Jerry Laiserin. [2] Jerry Laiserin helped popularize and standardize the expression as a common name for digital building display, offering a number of names for it. Since the mid-1980s, BIM has been commonly used to denote the concept of digital display of the design process, developed and marketed by software companies such as Bentley Systems, Autodesk and Graphisoft. [2] Graphisoft used the term soft ‘Virtual Buildings’, and Bentley Systems ‘Integrated Project Models’, in order to facilitate the exchange and interoperability of information in digital form. [3-5] In January 2014, European architects and other engineers from the AEC sector supported the proposal of the European Parliament to modernize the EU public procurement procedure by adopting new principles of work in order to increase competitiveness. In other words, the European Union chose to follow the United Kingdom and its BIS (Department of Business Innovation and Skills). The BIM strategy requires that by 2016 the BIM technology be exclusively used in the design of all projects resulting from public tenders. The European Union Public Procurement Directive (EUPPD) encourages, specifies and orders the use of BIM solutions by all EU Member States. It is important to note that the Netherlands, Denmark, Finland and Norway have insisted on the use of BIM in all publicly funded projects for a long time. [2]

1.1 Definition

Wikipedia, the free electronic encyclopedia, gives the following definition: ‘In design, the concept of BIM implies that each element of a project includes not only a visual representation of that element, but also information that is essential for the preparation of project documentation.’ Thus, BIM is used to create a model with relevant information or database. This information may be dimensions, quantities, types of materials, specifications, positions, manufacturer information, prices, etc. When the user has all the necessary information about the different project elements, producing technical documentation is much faster and more accurate than with any other system. [6] One definition says: ‘BIM (Building Information Modeling) is a comprehensive design process that begins by designing the concept of an object, and ends with the production of the project documentation for the facility construction, construction management and maintenance in the exploitation phase.’ Building Information Modeling (BIM) is a digital display of the physical and functional characteristics of a structure. BIM is a shared knowledge resource for information about a structure, which forms a sound basis for decision-making during its entire life cycle, defined as existing from the earliest design stage to the structure demolition. [7] Traditional building design is largely based on two-dimensional drawings (plans, sections, etc.). BIM extends that beyond the 3D by raising the level of the three basic spatial dimensions (width, height and depth - X, Y and Z). With the time as the fourth dimension and the price as the fifth dimension, BIM encompasses more than just geometry. It also includes spatial relationships, lighting analysis, geographic information, and quantities and properties of building components (e.g. manufacturer details). For professionals involved in a project, BIM allows the designer team (architects, surveyors, civil engineers, etc.) to deliver a virtual information model to the contractor and subcontractors, as well as to the owner / operator; each expert adds his or her discipline, creating a pool of specialist knowledge applied to a common model. This reduces the loss of information that typically occurs when a new team become the new ‘owners’ of a project, and provides more information to owners of complex structures. BIM can be used to show the entire cycle of building, support processes, including cost management, construction management, project management and op-
eration of the structure. It is easy to calculate the quantities and common properties of materials. The scope of work can be isolated and defined. Compositions, assemblies and sequences can be shown to scale in relation to the entire structure or a group of structures. Dynamic information about the construction process, such as sensor and control signal readings from the building system, can also be included in BIM to support construction, operation and maintenance analysis. Modern BIM design tools define objects parametrically. Objects and their relations to other objects are defined in the form of parameters, with changes to one object automatically leading to changes in all the other objects connected to it. Parametric objects are automatically rebuilt in accordance with the rules built into them. [3,7] BIM is actually similar to the concept of PLM (Product Lifecycle Management) because it overcomes the problems of geometry and tackles aspects such as cost management and project management, while also analyzing the various ways in which a structure can be used. Hence, transition to BIM is not like replacing one type of software with another. BIM requires a completely different approach to design and far more interactive exchange of data than most architects, engineers and other professionals are used to. BIM allows modeling individual parts and components of buildings, which is an advantage over conventional programs, which use vector drawings based on the lines that make up drawings. The biggest advantage of BIM is that it allows reliable transfer of information between different project teams, as well as designers and artists. [2]

2. BIM through the life cycle of an object

The use of BIM, the concept of modeling based on object data, goes beyond planning and designing a project. Equally important is its use during and after the construction phase, as well as during the phase of facility management. Today, the Internet supports cooperation between individuals and companies in processing and exchanging design and building data, as well as in life cycle projects. The U.S. National Institute of Standards and Technology (NIST) defines a computing environment in which communities and structures may be built publicly (maps and files), while still protecting the rights of persons (corporations). A hybrid cloud, according to the NIST, is a technology that manages the digital rights of data users working in it (safety) Models based on object data incorporate the time frame definition concept. To ensure effective management of information processes throughout this period, a BIM manager may be appointed to manage the project, develop and monitor an object-oriented BIM, support multidisciplinary building information models, water analysis, schedules and logistics. Those participating in the building process are continuously faced with the challenge to successfully deliver the project, despite tight budgets, limited manpower, busy schedules and limited or contradictory information. The BIM concept allows the virtual construction of a building before its actual physical construction, in order to reduce uncertainty, improve safety, solve problems, and perform potential impact simulation and analysis. Contractors from different fields can bring important information to the model before the commencement of construction, with possibilities for prefabrication or assembly of some systems outside the site and terrain. Waste can be reduced on the spot and products delivered on time, to prevent delays in the field. BIM can bridge the information gap associated with the project delivery of the design team to the construction team and the owner/operator, so that each group adds references to the information gained in the process of BIM model development. This can lead to benefits for the facility owner or operator. For example, a building owner may find evidence of a leak in his building. Rather than exploring the building physically, he can turn it into a model and see if there is a valve at the place of the suspected leak. The model may also contain the valve size, manufacturer, part number and all other information previously explored, as permitted by the available computing power. [8,9] Despite the fact BIM technologies were initially linked to architecture, the principles underlying the development of precise 3D digital models relate to almost all infrastructure projects that require the engagement of surveyors and civil engineers on a daily basis. The BIM system is based on 3D models of objects, which contain a lot of related information in addition to visual displays, e.g. geodetic coordinates, quantities of materials and elements, properties of
elements (thermal conductivity, mass or strength), structural elements of buildings, price and a lot of other information necessary for developing project documentation. BIM allows the creation of as-built models, i.e. models of existing buildings, to be used by engineers and contractors working on reconstruction or conversion. Researchers from all over the world dealing with sustainable development, green building and environmental protection increasingly emphasize the fact that buildings account for 40% of total energy consumption and annual greenhouse gas emissions and more than 30% of the total consumption of water resources. Also, the current economic situation has significantly limited new construction and promotes renovation or adaptive reuse projects as highly cost-effective. Experts claim that 60% of the projects in the next 20 years will use the existing structures. Having accurate data about existing buildings is becoming an essential link in the overall planning process and process creation in spatial planning of this kind. The process of adapting old buildings to new purposes, so-called adaptive reuse, is a kind of shift in the construction industry. [1]

3. International BIM development

Many countries around the whole world start to realize the benefits of these technologies and the opportunities they offer, so they invest heavily in their development. [1]

3.1 BIM in Canada

The Institute for BIM in Canada (IBC) leads and facilitates the coordinated use of BIM in the design, construction and management of the Canadian built environment. Its founding partner organizations represent specific industry sectors that have an interest in seeing that BIM is implemented in a way that allows the primary participants to understand their roles and responsibilities and evaluates their capacity to participate in the process. IBC priorities include awareness of the program, practical guides, and bibliography of useful resources and the whole environment, and evaluate the use of BIM in Canada and internationally.

3.2 BIM in France

In France, several bodies support the wider application of the integrated BIM standard, in order to improve software interoperability and cooperation among stakeholders in the construction industry. Examples include the FFB (Fédération française du bâtiment), the French arm of smart buildings.

3.3 BIM in India

In India, BIM is also known as VDC. BIM and Virtual Design Construction (VDC) is the ‘digital display of physical and functional characteristics of a facility.’ Building Information Modeling (BIM) specializes in manufacturing and managing building data during its life cycle. It uses a three-dimensional, real-time, dynamic building modeling technology to increase productivity, coordination and efficiency in building, design, construction and facility management. India is a nascent market with a lot of construction activity and a great potential for large-scale residential and commercial development (due to population and economic growth). India has excellent qualified, trained and experienced BIM experts, who implement this technology in construction projects around India, while also helping the United States, Australia, UK, Middle East, Singapore and North Africa in the design and delivery of construction projects on BIM platforms.

3.4 BIM in the United Kingdom

In the UK, awareness of the benefits of BIM has led to the development of an implementation strategy, BIS (Department of Business Innovation and Skills) BIM Strategy, which is the world’s most ambitious and the most advanced program of this kind. According to them, the UK has a formula for success at the national level, with the possibility of its becoming a leading global power in using the BIM technology (URL 1). [1]

In Great Britain, the Construction Project Information Committee (CPIC), responsible for delivering best practice knowledge and guidance for construction production data, comprises representatives of the major institutions of the industry in the UK. The Committee has produced a definition similar to the one produced by the American
National BIM Standard Project Committee. It was proposed to ensure agreement on a starting point, since different interpretations of the terms hampered its adoption.

In May 2011, the UK Government and Paul Morrell, its Chief Construction Advisor, called for the adoption of BIM in the British civil construction projects that are in the amount of 5 million pounds and more. Morrell also advised construction professionals to adopt BIM. In June 2011, the British government published a BIM strategy and announced its intention to require the application of 3D BIM in its projects by 2016. In the beginning compliance will require the construction of data submitted in the supply-neutral COBie format, with the intention to overcome the limited interoperability of BIM software packages available on the market. The British government website for BIM is a clear message to the entire chain about the Government’s BIM programs and requirements.

In March 2011, the National Building Specification, owned by the Royal Institute of British Architects (RIBA), published the results of its investigation of the adoption of BIM in the UK. The second national BIM report was published in February 2012, with the results of a survey that included 1,000 British construction professionals. One of the key finding is that almost a third (31 percent) of the construction professionals surveyed used BIM in at least some projects significantly higher than 13 percent in 2011.

3.5 BIM in the United States of America

3.5.1 Contractors

The Associated General Contractors of America and American construction companies have developed various working definitions of BIM to describe it generally as an object-oriented building development tool that uses a 5-D modeling concept, information technologies and software interoperability to design, construct and operate structures, as well as to communicate project details.

Although the concept of BIM and related processes are examined by the contractors and entrepreneurs, architects and developers alike, the very notion of the question and discussion with alternatives including Virtual Building Environment (VBE) and Virtual Design and Construction (VDC) is also considered.

BIM is seen as closely linked to integrated project delivery (IPD), where the primary motive is to make teams work early in the project. Full implementation of BIM also requires that project teams collaborate more in the preparatory phase

3.5.2 Designers

The American Institute of Architects has defined BIM as ‘a model-based technology linked with a database of project information,’ which reflects the general dependence on database technology as a foundation. In the future, it will be possible to browse structured text documents such as specifications and connect them with regional and international standards.

4. BIM in the countries of the region

The fact that Croatia and other countries of the region will likely be among the last to adopt BIM systems is understandable, taking into account the size of the market and people’s awareness. It is also a fact that Croatia, as a new EU Member State, will have to adapt to innovations that are becoming standard and put some effort into research, implementation and customization of new standards in its legal framework. [1]

4.1 BIM standards

BIM is often associated with the Industry Foundation Classes (IFCS) and aecXML included information. IFCS has developed buildingSMART – intelligent building (formerly the International Alliance for Interoperability), as a neutral, non-proprietary or open standard for exchanging data between different BIM software applications (some proprietary data structures have been developed by manufacturers and included in their BIM CAD software).

Poor interoperability has long been considered an obstacle to efficiency in the industry, and in particular an obstacle to the adoption of BIM. In August 2004, the American National Institute of Standards and Technology (NIST) released a report that conservatively estimated an annual loss
of 15.8 billion dollars by the American capital in the buildings industry due to inadequate interoperability stemming from the fragmented nature of the industry. [3] An early example of nationally approved BIM standards is that by the AISC (American Institute of Steel Construction), which approved the CIS/2 standard, a non-proprietary standard originating in the UK.

There have been attempts to create BIM for older, existing facilities. They usually indicate key metrics such as the Facility Condition Index (FCI). [10] The validity of these models will have to be monitored over time, since there have been attempts to model buildings built, for example, in 1927, which requires a number of assumptions about design standards, building codes, construction methods, materials, etc., and is therefore far more complex than developing a BIM at the time of project commencement. BIM is a relatively new technology in the industry, typically slow to adopt change. However, many early buyers are convinced that BIM will begin to play a key role in the construction documents. Proponents argue that BIM offers enhanced visualization, enhanced productivity due to easy retrieval of information, enhanced coordination of construction documents, embedding and linking of vital information such as suppliers of certain materials and quantities required for estimation and tendering, increased speed of delivery, and reduced costs. [3, 5, 7]

Green Building XML (gbXML) is the formation of patterns, a subset of the BIM effort directed toward green building and operation. gbXML is used as input in several energy simulation engines. But with the development of modern computer technology, a large number of building energy simulation tools are available on the market. When choosing which simulation tool to use in the project, the user must take into account the accuracy and reliability of the tool with respect to the construction of the information they have on hand, which will serve as input for the tool. Yezioro, Dong and Leite have developed an artificial intelligence approach to the assessment of construction results of simulations and found that more detailed simulation tools have the best simulation performance in terms of heating and cooling and electricity consumption, with the mean absolute error of 3 percent.

The concept and methods are: 3D BIM, 4D BIM, BIM 5D, 6D BIM, architectural engineering, architecture, BIM Wash, construction management, design engineering computing, integrated project delivery, virtual design and construction, a design guide for the entire building.

4.2 Software based on the BIM concept

BIM software for architectural design and construction of buildings has been present in the construction industry for over two decades. In recent years, it took precedence over the traditional CAD concept in all leading design offices in the world. It has become unthinkable to do big projects without the use of BIM technology. Besides standard geometric information, BIM contains information about spatial relations, light analysis, geographic parameters, quantity and technical description of elements (for example, details of manufacturers of certain elements of the building). [2]

BIM (Building Information Modeling) is the process of creating and managing project data during the development of the project. In contrast to the conventional CAD concept, BIM goes beyond seeing projects as drawings. Therefore, the transition from ordinary CAD software to BIM is not a simple change of the working environment of one kind but entry into a whole new world of amazing possibilities. The benefits of BIM usually emphasized by its proponents are better visualization, improved productivity due to easy exchange of information, better coordination of project documents, adding and linking key information (specification of materials, positions of details and parameters of the quantities required for ordering and costing), faster design and lower costs. The original task of the CAD system is actually making simple the process of graphic representation of elements. The initial focus of the application of CAD is the representation of 2D geometry using graphic elements such as lines, knots and symbols. In this context, walls are represented as parallel lines, to give one example. In order to better organize graphic elements, the concept of layers was introduced, which groups elements with the same characteristics. For example, the lines used to demarcate walls are assigned the wall layer. By working in this way it is possible to develop 2D
views, upgrade them and export them from CAD environments, but this cannot be used to show other, more complex relations between elements. The emergence of 3D CAD environments initially focused almost exclusively on the creation of geometry in favor of visualization, while subsequent progress concentrated on creating photo-realistic perspective views which included lighting effects etc. In recent years, object-oriented CAD systems (OOCAD) have replaced 2D objects with 3D objects capable of better showing relations between the common elements of a building. These objects can be displayed in multiple views and have associated non-graphic attributes. With the introduction of parametric 3D geometry, changeable dimensions and assigned rules, objects were made ‘intelligent’, which allowed the display of complex geometric and functional relations between elements of buildings.

BIM (Building Information Modeling) is the latest generation of OOCAD systems, which allows the combination of all elements of intelligent structures for the purpose of their common existence in a single database of the project or virtual structure, containing all relevant information. The BIM model is theoretically an integrated, logical and comprehensive source of information related to a structure.

BIM is a process that requires considerable experience and knowledge of all stakeholders / participants in order to avoid application problems. The BIM technology is supported by the fact that it is slowly becoming standard, with more investors not only requiring but insisting on working in the BIM environment (URL-2). [1]

A range of software based on the BIM concept is available: ArchiCAD from Graphisoft, MicroStation from Bentley Systems, Revit from Autodesk, Tekla BIMsight from Tekla Corporation, VectorWorks and Allplan from Nemetschek, Bocad from Aveva. [1] BIM is digital software that creates 3D representations of objects with layers of additional project information. This is sometimes referred to as the 5D representation of structures, where the 4th and 5th dimensions are the time and cost. For example, using BIM an architect can simulate how wind blows around and through a building and how the ventilation and wind speed may change if you change the shape or size of the building materials. Additional information that can be modeled in BIM includes details of components and specifications, materials, structural loads, air flow, water flow, spatial relations, information layout, price and more. They are often facilitated directly when BIM authoring tools such as REVIT or Ecotect are used. BIM is not the same thing as 3D CAD. The fundamental purpose of CAD is to illustrate and help people visualize how buildings look, while BIM provides detailed information on how buildings work. Architects and civil engineers like BIM because it saves time in the design process, and builders and construction companies claim that it can also save money and time. BIM is best used when analyzing how a whole group of complex variables function together and it facilitates communication between the various parties involved in the design of structures making building design much easier. Since BIM increases the efficiency of the design process, it is a boon in sustainable design and architecture. [7, 8]

5. BIM management

BIM management encompasses all IT processes in design based on the BIM system, including data storage, stakeholder collaboration, modeling, project design and printing finished documents. It is especially important to adapt the application to the regional standards and visual identity and standards of the company. In addition, a very important part of 3D modeling is the creation of 3D BIM elements according to the needs of the project, which can be very challenging for designers. BIM management can achieve the standardization of work processes, unification of operation and automation of work processes. Thus, it results in significant savings on the time required to produce documentation and reduces or almost eliminates the possibility of errors, particularly in calculating the amount and consistency of projects by different specialists. When developing project documentation from a concept to detailed design, a range of different actions and protocols are used in order to obtain the final version. In many stages much more time is lost than is really needed. When total losses on an annual basis are added up, the figures are more than too much. For this reason, BIM addresses such issues as the introduction of standards and unification and automation of work processes.
This especially applies to the following aspects of work:

- **Storage data:**
  - directory structure
  - file structure
  - file nomenclature
  - versioning
  - data archives
  - data backup.

- **Creating drawing templates**
  - site plans
  - floorplans (preliminary, main, construction)
  - sections
  - elevations
  - cladding
  - floor sections
  - water connections etc.

Due to the fact that BIM is used to build only one model, using predefined templates easily and quickly determines the type of display according to use.

6. **BIM technology in practice**

Architects and designers spend a great deal of time developing project documentation. It is more than 30 years since the introduction of information technology in design. Many things have changed and evolved in the meantime that today’s designers must be exceptionally computer literate. As technology progresses, it is increasingly difficult for them to follow the development of new technologies and trends. Builders have always made sketches and drawings that visually portray the objects to be built. Over time, these drawings have become more complex and detailed. As it developed, technology transformed 2D drawings into three-dimensional models. There is no longer a need to draw lines to represent e.g. a wall; instead, a virtual wall is modeled, which can be shown graphically in the documentation (plan, section, elevation or 3D), or parametrically, to include other important information (its purpose (load-bearing, non-load-bearing, partition), materials, layers, physical properties, life stage (existing, for demolition), and the like). Using tools for three-dimensional design puts an emphasis on the process of design itself and facilitates the preparation of technical documents, while excluding possible errors in the early stage of the project (URL-5). The modeling procedure takes place in a few phases. In the early stages the basic building elements are modeled, such as walls, floors, ceilings and roof. Next, doors and windows, fences, and other details are modeled. As the final step, the surrounding terrain is modeled. [1]

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6.1. **Use of BIM in static load analysis**

The BIM concept and its software allow various types of analyses of buildings and structures. Beside allowing clear insight into the 3D structure of building and providing time and cost-related information, it is also allows the making of a number of simulations for different analyses. What the
computer produces as analysis and testing results is checked computationally to determine the reliability of the program by comparing the results.

Figure 1. Diagram of cross sectional forces

Architects design using special architectural BIM software, construction engineers do their calculations using special construction BIM software, mechanical engineers do energy modeling using special mechanical engineering BIM software, thus, all engineers do their part of work on the same model, but each using their own specialized BIM software. In this way, a high degree of design reliability through various design phases is enabled. A static load analysis was carried out of the steel scaffolding designed in the UK by the Layher design studio. BIM software was a perfect medium between the design drawings and CAD models and analyses. Figures 2 and 3 show the results of the analyses that are obtained by entering the values of the parameters of the structure.

Figure 1 shows a diagram of cross-sectional forces, which clearly shows that the vertical rods are withstand compression and the rods tension. Steel is the kind of material that better tolerates tension, while concrete can better withstand compression. It can be seen that the impact of forces is high around the roof ridge. The forces are the most negligible at the support points, increasing with the growing height of the structure.

In the upper parts the rods are also exposed to wind loading. According to the diagram shown in the figure (red), it is the slanted rods that take most of the loading because they are directly exposed to the impact of forces, transferring the load to the column rods. This simulation was made using BIM software to obtain the value of cross-sectional forces based on input parameters and values for the given structure.

Figure 2 shows a diagram showing the tensile loading of crossbeams. The red color shows compression, expressed as positive values (+), which is also the highest compressive load equaling 6.80 kN / m², while dark blue shows tensile loading, which is negative (-), amounting to -6.19 kN / m² as the highest value. Tensile stress is evidently the highest in the
area of the middle beams, i.e. the middle of the roof truss, while compressive stress is highest at the places where slanted rods support the beams. The rods were dimensioned taking into account the highest permitted stresses for the particular type of steel used, while making sure the structure was as light as possible to minimize the tensile loading along the ridge.

7. Conclusion

The advancement of information technology has also enabled the progress of technical science, which has used IT as a tool to solve its problems and issues. One such instance of ongoing advancement is the development of BIM technology, which has wide applications in practice. BIM technology, which was introduced to the AEC sector through the front door, promotes an interdisciplinary approach to the life cycle of a structure, including the design stage, building management and renovation or adaptive reuse. Since BIM management is at an early stage of development in most of Europe, the time is right to define the related work model and the role of experts. The concept is such that allows collaboration and parallel data input by experts from various technical areas, which is then processed by the program to create a single database. Concrete examples of structures were presented to demonstrate the application of BIM software, which creates a clear picture by visualizing the static loading of the analyzed building. The obtained values were used to dimension the elements of the structure, as dictated by the output parameters and load values. The results of the analysis shown in Figures 1 and 2 may be used to monitor structural loading and, if necessary, resize parts of the structure to ensure greater stability and safety. This is just one of many applications and possibilities provided by BIM software, which is of great importance in practice, particularly if simulations are carried out in the field using technology (tablets and other devices suitable for field work). This paper presents a methodology of creating BIM models, i.e. static load analysis. In conclusion, it may be said that BIM is highly applicable. BIM design is pretty simple as it allows the collection of variables and parameters, as well as their better visualization and presentation, which are certainly very important factors that positively impact the efficiency of BIM, especially when assessing the current state of a building. Naturally, the implementation of this type of methodology and tools requires considerable investment in hardware and software. Most of all, staff training must be a number one priority, who will learn how to work in a challenging software environment and thus be able to promote new approaches and business models.

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Hindrances to the use of E-learning system by architecture students

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Abstract

The significance of E-learning systems has been long recognized by higher education institutes around the world. It is proven that the success of use largely depends on the user’s attitude and ability to use the E-learning system. However, it was noticed that students at the University of Dammam, College of Architecture and Planning were reluctant to use the E-learning system. So, a questionnaire survey was launched in May 2014 and it aims to find out why students do not utilize the E-learning system and the utilization’s obstacles. The survey’s results showed that many students relied heavily on the Internet resources and online social networks, and few of them have used the University’s E-learning system and e-resources. The reason, as the students pointed out that the E-learning system does not help them in to undertake design studio’s activities, to overcome difficult design situations, and produce innovative projects. The students also highlighted a number of personal and technical shortages that limit the effective utilization of the E-learning system. This paper argues that potential shortages of the E-learning system should be dealt with; otherwise, the present E-learning system, as it is, will not respond to the architecture students’ needs and inspirations.

Key words: E-learning system, architectural education, virtual design studio, innovation

1. Introduction

Higher education institutions have long recognized the importance of E-learning in providing a flexible delivery of teachings and supporting the learning needs of students. E-learning tools such as Blackboard help tutors to manage virtual classes and communicate with students out of the class hours. However, the potential of E-learning will be realized if students possess positive attitudes and have the ability to use them. On the other hand, the design studio is the core of architectural education. Through the design studio, students learn how to gain creative skills and produce innovative solutions and this would be considered as the real value of design studio’s education. This would help them when they start practicing architecture, to apply their creative problem-solving skills to real life design problems and produce creative design solutions. At the University of Dammam, an ambitious E-learning system plan was initiated in 2011. The students have been encouraged to use the E-learning system for their daily academic tasks. However, it was noticed that students are reluctant to use E-learning tools and they prefer to stick to the traditional face-to-face learning methodology and traditional communication tools. The aim of the present research is to find out the reasons behind the negligence of E-learning tools by students, and how to encourage students to adopt and implement these E-learning tools in their daily architectural learning process.

2. Features of the architectural education

The purpose of learning in and about architecture rely heavily on the notion that thinking consists of mental images and principled manipulation of mental images. This is based on what is known as visuospatial thinking theories [1]. Appropriate visuospatial thinking during learning can enhance the learner’s understanding, and multimedia presentation can be designed to prime appropriate visuospatial thinking during learning [1]. The education in the design studio stimulates its’ characteristics from the nature and process of architectural design. The development of architectural project from initial concept to the end product is an interactive social and psychological process. Through the design process, the designer negotiates various solutions of the design problem with oneself and communicates
ideas with colleagues and tutors [2, 3]. This would help in exploring new solutions thus it would lead to the discovery of creative solutions of a design problem. The architectural design studio offers a prime example of a collaborative, multi-sensory, learner-centred, constructivist, experiential problem-based teaching environment [2, 3]. Learning about how to do architecture and how to ‘think’ architecture requires a great deal of cognitive processing, the manipulation of mental images, understanding of complex cause and effect relationships, functional, technical, performance, aesthetic, cultural and physical aspects [4]. Before a project begins, the tutor(s) may establish the goals, expectations, general procedure, and assessment criteria he/she will employ for the project. Architectural curriculum consists of a number of theoretical, lab and design studio courses. Most of the colleges of Architecture in the Kingdom of Saudi Arabia (KSA) have ten design studio courses (i.e. Design I to Design X) at undergraduate level. These courses are the core of architectural education. The architectural curriculum is based on the design studio model which focuses on “learning by doing”. During each semester, tutors meet students either individually or in groups for design-related discussions and clarifications. Architects who aim at producing innovative design products should explore unfamiliar and unconventional design solutions and they should perceive the design problem from unorthodox and innovative perspectives [5]. Lawson [6] indicated that designers should inspect the underlying pattern and made connections in a design situation (between design aspects) and also make a connection with some precedent in the episodic memory. Gero and Maher [7] provided more definite definition of innovation. They argue that groundbreaking designs are those which possess innovative and creative qualities and provide solutions that were previously unknown (innovative design) or subsequently produce entirely new products (creative design).

3. The use of E-learning and other digital systems in architectural education

There are a number of E-learning systems used in higher education. Blackboard is a Learning Management System that supports online learning and teaching. Blackboard provides an integrated environment for the learners to interact by using course. Blackboard forms the core of the Virtual Learning Environment (VLE). It integrates various components of the VLE, such as BB Mobile, Elluminate, Tegrity and Elicitus to each other and it also integrates the VLE to the university systems such as the library systems, university portal and student information system. Oracle’s PeopleSoft is used for student administration and it is a feature-rich student information system. Architectural students and faculty usually use the University email, Blackboard, and online social communication channels such as Facebook, Academia and Twitter for communications. The use of E-learning pedagogies and methodologies is an area that is rapidly becoming core to many teaching and learning institutions worldwide such as Bartlett School of Architecture, UCL [8] and Welsh school of Architecture, Cardiff University [9], in the effort to enhance their educational provision and meet current professional demands.

Juvancic et al. [10] highlighted a number of E-learning platforms or what so called Learning Management Systems (LMS). These systems share common aspects and elements that are suitable for a cross-section of common E-learning activities and tools for running and managing (blended) courses. Moodle, for example, can be applied to many levels of teaching and used for different topics and in different settings [ibid]. Another E-learning system is VIPA which addresses many relevant issues of E-learning in architecture, using traditional LMS E-learning tools and integrating new ones [11].

Mizban, and Roberts [12] reviewed the use of E-learning system in schools of architecture, UK, and its implication on architectural education. They highlighted that schools of Architecture could benefit from the use of E-learning system if they do the followings:

- provide professional advanced technical support for both staff and students;
- select appropriate technology;
- investigate how technology can best be integrated into the traditional studio setting and the curriculum; and
- assess the time and effort necessary to introduce and maintain this mode of learning.
On the other hand, virtual Environments can support teaching in a single studio within an institution and bring together students from several institutions [13, 14]. Virtual Environments present an essential learning for practice of the future, exploiting technology in design teaching, researching the nature of design communication and processes, and searching for ways to improve the educational experience of a student [15, 16]. The advent of Virtual Design Studio (VDS) appears to raise promising opportunities for reconsidering the way we teach design [17]. Pioneering schools of architecture, such as the University of Sydney, Cornell University, Eidgenössische Technische Hochschule (ETH), Massachusetts Institute of Technology, the National University of Singapore and the University of British Columbia have experimented the use of worldwide virtual design studios. In these studios, students and tutors work together on a design project. They discuss design problems and try possible solutions. The virtual design studio provides the students with an opportunity to practice their creative thinking skills by sharing their concepts and ideas with a broader spectrum of students and instructors from different cultural, educational, and even philosophical backgrounds [17]. VDS provides a powerful communication and navigation environment where users can collaboratively design in centralized or distributed real-time virtual environments [16].

Regina et al. [18] highlighted the viability to promote collaborative learning with the support of the electronic learning open source system TIDIA-Ae in distance education courses for competent designers. However, the researchers found this open source system falls short in the support of collaborative design. Pinho et al. [19] also found that the 3D collaborative environments mostly promote interaction in chat modes whereas cooperative object manipulation is still limited. Hodgson et al (2009) [20] reported their use of E-learning materials for building measurement to undergraduate students in Loughborough University, UK and the University of Newcastle, Australia. One aspect of their E-learning delivery aims to improve quantity surveying students’ understanding of construction drawings; thus, various 3D models using Google SketchUp and Camtasia Studio are utilised. An on-line survey (28 responses) was conducted among the on-campus and distance learners in both the universities (i.e. Loughborough and Newcastle) using the E-learning materials for building measurement. Most students (56%) from the survey responded that they wanted online as well as face-to-face tutorials. It was also reported that some students found it difficult to acquire the mix of skills and knowledge within the timeframe allowed.

In Asia, Chung et al (2006) [21] indicated the use of E-learning to deliver construction technology to undergraduate students in the Hong Kong Polytechnic University. Their online mode is offered through the Hong Kong CyberU software. Their on-line survey (185 responses) conclude that E-learning is a practical method to deliver teaching in construction technology as it helps student to improve their learning independence, learning efficiency and, to a certain extent, learning effectiveness. It is however to be noted, these improvements would not necessarily result in achieving a better examination result. Ramilo and Bin Embi [22] found that Digital technologies such as parametric based tools (e.g. Autodesk Revit) and building performance simulation tools that are used in architectural practices, have proven to initiate digital innovations, and improve productivity and design quality. However, there are some impediments to the use of these technologies and these include: insufficient technical knowledge of the team, lack of interest for digital innovation, poor organization attitude to innovation, and lack of empowerment and support to digital innovation.

Blended learning methodology has been recommended by researchers as it spans over face-to-face (f2f) and E-learning connecting them, combining learning on site with distant learning under the joint name of distributed learning [11]. Blended learning with f2f component can produce a stronger sense of community among participants than fully online course [11], socio-cultural context for learning environment and helps maintain the link with traditional design studio practices in the field of architecture [11]. So, it can be argued that blended learning would enhance design studio courses [23]. Blended learning would be a possible solution as it offers a great deal when used to enhance teacher education programmes [24]. It can bring together students from all locations and
a range of backgrounds and can provide a media-rich, collaborative, personalized and interactive learning environment (ibid).

Previous research showed that university teaching staff and students have generally positive attitudes towards integrating technologies into teaching [25]. Alenezi [26] reported an overall positive attitude toward the adoption of E-learning among faculty members, students, and administrators [see also 27]. Hussein [28] conducted a study in the KSA on the attitude of faculty members toward E-learning; it was found that faculty members in Saudi universities have positive perceptions of E-learning. Al-Nuaimi and Aboukhatwa [24] conducted a survey on university tutors and they inspected the tutors’ views on blended learning. The surveyed tutors said that blended learning can be implemented in the subject of architectural design, meanwhile they were concerned about the efficiency of such implementation and they said that they would have a difficulty in teaching architectural design using blended learning methodology.

Despite the benefits that the use of E-learning system would provide to students and educators, there is a considerable resistance of faculty including the architectural faculty to the use of E-learning. Recent research has shown limited use of educational technologies in university teaching [4, 29, 30]. Among various other concerns, there is a common doubt that E-learning can be as equally effective as traditional face-to-face architectural studio teaching and culture [10, 31]. There is also doubt on how and whether these systems would develop the student’s competence in design courses [32, 33, 34]. There is a concern that some students who have negative attitudes throughout the traditional learning process, would have the same attitude throughout the E-learning process [31]. Such negative attitudes towards technology would be explained by the influence of a number of factors such as limitations in national and institutional policies and management practices [30]. Also, poor Internet infrastructure, and a lack of distance learning education, as well as lack of support are still major barriers [26]. In the KSA, recent research on e-learning has indicated that despite the importance and usefulness of E-learning, the most apparent inhibiting factors are lack of knowledge and skills [35].

However, the negative attitudes are not merely influenced by the lack of technological knowledge or poor infrastructure but the fact that the university teaching staff are more focused on institutional issues and pedagogical applications of technologies, so they would choose to integrate technologies into their teaching if and when they see educational value in doing so [36]. Also, it can be referred to the nature of academics’ beliefs about what constitutes good teaching [37]. So, the staff attitudes towards the use of technologies in higher education are substantially influenced by their approach to teaching [ibid]. Abouchedid and Eid [38] suggested that E-learning attitudes among faculty members varied significantly depending upon the level of perceived usefulness of E-learning technology in promoting job performance.

On the other hand, the strategic plan of for the implementation of E-learning system on the University of Dammam and colleges’ level does not support the whole E-learning process as it does not have a financial, ethical, and administrative/managerial framework to do so [31]. The E-learning strategy did not take into account the possibility of interdisciplinary, cross-disciplinary, multi-disciplinary education/courses between the university’s departments and colleges. The strategy did not consider how to provide an E-learning system that integrates the professional training and Continuous Professional Development (CPD) with the architectural education as in the case of the Western Universities [see for instance 8& 9]. The document suggested that a quantitative measurement of the user’s performance (i.e. the student and the tutor) would be applied. However, the measurement of user’s performance cannot be achieved by applying quantitative measures only as qualitative/tangible issues should be considered. The matter is not about the mere satisfaction of students, it is rather about possible problematic issues such as social and psychological issues surrounding the utilization of the E-learning system [31].

4. The research design and methodology

The literature review has highlighted some of the possible reasons behind the little use of E-learning technology by the students and their negative attitudes towards the emerging technologies.
At the University of Dammam, College of Architecture and planning, the E-learning committee has noticed that the E-leaning system is of little use by students. To find out the reasons behind the little use, a field study was initiated at the College of Architecture and the research objectives are:

- to find out the level of use of E-leaning system by students in term of frequency of use;
- to find out whether the E-learning system would help students to produce innovative projects;
- to investigate possible present technical and personal impediments to the use of E-learning system; and
- to make recommendations on how to improve the E-learning system to respond to the students’ needs and inspirations.

The questionnaire survey was conducted in May 2014 on students of the College of architecture and planning, the University of Dammam (UD). Prior to the initiation of the survey, a verbal consent was obtained from the heads of departments of College of architecture. The sample was chosen from the third to fifth year students as the first and second academic years are preparatory and joint year’s education. In May 2014, a questionnaire survey was handed to the students at the five departments of the College of Architecture and Planning. The total number of the third to fifth year students in the College of Architecture and Planning, UD is 387 students. 150 students filled in the questionnaire and handed back (see table 1). This represents 39% of the total number of third to fifth year students from College of architecture, UD. SPSS software was used to analyse the results. The next section discusses results of the questionnaire survey.

### Table 1. The number of students at each department and the number of respondents who participated in the survey

<table>
<thead>
<tr>
<th>Department</th>
<th>Number of students</th>
<th>Number of respondents</th>
<th>Percentage of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture</td>
<td>126</td>
<td>53</td>
<td>%42</td>
</tr>
<tr>
<td>Landscaping Architecture</td>
<td>59</td>
<td>19</td>
<td>%32</td>
</tr>
<tr>
<td>Urban &amp; Regional Planning</td>
<td>96</td>
<td>26</td>
<td>%27</td>
</tr>
<tr>
<td>Building Technology</td>
<td>76</td>
<td>34</td>
<td>%44</td>
</tr>
<tr>
<td>Interior Design</td>
<td>30</td>
<td>18</td>
<td>%60</td>
</tr>
<tr>
<td>Total</td>
<td>387</td>
<td>150</td>
<td>%39</td>
</tr>
</tbody>
</table>

5. The survey results

5.1. The direct results

Students were asked to rate their level of experience in using online resources. Around 80% said that they have novice to beginner experience in using Blackboard, UD Library catalogue and UD e-resources. On the other hand, around 60% of students said that they have proficient to expert experience in using online intelligent search engines and communication and social networks whereas around the third of respondents said that they have good experience in using online architectural resources. 41% of respondents said that they never or rarely used PeopleSoft. Blackboard is also less frequently used by around 70% of respondents. 76% of respondents less frequently used UD library catalogue and 68% used UD’s e-resources. On the other hand, more than 70% (i.e. 74-78%) used more frequently online intelligent search engines, e-architectural resources, e-communication and online social networks. Students were asked how far web tools would help them in producing innovative design projects. Around 90% (i.e. 87%- 90%) of students said that Blackboard and UD’s Library catalogue are not helpful or somehow helpful. 70% of students said that UD’s e-resources are not to somehow helpful. On the other hand, 86% of students said that the online intelligent search engines are helpful to very helpful. Around 70% (i.e. 66%-74%) said that online communication and social networking tools and online architectural resources are helpful to very helpful in producing innovative projects.

Students were asked how far the web tools that they used, would help them overcoming challenging design situations. Around 50% (i.e. 49% to 52%) said that the tools that they used; are helpful.
or very helpful in sorting out the following troublesome design situations (table 2):

- low level of knowledge regarding the design of one of the project aspects;
- uncertainty of how to design one of the project aspects; and
- lack of the design skills required to design the project

Around 75% of the students said that the absence or shortage of the UD’s Wi-Fi network hinder their use of UD’s E-learning tools. Around 60% (i.e. 56% to 66%) said that the following issues hinder their use of UD’s E-learning tools:

- slowness of the UD network;
- repeated network problems;
- lack of professional advanced technical support; and
- slowness of help provided by IT staff.

Table 2. The number of students at each department and the number of respondents who participated in the survey

<table>
<thead>
<tr>
<th>Challenging/ troublesome design situations</th>
<th>Not helpful (%)</th>
<th>Somehow helpful (%)</th>
<th>Helpful (%)</th>
<th>Very helpful (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stuckness</td>
<td>17</td>
<td>37</td>
<td>35</td>
<td>11</td>
</tr>
<tr>
<td>Hesitation to take the next step</td>
<td>7</td>
<td>53</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>Low level of knowledge regarding the design of one of the project aspects</td>
<td>9</td>
<td>39</td>
<td>36</td>
<td>16</td>
</tr>
<tr>
<td>Misjudgement of some project requirements</td>
<td>15</td>
<td>41</td>
<td>36</td>
<td>8</td>
</tr>
<tr>
<td>following a wrong route during the design process</td>
<td>19</td>
<td>43</td>
<td>30</td>
<td>7</td>
</tr>
<tr>
<td>Uncertainty of how to design one of the project aspects</td>
<td>6</td>
<td>43</td>
<td>40</td>
<td>11</td>
</tr>
<tr>
<td>Misjudgement about the resulted design of one of project aspects</td>
<td>10</td>
<td>48</td>
<td>31</td>
<td>11</td>
</tr>
<tr>
<td>The attempt to change of the approach to the design solution during design process</td>
<td>8</td>
<td>48</td>
<td>35</td>
<td>8</td>
</tr>
<tr>
<td>The attempt to change the whole design solution during the design process</td>
<td>18</td>
<td>38</td>
<td>32</td>
<td>12</td>
</tr>
<tr>
<td>Confusion over the nature and context of the design process</td>
<td>16</td>
<td>50</td>
<td>26</td>
<td>9</td>
</tr>
<tr>
<td>Confusion over the context of the prospected design outcome</td>
<td>16</td>
<td>48</td>
<td>30</td>
<td>6</td>
</tr>
<tr>
<td>Lack of the design skills required to design the project</td>
<td>11</td>
<td>40</td>
<td>38</td>
<td>11</td>
</tr>
<tr>
<td>Misapplication of one of the design requirements</td>
<td>12</td>
<td>45</td>
<td>31</td>
<td>12</td>
</tr>
<tr>
<td>Stuckness</td>
<td>17</td>
<td>37</td>
<td>35</td>
<td>11</td>
</tr>
<tr>
<td>Hesitation to take the next step</td>
<td>7</td>
<td>53</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>Low level of knowledge regarding the design of one of the project aspects</td>
<td>9</td>
<td>39</td>
<td>36</td>
<td>16</td>
</tr>
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<td>15</td>
<td>41</td>
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<td>following a wrong route during the design process</td>
<td>19</td>
<td>43</td>
<td>30</td>
<td>7</td>
</tr>
</tbody>
</table>

5.2. The study of factors that affect the E-learning system use

5.2.1. The relation between level of user’s experience and frequency of use with the level of help that web tools would provide

The ANOVA test showed a number of significant relations between the user experience and frequency of use – as independent variables- with the students’ views on the level of help that the web tools would provide them. For example, the results showed that students, who have higher experience of using PeopleSoft, are the more frequent users of PeopleSoft and Blackboard and these students pointed out that Blackboard provides more support to the student in his attempt to produce innovative design projects.

Students, who have higher experience in using Blackboard, said that they more frequently used...
Blackboard, UD library catalogue and highlighted that Blackboard provides more support to the student in his attempt to produce innovative projects. These students also indicated that the web tools that they used help them more in overcoming a troublesome design situation i.e. misunderstanding of some project requirements. Students, who have higher experience in using UD’s library resources, said that they more frequently used library catalogue and UD’s e-resources. These students also highlighted that Blackboard and UD’s e-resources provide more support to student in his attempt to produce innovative design projects.

Students, who have higher experience in using UD library resources, said that:
- they more frequently used UD e-resources;
- Blackboard and UD Library catalogue and UD e-resources provide more support to the student to produce innovative projects; and
- the web tools that they used help them to overcome a difficult design situation i.e. misjudgment about the resulted design of one of project aspects and confusion over the nature and context of the design process.

Students, who have higher experience in using online intelligent search engines, said that:
- they more frequently used Online intelligent search engines;
- online intelligent search engines, online communication and social networking tools and online architectural resources provide more support to the student in his attempt to produce innovative design projects; and
- the web tools that they used, help them more to overcome the following challenging design situations:
  ○ Stuckness;
  ○ Misunderstanding of some project requirements;
  ○ Uncertainty of how to design one of the project aspects.
- Students, who have higher experience in using online communications and social networking tools, said that:
  - they more frequently used Online intelligent search engines;
  - online intelligent search engines, online communication and social networking tools, online architectural resources provide more support to the student to produce innovative design projects; and
  - the web tools that they used, help them more to overcome the following challenging design situations:
    ○ Stuckness, misunderstanding of some project requirements, following a wrong route during the design process, and the attempt of the student to change of the approach to the design solution during design process.

Students, who have higher experience in using online architectural resources, said that they more frequently used online intelligent search engines, and the web tools that they used, help them more to overcome stuckness situation during the design process.

Students, who more frequently used UD library catalogue, said that Blackboard, UD’s Library catalogue and UD’s e-resources provide more support to the student in his attempt to produce innovative design projects. Students who more frequently used UD’s e-resources, said that UD’s e-resources provide more support to the student in his attempt to produce innovative design projects, and the web tools that they used, help more in overcoming difficult design situation; namely: misjudgment about the resulted design of one of project aspects.

Students, who more frequently used online intelligent Search Engines, said that:
- online intelligent search engines, online communication and social networking tools and online architectural resources provide more support to the student to produce innovative design projects; and
- support the student to overcome a number of troublesome design situations.

Students, who more frequently used online communication and social networking tools, said that:
- online intelligent search engines, online communication and social networking tools and online architectural resources provide more support to the student in his attempt to produce innovative design projects; and
- support the student to overcome the following troublesome design situations:
○ Stuckness
○ Low level of knowledge regarding one of the design aspects; and
○ The attempt to change of the approach to the design solution during design process
  – Students, who more frequently used online architectural resources, said that:
  – online Communication and social networking tools and Online architectural resources provide more support to the student in his attempt to produce innovative design projects; and
  – support the student to overcome the following troublesome design situations:
    ○ Stuckness;
    ○ hesitation to take the next step;
    ○ following a wrong route during the design process;
    ○ uncertainty of how to design one of the project aspects; and
    ○ the attempt to change of the approach to the design solution during design process.

5.2.2. The relation between the level of help that web tools provide in overcoming troublesome design situations and in producing innovative design projects

ANOVA results showed that students, who indicated that web tools they used, help them more in overcoming stuckness situation, said that online intelligent search engines, online communication and social networking tools and online architectural resources provide the student with more support in his attempt to produce innovative design projects.

Students who pointed out that web tools they used, help them more in overcoming hesitation to take the next step during the design process, said that online intelligent search engines, online communication and social networking tools and online architectural resources provide the student with more support in his attempt to produce innovative design projects.

Students, who highlighted that web tools they used, help them more in overcoming their low level of knowledge regarding one of the design aspects situations, said that online intelligent search engines, online communication and social networking tools and online architectural resources provide the student with more support in his attempt to produce innovative design projects.

Students who mentioned that web tools they used, help them more in overcoming following of a wrong route during the design process situation, said that online intelligent search engines, online communication and social networking tools and online architectural resources provide the student with more support to produce innovative design projects. Students who pointed out that web tools they used, help them more in overcoming following of a wrong route during the design process situation, said that online intelligent search engines, online communication and social networking tools and online architectural resources provide the student with more support in his attempt to produce innovative design projects.

Students who pointed out web tools that they used, help them more in overcoming the uncertainty of how to design one of the project aspects situation, said that online communication and social networking tools and online architectural resources provide the student with more support in his attempt to produce innovative design projects.

Students, who pointed out web tools that they used, help them more in overcoming their misunderstanding of some project requirements, said that online intelligent search engines, online communication and social networking tools and online architectural resources provide the student with more support in his attempt to produce innovative design projects.

Students who highlighted that web tools they used, help them more in overcoming their misunderstanding of some project requirements, said that online intelligent search engines, online communication and social networking tools and online architectural resources provide the student with more support in his attempt to produce innovative design projects.

Students, who indicated web tools that they used, help them more in overcoming their misunderstanding of some project requirements, said that online intelligent search engines, online communication and social networking tools and online architectural resources provide the student with more support in his attempt to produce innovative design projects.

Students who mentioned that web tools they used, help them more in overcoming the misjudgment about the resulted design of one of project aspects situation, said that online communication and social networking tools provide them with more support in his attempt to produce innovative design projects.

Students who pointed out web tools that they used, help them more in the attempt to change of the approach to the design solution during design process, said that UD's e-resources, online communication and social networking tools and online architectural resources provide them with more support to the student in his attempt to produce innovative design projects. Students who pointed out web tools that they used, help them more in overcoming the confusion over the nature and context of the design process situation, said that UD's Library catalogue provide them with more support to produce innovative design projects.

5.2.3. The impact of technical support on the use experience, frequency of use and student's views

The regression test showed that frequent slowness of the UD’s network is associated with lower
level of student’s experience in using PeopleSoft and infrequent use of PeopleSoft and UD library catalogue, and vice versa (table 3). The inflexibility, non-interactivity and complexity of the use of E-learning tools are associated with lower level of student’s experience in using UD e-resources and vice versa. The frequent lack of personal E-learning training is linked with lower level of student’s experience in using online architectural resources and vice versa. The frequent lack of professional advanced technical support is associated with an infrequent use of Blackboard and vice versa. The frequent lack of personal interest to use the E-learning technology is associated with an infrequent use of online intelligent search engines. The repeated network problems are associated with an infrequent (i.e. lesser) use of online architectural resources.

5.2.4. Differences between the study groups

The Kruskal Wallis Test showed significant differences in opinions (i.e. P<0.05) between students of different departments and this is concerning the following aspects:

- the level of student’s experience in using Blackboard; UD’s e-resources; online architectural resources
- the frequency of use of PeopleSoft and Blackboard
- the help that UD’s e-resources and online architectural resources provide the student in his attempt to produce innovative design projects; and
- the support that web tools that are used, provide support to the student in difficult design situations, namely; hesitation to take the next step and confusion over the context of the prospected design outcome.

The Mean Rank results for the same test (i.e. Kruskal Wallis) suggested that architecture students have less experience in using Blackboard than other students from other departments. Planning students have less experience in using e-resources than students from other departments. Architecture students used PeopleSoft less frequently than students from other departments. Interior design students used Blackboard less frequently than students from other departments. Planning students said that UD e-resources and online architectural resources provide lesser help to the student to produce innovative projects, in comparison with what students from other departments have indicated. Building technology students said that web tools that they used provide lesser support to the student to overcome difficult design situations, in comparison with what other students have indicated.

6. Discussion

The field survey, supported by research findings of various researchers a number of problematic issues inhibiting the utilization of E-learning system by the students at the College of Architecture and why students are reluctant to use them [see also 4, 30, 31]. There is unclear and limited strategy and policy concerning the implementation of E-learning system (see also [31]). One of the issues is the weak infrastructure and technical support. The previous research identified some technical limitations of the virtual design studios such as the limited cooperative object manipulation (see for instance [19, 20]). Also, there is a problem in integrating architectural software such as 3D modelling, virtual environment, visualization and simulation systems with online learning systems.

The results showed many students have novice level of experience in using E-learning tools such as UD’s library catalogue and UD’s e-resources whereas many of them have proficient to expert experience in using online resources and communication tools. Students infrequently used UD’s resources and E-learning system i.e. Blackboard and PeopleSoft whereas many students used frequently online resources and utilize online communication and social networks. The majority of students said that Blackboard and UD’s Library catalogue do not help students in their attempt to produce innovative projects. Also, many of them regret that UD’s e-resources are not helpful. On the other hand, many students said that online resources, search engines, communication and social networking tools help the student in his attempt to produce innovative design projects.

Half of the students said that the web/ tools that they used help them in overcoming a number of troublesome design situations such as low level of knowledge regarding the design of one of the
project aspects; uncertainty of how to design one of the project aspects; and lack of the design skills required to design the project.

Students highlighted the personnel and technical problems that they have. They said that the shortages in IT support, IT infrastructure, personal training and lack of personal interest hinder their use of UD’s E-learning tools.

The study showed significant relations between the level of user’s experience and frequency of use with the help that web tools provide to the student in overcoming difficult design situations and in his attempt to produce innovative projects. The higher level of experience and frequent use of UD’s E-learning tools and e-resources are associated with higher level of help that is provided by UD’s E-learning tools and e-resources tools and online tools to the student in his attempt to sort out design problems and produce innovative projects.

The higher level of experience of web/online tools and frequency of use of these tools are associated with the help that web tools provide to the student in overcoming difficult design situations and in his attempt to produce innovative projects. For instance, students, who more frequently used online communication and social networking tools, said that online intelligent search engines, online communication and social networking tools and online architectural resources provide more support to the student in his attempt to produce innovative design projects; and support the student to overcome the following troublesome design situations.

The study also found significant relations between the levels of help that web tools provide in overcoming troublesome design situations and in producing innovative design projects. Students highlighted that web tools such as online intelligent search engines, online communication and social networking tools and online architectural resources, which they used enable them in overcoming a number of troublesome design situations and produce innovative projects. Apart of two links between the UD’s library catalogue and e-resources with the student’s experience, the study did not find any significant relations between the use of UD’s tools and the help and support that these tools would provide the student in overcoming the difficult design situations and producing innovative design projects.

The study revealed significant impact of the technical and personnel support on the user’s experience, frequency of use and how far web tools can be used to support design activities. Student highlighted the shortage in IT infrastructure and complexity of E-learning tools affect their experience and frequency of use. The IT shortage i.e. repeated network problems also affect negatively the use of online architectural resources. The lack of professional IT support has also a negative impact on the student use of UD’s E-learning tool and e-resources. The lack of personal training plays a significant role in impacting student’s use of UD’s E-learning system. The students however admitted that they have lack of interest of E-learning technology and this is in turn affects their use of web/online search engines. The study indicated significant differences between students from different departments and this in regards to the experience, frequency of use and the student’s views concerning the help that web tools would offer to the student during the design process.

7. Recommendations

The following recommendations indicate how to design, customize and structure the UD’s E-learning tools and e-resources so they would effectively help architectural students, support innovative activities and thinking in the architectural education. These recommendations are based on the findings of this research supported by the literature review.

7.1. The student experience and use

The survey results indicated that the user’s experience can be enhanced by the frequent use of UD’s E-learning tools and UD resources. This however, cannot be left to students to do it by themselves, and the library’s affairs and IT deanships should set training programs for students on how to use the E-learning tools and e-resources and set online helpline that would instantly respond to the students’ enquiries.

7.2. The E-learning strategy, IT personnel and infrastructure

A clear strategy and policy should be developed concerning the implementation of online teaching courses in the architectural education and a clear vi-
sion, mission and objectives should be set for the online curriculum. The strategy should consider possible integration between the professional training, the Continuous Professional Development (CPD) schemes and the architectural education.

The study highlighted the negative impact of the shortages of IT infrastructure on the user experience and frequency of use. Potential technical problems should be identified and sorted out as possible. Robust infrastructure should be implemented and advanced technical support should be provided to the faculty and students. Sorting out the IT shortages would give students more freedom/ flexibility to explore the UD’s E-learning tools and e-resources and effectively use it. Professional training for the IT staff is essential as it would enable them to deal with the students’ enquiries in a professional and delicate way. Accordingly, innovative synchronous communication and visualization tools should be designed, specifically for architectural design users [11, 18]. Therefore, the future research should inspect how new E-learning systems should be developed to overcome the present shortages and meet architectural education requirements.

The previous research found that virtual design studio would offer real benefits to tutors and students as it crosses the traditional design studio boundaries, blends the traditional design studio teaching with the virtual design teaching thus would enhance the design studio teaching [16, 39]. So, the benefits of virtual design studio concept and approach should be demonstrated to the faculty. Thus, the development of virtual design courses can be discussed with the faculty and see how it can be integrated into the traditional design studio settings and the curriculum (see also [12]) taking into account how to overcome the present technical, policy, and knowledge-wise barriers.

7.3. E-learning tools, e-resources and architectural design

The study revealed the dissatisfaction of students with the support of UD’s E-learning tools and e-resources to the student in his attempt to find architectural information, overcome challenging design situations and develop innovative design projects. It is obvious that the present E-learning system is not neither flexible, nor integrated with the architectural education system and tools. The E-learning system should be customized so it would respond effectively and dynamically to the architectural students’ needs during the design process and throughout the educational process. One way to do so is to design innovative synchronous communication and visualization tools for architectural design users. Possible problems in integrating architectural software such as parametric 3D modelling (i.e. BIM software), virtual environment, visualization, and simulation systems with online learning systems should be identified and sorted out.

On the other hand, the e-resources should be structured according to the architecture students’ needs. This can be done by setting architectural information on the library’s web site and listing web links to important and innovative architectural resources and sites. The provision of digital maps and innovative design precedents is essential for students. However, the structure of design precedents should enable students to look for innovative architectural solutions, explore the innovative aspects of each case study, experiment with possible links between innovative design aspects/solutions and each dimension of the design problem, in line with expert designers’ usual practice.

It is essential to provide online Architecture-wise system that can be integrated with e-education system and can be used by distant learners. Such system would help them appreciating certain design parameters and constraints. For example Eco-spatial interface that enables the learner to choose the spatial settings for the building and choose the greenery around and apply external finishing to the building. Another example is the virtual design through virtual environment and virtual Design Studios’ systems and tools.
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Definitions

1. Virtual Learning Environment: is a system for delivering learning materials to students via the web. These systems include assessment, student tracking, collaboration and communication tools. (Source: http://global.oup.com/uk/orc/learnvle/)

2. Virtual Design Studio: is a software platform currently under development in support of an integrated, coordinated and optimized design of buildings and their energy and environmental systems. (Source: http://link.springer.com/article/10.1007%2Fs12273-013-0110-2)

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Abstract

Slovenia and Bosnia are both transition economies with many similarities. The institutional phase of the socio-political transition has been concluded but the socio-economic transition has not yet been completed. This article presents the Six Sigma and Lean business strategies, and their basics, integration and implementation. Six Sigma improves the quality of value adding steps whereas Lean eliminates non-value adding steps. Lean Six Sigma simultaneously drives quality, speed and cost. Implementation of much needed organizational changes, such as Lean Six Sigma requires time and support from top management. Research has revealed the most common barriers and key success factors (CSFs) to Lean Six Sigma implementation in Slovenian manufacturing companies. The article presents some of the previous findings of the authors in this field in Slovenia. The findings are supplemented with an analytical research approach and the author’s experiences. Lessons gained from Slovenia are presented as well as benefits for Bosnian manufacturing companies (geographically located in the territory of Bosnia and Herzegovina). This topic has not yet been analysed by researchers and represents a unique study in the field of Lean Six Sigma in transition countries such as Slovenia and Bosnia.

Key words: Six Sigma, Lean, manufacturing, Slovenia, Bosnia.

1. Introduction

Increasing demand for high quality products and the need for highly capable business processes have encouraged organizations to include Six Sigma and Lean in their business strategy. In the future, many organizations and industries, including the Slovene and Bosnian manufacturing industries, will focus more on the following projects: globalisation management projects, research and sustainable development projects, cost management-oriented projects, production cost management projects, innovative product development and brand management-related projects. [1] Thus, for a successful project selection and implementation, we need good product management supported by Lean and Six Sigma and customer benefit-oriented projects [1,2,3] In the last decade, one very exposed and growing methodology in transition countries, including Slovenia has been the Six Sigma and emerging Lean manufacturing methods and their integration, known as Lean Six Sigma.

2. Six Sigma and Lean

2.1 Six Sigma

Six Sigma is a well-established approach that seeks to identify and eliminate defects, mistakes or failures in business processes or systems by focusing on those process performance characteristics that are of critical importance to customers [4]. Schroeder [5] highlight four elements that are distinctive to Six Sigma with respect to quality: “the focus on financial and business results is to some extent unique”, “the use of a structured method for process improvement or new product and service introduction is also not entirely distinctive”, “the use of specific metrics is also new with Six Sigma”, and “the use of a significant number of full-time improvement specialists in Six Sigma is new to many organizations.” [6]. The development and application of Six Sigma performance measures that cover both strategic and operational performance measures lead to a more sustainable approach to business improvement. [7] There are many aspects of the Six Sigma management business strategy which support development strategies [7]:

1. Six Sigma places a clear focus on the bottom-line impact of costs and savings. The Six Sigma project will be approved unless the team determines the savings generated from it.
However, not all Six Sigma projects produce direct large benefits, many produce only local improvements and about 20 percent of projects are cancelled [8].

2. Six Sigma has been very successful in integrating both the human aspects (culture change, training, customer focus, etc.) and process aspects (process stability, variation reduction, capability, etc.) of continuous improvement. Every individual employee at the different levels of an organization has to execute their tasks in order to improve success and efficiency.

3. Six Sigma methodology DMAIC (define-measure-analyse-improve-control) links the tools and techniques in a sequential manner.

4. Six Sigma creates a powerful infrastructure for the training of champions, master black belts, black belts, green belts and yellow belts.

5. On the other hand, other rapidly emerging methodologies such as Lean manufacturing have been gaining popularity in western countries and abroad, which with the support of Six Sigma can increase process and company efficiency.

2.2 Lean

The source of the term lean production (or Lean manufacturing), can be traced to the International Motor Vehicle Program (IMVP), and was first used by Krafcik [9] and Holweg [10]. However, the just-in-time (JIT) system or Toyota production system (TPS) was the forerunner of lean manufacturing, with the works of Taiichi Ohno, Shigeo Shingo and Yasuhiro Monden a notable milestone in the rise of JIT/TPS/lean in the 1980s [11]. Later, Womack et al. [12] reported on the results from the IMVP study and coined the term lean manufacturing as a synonym for the practices pioneered by Toyota; the concepts and techniques under the lean label were the same as those of JIT a decade earlier [11]. Womack and Jones [13] provided five lean principles: value, value stream, flow, pull, and perfection, described in the following way: (1) value is defined by the ultimate customer; (2) value stream is the set of all specific activities required to push a specific product through the internal value chain; (3) flow is about making value-creating steps flow; (4) pull refers to using a pull schedule; and (5) perfection is concerned with making improvement a continuous effort.

The success of lean production is dependent upon contextual factors such as the type of market, the dominant technology, and the supply chain structure. The more successfully a firm applies Lean principles, the less successfully it will engage in general innovative activity. Lean production that develops a value stream, helps eliminate all waste, including time, and ensures a level schedule. A level schedule means that the manufacturing process must be protected from uncertainty and variation. This makes high-capacity utilization feasible, thus leading to lower manufacturing costs. Lean manufacturing in this sense is a program aimed mainly at increasing the efficiency of operations.

The integration of Six Sigma and Lean are presented below in Table 1 and Figure 1.

<table>
<thead>
<tr>
<th>Table 1. Integration of Six Sigma and Lean</th>
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</thead>
<tbody>
<tr>
<td><strong>Customer quality</strong></td>
</tr>
<tr>
<td>Six Sigma</td>
</tr>
<tr>
<td>Management Engagement</td>
</tr>
<tr>
<td>Dedicated Infrastructure/People</td>
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<tr>
<td>Voice of the Customer</td>
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<tr>
<td>Statistical Process Control</td>
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<tr>
<td>Design of Experiment</td>
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<tr>
<td>Poka-Yoke</td>
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<tr>
<td>Gage R&amp;R</td>
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<tr>
<td>Failure Modes Effect Analysis</td>
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<tr>
<td>Cause and Effect Analysis</td>
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<tr>
<td>Six Sigma Quality</td>
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</table>

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Six Sigma improves the quality of value adding steps. Lean reduces non-value adding steps. Lean Six Sigma simultaneously drives quality, speed and cost. So, today we speak of the Lean Six Sigma methodology.

Both Lean and Six Sigma tools need to be used concurrently to ensure effectiveness. The integration of these two paradigms enables the attainment of common goals. [14]

2.3 Supply chain and Lean Six Sigma methodology

In today’s highly competitive environment, supply chain (SC) performance is very vital for the survival of firms because customers judge the performance of firms based on their SC performance. Competition no longer exists between firms, but between entire SCs. So, SC has become an important dimension with firms forced to give maximum attention to this area in order to excel in a competitive environment. The field of supply chain management (SCM) is growing day by day. SCM has become a key strategic factor/tool for firms to improve their performance and secure their competitiveness in the market place. In order to successfully implement SCM, all firms within a SC must reduce functional silos and adopt a process approach [15]. In recent years, SCM performance has become extremely vital for the survival of firms for customers judge the performance of firms based on their SC performance. [16]

The unified structure provided in the framework encourages various SC players to support the improvement process, based on the P-D-C-A (plan – do – check – act) cycle. Management can receive feedback from the operational level which aids in enhancing improvements within the process. From the study, it has been concluded that Six Sigma (DMAIC) with the integration of the SIPOC model (supplier – input – process – output – customer) been established as winning practice in improving the manufacturing process – the key entity in the SC network. The success of the framework can encourage the various stakeholders to use the presented methodology to improve and reduce losses in their processes after identifying key performance attributes related to process dimensions. [16]

3. Lean Six Sigma implementation

The Lean Six Sigma initiative in many organizations has failed either due to a lack of understanding of how to get started or due to a failure to link the initiative to strategic business goals and measurable objectives. Lean Six Sigma deployment needs to be considered based on an organization’s available resources and skills base [17]. Additionally, Porter’s value chain analysis and the five forces model could be applied to analyze business processes prior to applying Lean Six Sigma methodologies. [17] These models could be used to provide strategic alignment to business objectives as well as identify training needs and project selection prioritisation. Snee and Hoerl [4] suggest that the greatest barrier to implementation in organizations to date has been the manner in which major Lean Six Sigma training providers have structured their offerings. Lean Six Sigma can also be an effective methodology for small and middle-sized organizations and plays a major role in continual improvement based on ISO 9001:2000 requirements. To make the framework for Lean Six Sigma and also Lean more applicable and suitable for organizations, critical success factors for implementing Lean Six Sigma have been developed and include [17]: top management leadership and commitment, a well-implemented customer management system, an education and training system, a well-implemented process management system, a well-developed strategic planning system, a well-developed supplier management system and a well-developed human resource management system.
3.1 Implementation of Lean Six Sigma in Slovenia

**Research methodology**

The bulk of the study is oriented at Lean Six Sigma implementation in transition countries, in this case Slovenia, so as to study the reasons Slovenian manufacturing organizations are implementing the Lean Six Sigma methodology and the role of top management in Lean Six Sigma implementation. In order to do this effectively, the general objective is further divided into a number of specific research questions (RQ) as follows:

* RQ1: To what extent are organizations in Slovenia implementing Lean Six Sigma?
* RQ2: What are the common barriers and benefits in the implementation of Lean Six Sigma in Slovenia?
* RQ3: What are the essential factors for successful implementation of Lean Six Sigma in transition countries similar to Slovenia?

The study was broken down into three phases:

1. A wide-ranging analysis was conducted of existent literature on quality management and especially regarding the Lean Six Sigma methodology.
2. A questionnaire was designed to investigate the quality management practice, which was sent by mail to the quality managers responsible for quality or those participating in Lean Six Sigma projects. The items in the questionnaire were designed in the form of binary ‘yes’ or ‘no’ questions and Likert scales, ranging from ‘strongly disagree’ to ‘strongly agree’.
3. Analysis of the survey research results with directions for future work.

The main objective of this study is to research Lean Six Sigma adoption in Slovenian manufacturing companies.

The questionnaire was e-mailed to 100 production companies in Slovenia in April 2012. Of the 100 questionnaires mailed, a total of 33 completed questionnaires were returned in a 3-month period. This represented a response rate of 33 per cent which is similar to other studies worldwide using this tool (survey). The questionnaire was designed based on researchers’ experiences, taking into account similar studies [17]. The questionnaire was e-mailed to the 100 largest manufacturing organizations in Slovenia. The e-mail addresses were obtained from the database of the Slovenian Lean Six Sigma academy and from available public databases. Because the extent of the Lean Six Sigma methodology was not known in Slovenia prior to this study, a broader number of organizations from different branches was included in the study.

According to the data gathered, the questionnaires were completed by Lean Six Sigma’s master black belts (MBB), black belts (BB), green belts (GB) and yellow belts (YB). In the organizations where no Lean Six Sigma methodologies had yet been implemented, participants comprised quality managers working in the field of quality management in manufacturing organizations.

Of the one hundred targeted companies, the response rate was 33 % and included manufacturing companies in the following industries: mechanical (automotive) engineering (73 per cent), automotive (24 per cent) and chemical (3 per cent).

Data available from the Lean Six Sigma academy of Slovenia and the Lean Six Sigma Association of Slovenia was used for analysing companies. The companies and members of this association are active experts from various companies in Slovenia and were also interested in this study. The number of companies was limited by the number that implemented Lean Six Sigma. Participants were middle management experts and managers working in the quality management field.

4. Results

4.1 Analysis of the reasons for not implementing Lean Six Sigma

Previous research in this field [1,3] shows us that many of the big manufacturing organizations in Slovenia have already implemented Lean Six Sigma while quite a few have not. One of the questions in this study dealt with the reasons that manufacturing organizations in Slovenia are not implementing Lean Six Sigma. A questionnaire was designed and the issue researched. The most important reason is that manufacturing organiza-
tions in Slovenia are satisfied with the existing quality system they have in place (30.77 percent); further results showed that top management is not interested in implementing Lean Six Sigma (30.77 percent) while the third most common reason is the lack of human resources in the organization (15.38 percent) to support implementation. Only 7.69 percent of the organizations were not familiar with Lean Six Sigma. [1,3]

4.2 Analysis of the reasons for implementing Lean Six Sigma

Respondents from Slovenian manufacturing organizations which have already implemented Lean Six Sigma methodology were asked which motivation the organization had for implementing Lean Six Sigma. Factors which affect motivation were defined based upon literature study and previous research [18]. The results of the respondents can be compared to the early stage of Lean Six Sigma implementation in Slovenian organizations, where analysis showed that 49 per cent of the organizations use Lean Six Sigma for up to one year and 87 per cent for a period of one to three years. In this early stage of implementation, it is reasonable that the initial projects (usually pilot projects) are oriented at customer benefit, strategy and finance, because they are usually used to demonstrate the best effects for a later stage or further projects. In addition, they are much more oriented at quick wins that have a high probability of success. [19]

Today, organizations strive for an improved level of process capability and a reduced level of cost of poor quality (COPQ). The bottom-line objective is to generate a profitable margin and sustainable competitiveness in the market. COPQ is the cost associated with poor quality of products and services. For a manufacturing company, COPQ is the total cost of repair, rework, scrap, service calls, warranty claims and write-offs from obsolete finished goods. The concept of COPQ connects the improvement priorities of a company with its strategic objectives of achieving improved financial performance and greater customer satisfaction. [20]

The respondents were asked to rate the benefits that Lean Six Sigma had brought to their organizations since its implementation. The areas that have experienced the greatest benefits are reduction in process variability, reduction in COPQ, increase in profitability, reduction in operational costs, increase in productivity, etc. Overall, these scores show us that participating organizations perceive a benefit in their processes.

4.3 Critical success factors for Lean Six Sigma implementation

The respondents were asked to rank pre-defined CSFs. The factors were defined based on existing literature regarding TQM and Lean Six Sigma and for large organizations. The 11 identified critical success factors were as follows [17]: linking Lean Six Sigma to customers, linking Lean Six Sigma to business strategy, linking Lean Six Sigma to employees, linking Lean Six Sigma to suppliers, management involvement and participation, organizational infrastructure, under-

<table>
<thead>
<tr>
<th>Table 2. Motivation and objectives related to Six Sigma implementation in Slovenian manufacturing companies</th>
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</thead>
<tbody>
<tr>
<td>Motivation factor</td>
</tr>
<tr>
<td>To reduce variation in our processes.</td>
</tr>
<tr>
<td>To achieve positive financial effects.</td>
</tr>
<tr>
<td>To increase customer satisfaction.</td>
</tr>
<tr>
<td>To reduce all types of costs.</td>
</tr>
<tr>
<td>To change organizational culture and thinking.</td>
</tr>
<tr>
<td>To decrease the service call rate (SCR)</td>
</tr>
<tr>
<td>To increase market share.</td>
</tr>
<tr>
<td>To achieve further organizational growth.</td>
</tr>
</tbody>
</table>

Note: Avg….average according to five-stage Likert scale was used to evaluate each of the pre-defined motivation factors (1 was not motivation at all, 5 – was very high motivating impact factor for Six Sigma implementation in the organization); Std. Dev….standard deviation.
standing Lean Six Sigma methodology, project management skills, project prioritisation and selection and training and cultural change. Table 3 shows the ranking of essential success factors for the successful implementation of Lean Six Sigma in manufacturing organizations in Slovenia.

Table 3 shows that management involvement and participation, Lean Six Sigma training, understanding Lean Six Sigma methodology and organizational infrastructure are the most important factors for successful implementation. Following those are cultural change, linking Lean Six Sigma to employees, Lean Six Sigma prioritisation and project selection, Lean Six Sigma management skills and linking to business strategy.

The institutional phase of the socio-political transition in Slovenia has been fully implemented but the socio-economic transition has not yet been completed. Implementation of much needed organizational changes, such as Lean Six Sigma, require time and support from top management. This is related to top management priorities and organizational long-term objectives. Many organizations in transition have not yet consolidated their ownership, thus management buy-outs are often a top priority.

The study is limited by the number of Lean Six Sigma organizations in Slovenia. Additionally, the number of educated Lean Six Sigma BGs, BBs and MBBS is limited. The authors also believe that the larger sample of the research might affect the results of the study. The authors will take the results of the survey into account for further research as well as further periodical comparison studies. The study is limited to industrial organizations in Slovenia, but the results may be generalized for economies similar to that of Slovenia. The study does not present a comparison between industrial and service sectors, because not enough service organizations that have already implemented Lean Six Sigma exist.

4.4 Recommendations for Bosnian manufacturing companies

The following recommendations can be given to Bosnian managers based on Slovene experiences:

Our recommendation for Bosnia is that Lean Six Sigma and Lean implementation should be started at the top management level and a top-down approach used. Lean Six Sigma and Lean represent a management philosophy, vision, methodology and religion which must first receive the support of top management. A bottom-up approach can result in a lack of management support, low management commitment and definition and selection of the wrong priorities and Lean Six Sigma projects, failure of the business strategy and can also result in employee and customer disappointment. On the other hand, the recommended top-down strategy for Lean Six Sigma and Lean implementation helps us define priority problems and focus on them with top management support and empowers employees to implement changes in processes, optimisations and innovations in the company with the support of top management.

Table 3. Critical success factors for the successful implementation of Lean Six Sigma in Slovenian manufacturing companies

<table>
<thead>
<tr>
<th>Success factor</th>
<th>Avg.</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top management participation</td>
<td>4.93 (1)</td>
<td>0.26</td>
</tr>
<tr>
<td>Lean Six Sigma training</td>
<td>4.68 (2)</td>
<td>0.46</td>
</tr>
<tr>
<td>Understanding Lean Six Sigma</td>
<td>4.56 (3)</td>
<td>0.52</td>
</tr>
<tr>
<td>Organizational infrastructure</td>
<td>4.31</td>
<td>0.90</td>
</tr>
<tr>
<td>Cultural change</td>
<td>4.31</td>
<td>0.56</td>
</tr>
<tr>
<td>Linking Lean Six Sigma to employees</td>
<td>4.25</td>
<td>0.68</td>
</tr>
<tr>
<td>Lean Six Sigma project prioritisation</td>
<td>4.18</td>
<td>0.52</td>
</tr>
<tr>
<td>Lean Six Sigma management skills</td>
<td>3.93</td>
<td>0.83</td>
</tr>
<tr>
<td>Linking Lean Six Sigma to business</td>
<td>3.93</td>
<td>0.92</td>
</tr>
<tr>
<td>Linking Lean Six Sigma to customers</td>
<td>3.62</td>
<td>0.92</td>
</tr>
<tr>
<td>Linking Lean Six Sigma to suppliers</td>
<td>3.31</td>
<td>1.10</td>
</tr>
</tbody>
</table>

Note: Avg...average according to the Likert 5-stage scale (1...factor is not important, 2...factor is important, 3...factor is more important, 4...factor is very important 5...factor is extremely important and crucial); Std. Dev...standard deviation
The use of ISO standards or TQM can also support Lean Six Sigma and Lean. Experience from Slovenia has shown us that 100% of the companies which use Lean Six Sigma in Slovenia already use ISO standards, project management or TQM. Lean Six Sigma is merely an upgrade. Many improvements within the company can be achieved with the use of ISO, TQM, 20 Keys and similar tools. Lean Six Sigma is much more sophisticated and represents an upgrade of all existing tools and methods used in the company. Our recommendation is that companies in Bosnia that decide to implement Lean Six Sigma should first implement ISO standards and project management practices.

Once the objectives to be achieved with the support of Lean Six Sigma have been carefully planned, our suggestion for Bosnia is that top management be the first and key facilitator of Lean Six Sigma initiatives within the company. Their understanding of Lean Six Sigma, Lean and thus related objectives provide support to structures, processes and rules within the company. Employees will appreciate the support of top management as was also observed in the study of Slovenia presented in this paper.

Top management personnel need to first be educated and professionally trained in the field of Lean Six Sigma (champions, black belts and master black belts) and also in the field of Lean. Lean Six Sigma and Lean training has to be done by Lean Six Sigma professionals. Trainings can be performed within a single company or as open training on the market, where future Lean Six Sigma experts can meet other candidates and practices.

An additional recommendation is that companies in Bosnia first educate at least one Lean Six Sigma master black belt, rather than train many Lean Six Sigma yellow and green belts. The role of a Lean Six Sigma master black belt can be crucial for the successful implementation of Lean Six Sigma by providing know-how support and consulting to Lean Six Sigma green and yellow belts. It is also recommended that a Lean Master be trained within the company.

It is strongly recommended that Lean Six Sigma in Bosnia follow a well-prepared plan for implementation which will integrate all levels of management, including top, middle and operational managers. Lean Six Sigma does not begin and conclude solely based on education, but also requires the support of structures, systems and rules for Lean Six Sigma project detection, selection and progress measurement.

Another recommendation is that companies in Bosnia during Lean Six Sigma and Lean implementation establish a permanent structure or department of trained Lean Six Sigma experts within the company. Many practices show that successful Lean Six Sigma implementation includes Lean Six Sigma education in conjunction with practical project implementation during Lean Six Sigma and Lean training, something which requires time. Therefore, personnel who attend trainings need to be integrated within the company structure to enable them to educate themselves and perform Lean Six Sigma projects at the same time.

Lean Six Sigma will cross the boundaries of a single company and will, for example, affect the processes of its suppliers. Regarding the discussed position of Slovenian and Bosnian manufacturing companies within the supply chain, we strongly depend on our customers (companies), subcontractors and suppliers. Lean Six Sigma and Lean implementation in the global environment must also include suppliers and subcontractors by detecting common interests, potential problems in future Lean Six Sigma processes and the Lean steps which will be performed. It needs to also consider cultural, political and process barriers regarding the company’s cooperation with global customers and suppliers.

The aim of this chapter is to briefly present several key consultant experiences in Slovenia regarding the field of Lean Six Sigma implementation. We will focus on the most frequent problems and how we are dealing with them, which can serve as a basis for a successful approach in Bosnia, too.

Are we familiar with the power of Lean Six Sigma? Management in many Slovenian manufacturing companies still do not use Six Sigma, Lean or a combined approach. Management usually are not familiar with the possibilities of the two tools, so many free workshops and free webinars are used to make these topics more recognizable. A possible approach to directing companies to improve their processes with the support of Lean Six Sigma, is to first perform value stream map analysis (VSM) in the company. Thus, a very
detailed overview of the selected process is made which clearly shows which improvements can be made in the future. So consequently, management usually becomes more enthusiastic about Lean Six Sigma tools and quickly comes to understand the meaning of Lean Six Sigma and lean tools. Once process improvement opportunities have been detected, it is much easier to break through with Lean Six Sigma, because the objective becomes more visible and the tool becomes the second priority. So the importance of the results comes before the tool, and results always attract management.

**Quality problems can decrease the power of lean tools.** Optimisation of the process can be efficient after key quality problems within the process have been resolved. Lean Six Sigma tools are usually used before Lean tools. Another possibility would be to use the VSM tool first to detect quality problems based on VSM. Lean Six Sigma can be used afterwards, based on the quality problems detected in the VSM analysis, or, for example, following the measurement of overall equipment efficiency (OEE) which provides data on quality issues, exchanges and the like.

**Do we have time for training?** Employees in companies usually do not have time to participate in long-term trainings, so in-company trainings are usually carried out. Companies, initially, are extremely doubtful about such training and the results thereof. So, the best way for introducing these tools is to combine in-company training with the Gemba strategy (on site) by studying direct problems in the selected company with coaching after training.

**Doubts about the efficiency of Lean Six Sigma tools** can be eliminated with a clear top-down approach: first a Lean vision, than Lean objectives, followed by a Lean strategy.

**A newly designed process will cause us more problems than the one we currently have in place, even if it is not that perfect.** Management often fears that a newly designed process will lead to more unplanned production breaks – that it will not work at the beginning. If we proceed in small steps in a controlled way using an approach: pilot project first, working place, cell, line, and finally the entire plant, risks can be eliminated.

**Some people and groups in the company defend their position** and are not enthusiastic about Lean Six Sigma. The solution is project approach, communication and the walk&talk strategy. If we once embark on a change to only give up later, whatever the reason is, the change will not be efficient and possible any more (with the same team of people). Lean Six Sigma requires from us that we relate to processes in a way we have not before. That requires that we define a person (for example a lean manager), who will actually look at the “whole picture” of the process and who will play the role of the Lean Six Sigma manager and relate to different processes which support production beyond the boundaries of traditional organizational structure. Thus, a Lean Six Sigma manager is often employed.

**Conclusion**

Slovenia and Bosnia are both transition economies with many similarities. The institutional phase of the socio-political transition has been concluded but the socio-economic transition has yet to be completed. Implementation of much needed organizational changes, such as Lean Six Sigma requires time and the support from top management.

Slovenian and Bosnian manufacturing companies are also strongly characterized by their positions in the supply chains of much larger EU companies. Implementation of necessary organizational changes, such as Six Sigma and Lean, requires time and the support from top management. This regards top management priorities and long-term organizational objectives. Many organizations in transition have not yet consolidated their ownership, and management buy-outs are often a top priority. In this aspect, they have both experienced similar challenges from the external environment in their recent histories (in the last two decades) such as: increased competition and globalisation, changes in the national economy, deregulation of the local market, changes in ownership structures and the threat of bankruptcy. These facts represent a strong basis for future company reactions and opportunities for the transfer of knowledge and experiences between companies in post-transition countries such as Slovenia and Bosnia.

On the other hand, many previously successful organizations have closed because they were not oriented towards the end customer, their business processes were not optimised at the time of
entering the global market and consequently, their products failed to meet market expectations in a highly competitive global market. Their growth in the past was not based on research and the development of new innovative processes, products and services, but rather on quick wins and a short-term orientation. Many of these companies have already faced the need for further growth based on process innovations and the optimisation of different fields of business activities and are considering growth by implementing Lean Six Sigma methodology, which can also be considered as a process innovation. Slovenian and Bosnian manufacturing companies are also strongly characterized by their positions in the supply chain. Many Slovenian and Bosnian manufacturing organizations are holding onto their positions as suppliers of assembly parts for automotive and other engineering companies. They also often play the role of a parts and assembly manufacturer and to a large extent, do not deal with final product research and development, which is often an action taken by their customer companies (for example: the automotive industry, tool production industries, etc). From this aspect, their success is still limited by the success of their final products and the success of the end user. In this regard, manufacturing companies in both countries have a limited influence on the supply chain and are often limited in achieving efficiency in production processes where the Lean Six Sigma methodology DMAIC takes place. Considering the fact that Slovenian and Bosnian manufacturing companies are often limited by low- and middle-positioned product brand names, and considering the fact that they are often limited by the manufacture of low added value products, their only opportunity will lie in process optimisation and innovation, which can be aided by Lean Six Sigma. Because of all the similarities between Slovenia and Bosnia, the case of Lean Six Sigma use in Slovenia has some potential value for Bosnia, too. All similarities and start up positions will lead to a better understanding of the importance of this study on Lean Six Sigma in Slovenia for Bosnia, and help develop recommendations for Lean Six Sigma implementation in Bosnian companies and enable a proactive managerial approach and initiatives regarding Lean Six Sigma implementation.

References


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Abstract

The objective of this research is to establish whether geometry rules were applied in the project of the captain’s house dating from 1842 situated in Lepetani in the Bay of Kotor.

The aim of the work is to attempt to determine the existence of patterns in the application of certain geometry rules on this object. It was achieved through graphical and numerical addenda based on the original project (base, facades and details) as well as on-site measurements. The goal was also to determine the presence of certain aesthetic rules on the facades through the analysis of the applied principles of aesthetic order (harmony, contrast, rhythm, etc.).

The main result of the research is confirmation of the existence of geometry rules, reflected in the application of certain proportion systems in architectural elements, as well as in structure as a part of a unique system.

The golden ratio and some other proportion were known to architects of that age. They used their knowledge to skillfully make designs, and they left it for us to learn to correctly understand them.

Key words: Proportions of the house, captain’s house, architecture of the Bay of Kotor

Introduction

Basic principles of composition used for building various objects, during the development of mankind, have been symmetry and asymmetry, and subsequently different proportional systems, all of those within an anthropometric system of measurements.

Length measurements the first civilizations used were of anthropomorphic character (Greek anthropos – man and morphe - shape), which allowed for this system of measurements, applicable for measuring cottages, houses, as well as temples, to last for centuries. Elbow (pygmē), pace, foot and thumb (inch) are prehistoric and modern means people use for measuring [1].

Relations between units were constant, while architects themselves chose a system of proportions, which was usually typical for a certain epoch, and varied the ratios to their liking.

Greek teachings about proportions defied the mathematical static-mechanical and craft-conventional teaching of Egypt as elastic, dynamic-organic and aesthetically normative. Greek mathematicians discovered laws of arithmetic, geometric and harmonic proportions, they knew about the “golden section”, and they applied modular proportions [2].

The “golden section”, whose construction was a strictly kept mathematical secret of Pythagorean brotherhood, ruled not only the Greek but also gothic architecture and biological morphology.

The existence of standard measurements could be based only on some precise and constant unit. Thus, in the Bay of Kotor, during the Venetian reign, which lasted from 1684 to the mid-19th century, the only units were a foot and a Venetian elbow. They were in use simultaneously. Before this period, in Kotor and the region, Kotor elbow had been used, which was pushed out by the Venetian elbow at the end of the 17th century. There is no exact data on how big a Kotor elbow was. According to some sources, it was the same as Dubrovnik elbow – 51, 189 cm (see the manuscript in Dubrovnik archives: “Notizie storiche e statistiche del Circolo di Ragusa compilate dall’ingegner circolare”).

A Venetian foot equaled 34, 773485 cm or in short: $1’ = 34, 77 \text{ cm} = 34, 8 \text{ cm}$ and it was divided into 12 unciae,

i.e. $1” = 2, 8975 \text{ cm}$,

(or shorter $1” = 2, 9 \text{ cm}$) [3].

Venetian elbow corresponded to $20’’$:

$1 \text{ br} = 20”’ = 1’, 8”’ = 57, 95 \text{ cm} = 58 \text{ cm}$, and it was usually divided into halves and quarters [4].
Material and methods

The following will be analysed in these theses:
- Characteristics of the house
- Proportions of the house and its sections

Characteristics of the house

This palace was built according to the project of an Italian architect Boriani, in the year 1842, for Captain Spiridon Tomanović from Lepetani[5]. By definition a palace is a “large and beautiful house” or a building that stands out from its neighborhood because of its size and luxury. The word “palatium” in Latin stands for ‘imperial court’ and it comes from the name of Palatine Hill in Ancient Rome, where Emperor Augustus’ palace was situated and where his descendants built their luxurious residences – palaces. Palaces in the Bay of Kotor during this period were under the strong influence of representative palaces in Italy, and particularly in Venice.

The object is located on the western slopes of Vrmac peninsula in Lepetani in the Bay of Kotor. The main facade is oriented towards southwest, and the front side of the parcel, on which the house is built, faces the sea. At the moment these groups formed, the sea served as the main and only road in the Bay of Kotor.

The base is rectangle-shaped and has an inner garden from the rear side, enclosed with a tall stone wall and a separate entrance. The wall is built as “double skin wall” with an inner middle layer of smaller rubble stones and enormous quantities of lime[6].

In architectural sense, this type of house is one of the finest examples of marine captain houses (Palac) in the 19th century, a house with a ground floor, first floor and a useful loft [7]. Similarly to the other houses of the type, it retained the fundamental functions distributed along the vertical axis.

The base of the object can be inscribed into a rectangle with the approximate ratio of sides of 2:3. It is defined by 3 modular units along the Y axis.
Figure 3. Present appearance of the captain’s house in Lepetani

Figure 4. Document OK. IX-169/1 – The base of the floor with linear scale expressed in Venetian feet

Figure 5. Rectangular base with an approximate side ratio of 2:3

Through geometric partition of the given modular network at 1/2 m, 1/4 m and 1/8m, positions of walls and stairways are found.

Figure 6. It appears that the entire corpus of the building with the loft was inscribed into a parallelogram in 1: x: y ratio.
The house proportions

Proportions of the “golden section” were applied for the projecting of the facade. The initial ‘golden rectangle’ was determined by constructing a square in the height of a skylight in the attic and it encompasses three windows on the first floor and both windows on the ground floor.

![Golden rectangle acquired by constructing a square in the height of the skylight. The ratio 12:7 is 1:√2 with the relative error of 1/1000](image)

The golden rectangle bounded this way on the central part of the facade becomes the proportional key from which proportions of the whole are derived. Different sizes of facade sections are connected by this proportion and all other forms are derived from it according to the law of similarity.

Analysing the facade of this object, we notice the application of the following aesthetic principles:

- Harmony is achieved through the application of the golden ratio, so that the front side of the facade in its whole length stands in proportion 12 : 17 with its height, which is 1 : √2 with the relative error of 1/1000, i.e. √2 = 1.414, whereas 17 : 12 = 1.416.

- Contrast on the facade was achieved through the application of stone but also through the use of colors on the details of the exterior (window shutters “škure” and doors are green).

- Rhythm of windows on the first floor horizontally creates a symmetrical sequence. The loft part of the facade was also composed in a symmetrical fashion. Vertical rhythm of windows was achieved by rhythmic lining up of the windows on the front facade of the object. They are distributed in a vertical sequence, one below another, in window axes. This balance is broken by the asymmetrical position of doors on the main facade on the ground floor, which are set in between two windows on the first floor. The position of the tavern door on the ground floor is different from the position of the door previously planned on the original drawing. That change was probably made by the owner during the building.

![Front side of the facade in its whole length stands in proportion 12:17 with its height](image)

![Front facade (dimensions expressed in centimeters)](image)

The facade is split vertically into three fields. Central facade field has a separate window group (4 windows), and on both sides of the central field there is a window group.
The proportional diagram of the quartile group of window openings 4’6”/3’6” is characterized by axial distance from window to window of 8’6” and floor height of 10’. For the opening width a=3’6”, for its height b=4’6”, for the distance between openings c=4’6” and for the height between two parts of the opening d=6’. Thus a: b: c: d, i.e. the mentioned lengths are growing in arithmetic progression. Measurement quotient of the facade element (floor height to axial distance between windows ratio), K = 10’ / 8’6” = 5:4 fits the quotient of the window frame and is very close to the irrational ratio 2: F = 5:4, i.e. one of the classical ratios in the system of continuous partitioning or “golden section”.

All outer doors on the ground floor and on the first floor are double, made of solid wood, with dimensions 2 x 57 / 192. On the main facade, on the ground floor they are placed in between two windows. From the rear side of the house, the doors appear on different spots, without any pattern. All these doors have no fanlights and open towards the inside. They are framed with thresholds made of Korčula stone, 1/2 Venetian foot wide (17cm) and above them is a relieving stone arch. From the inside, the doors were secured by a special system.
of devices and locks (as protection from pirates and outlaws).

The proportional diagram of the doors of the tavern (konoba) on the main facade, expressed in Venetian feet, looks like this:

**Figure 13. Proportional diagram of the tavern door**

**Discussion**

In our region only a few scientists engaged in researching proportions and those are primarily Prof. Arch. M. Zloković, Arch. M. Čanak - Medić, Prof. Arch. B. Milenković, Arch. N. Spremo - Petrović, Arch. Đ. Petrović and others.

M. Zloković was particularly dedicated to the subject of proportional systems. He conducted some research in the Bay of Kotor, together with some collaborators. Numerous palaces were technically recorded (Beskuća and Verona in Prčanj, Grurina in Kotor, as well as palaces Milošević in Dobrota). He clearly defined the typical architectural concept and characteristics of the captain’s house [9].

He was the founder of the area of modular shaping and composition. He points out in his research the importance of appropriately laid construction module in functional dependency on one starting anthropomorphic architectural measurement unit, which is based on a man’s dimensions. He advocated the adoption of an octal system (octal partition of the meter according to E. Neufert) and modular unit of $1M = 12, 5$ cm [10].

In his work “The effect of reciprocal concatenation of harmonic ratios on the proportional set of a certain facade system I and II”, Professor M. Zloković points out the practical use of reciprocal concatenation of harmonic proportions, along the middle geometric proportional line in many architectural achievements in the past, stressing that a similar way of concatenation was found during his research of stone architecture of the south coast from the 16th to the 19th century [11]. He believes that the appearance of reciprocal relations on many buildings is merely a consequence of inherited and mechanical recipes, whose origin should be sought in medieval circumstances and composition methods of the antique.

He concludes that proper composition methods in architecture demand a well thought choice of certain composition elements and their conscious connection into a whole will be doable only based on some clearly predefined proportional law [12].

In his next work “Anthropomorphic systems in architecture”, M. Zloković claims that all earlier measurement systems were, without exception, based on anthropomorphic elements. Integers as factors of a certain measurement unit were the basis of achieving proportional harmony among parts and between the parts and the whole [13]. M. Čanak-Medić, an architect, in his work “Procedures of old masons in designing and erecting buildings” concludes that study of old masons’ designing had several flaws, and that studying old buildings helps improve the method of contemporary architectural composition [14].

The problem of measurement and units also interested professor B. Milenković, who pointed out the value of proportions as a means of understanding the design procedure. According to him, we have three ways of establishing a set, and those are: through analogy, through a priori determined basic geometric form and through an adopted measurement (module) [15].
Architect N. Spremo-Petrović engaged in researching the proportions and standard units. In her book “Proportional relations in basilicas of Illyrian prefecture” we find important data about the problem of measurements and numbers, application of certain geometric figures and application of certain arithmetic relations in the design process [16].

Đ. Petrović, in his work „Composition of architectural shapes“, first gives the study of processes of creating the architectural morphology by stating five general laws of composition (symmetry, harmony, module, rhythm and proportion). [17] By analysing any architectural part, the author comes to the reciprocity ratio and indivisibility of the mentioned laws of composition, which take part in the process of creating the first building ideas.

**Conclusion**

Every proportional relation connects a separate-specific artwork with a general law of geometry. Proportion of masses, according to the “golden section”, or some other harmonic relation doesn’t always result in harmony in each architectural composition. A good choice of proportions of parts of a building does not guarantee for a good composition of the object as a whole. That is achieved also by realisation of harmony of all masses and surfaces that make up the composition. Thus it is important to coordinate all sub-parts, or to attain harmony of all proportions so that the object appears harmonious.

Boka builders, who worked without previously drawn schemes, did not know about the “golden section” neither had interest in it. What they thought mattered was the choice of integers within the measurement system of that age. That system was the Venetian foot. That is how the proportions of a house were adapted to proportions that the Korčula stonemasons used, whose elements were utilized to build this house. Thus the owner at that time anticipated the measures of his future house expressed in round numbers of Venetian feet. Today, observing the object with the metric system, we find that certain ratios of the house are difficult to understand and are very unclear.

However, the educated architects of that age, including Boriani, knew about the “golden section” or some other proportion. They knowledge-ably designed them, and the masons of that time skillfully and precisely put them into practice.

The accent that was put on the central axis of the object and multiple repetition of windows introduced order and strictness into the composition of this house. The same goes for symmetry which was and still remains one of the basic qualities of architectural aesthetics of all times.

This peaceful and staid building, based on a rectangular basis, with respect for order and rhythm, today and for many years to come tends to have an unforgettable impact on the beholder.

Architecture that grew out of nature is easy to recognize. It appears as if it has always belonged there, and stone houses are noticeable from afar in the coastal landscape.

This old building managed to survive for almost 200 years, owing to good material, quality of building techniques and a successful architectural concept.

However, stone houses, even the one described here, in its original shape don’t meet the needs of present day. Every activity to renovate these houses is welcome. Homes of the future should be improved and adapted to contemporary needs.

It is very important that as many investors as possible be acquainted with the great possibilities of these houses. It is up to the architects of today to give the municipalities the needed frame to renovate these old houses. Only on the condition that it is about bringing a stone house to life and bringing life back into a stone house, does this project make sense. Unfortunately, that is currently not the case.

**Photos and drawing sources**

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Evaluation of the parallel computing performances based on the nVIDIA GeForce GPU

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Abstract

Parallel programming is a form of computation in which the calculations are carried out simultaneously, operating on the principle where large problems can be divided into smaller, which are then solved in parallel.

Most common this programming is used in high performance computing, but due to the physical constraints which prevent frequency scaling the interest is even higher. As computers consumption has become a problem in the recent years, the parallel programming has grown into the dominant paradigm in computer architecture, mainly in the form of multicore processors.

The paper shows the process of designing parallel programs and it includes some results obtained by testing the parallel programming performance of different nVIDIA GeForce graphics cards. The purpose of the test is to compare performance of several types of GPUs for various applications. The results of the test could not specifically say which GPU is best due to the different features of the cards, but they can be used to determine which card offers better performances for different parts of the tests.

Key words: Parallel computing, GPU, CUDA, GeForce, nVIDIA

1. Introduction

Computer software is traditionally written for serial calculations. To solve a problem an algorithm implemented as a serial stream of instructions is created. These instructions are executed in the computer’s Central Processing Unit (CPU). Only one instruction can be executed at one time, and after instruction is completed, it is followed by the execution of the next instruction. [1]
with multiple processors, several networked computers, specialized hardware, or any combination of the foregoing.

The solving problem should allow dividing into several parts which will enable performing multiple program instructions at any time and speeding up the processing time using multiple computer’s resources rather than using a single computing resource.

Some of the reasons for the increased usage of the parallel computing are the following:
- saving time and money,
- solving big problems,
- ensuring competitiveness,
- using non-local resources,
- limitations of the serial programming.

The rest of the paper is organized as follows. The next section gives some basics about designing and building parallel programs. Moreover, section 3 explains the limitations and expenses related to the parallel computing. The next section gives a brief description of the experiment. Section 5 explains used techniques and programs during the experiment. The obtained results for all tested applications, as well as a comparison of these results are given in section 6. Finally, section 7 concludes our work.

2. Designing and Building Parallel Programs

Designing and building parallel programs is a manual process where the programmer is responsible for parallelism identification and implementation. Very often manual development of parallel code is time-consuming, and it is a complex, iterative process prone to errors. The tools that assist the programmer in converting serial programs into parallel programs exist for a while. The most commonly used tool for automated parallelizing of the serial program is paralleling compiler or pre-processor.

2.1. Understanding the problem and program

The first step in the parallel software development is to understand the problem which should be solved in parallel. Before spending time trying to develop a parallel solution to the problem, it should be determined whether the problem can ever be parallelized.

The following example shows a problem that can be solved in parallel.

| Calculate the potential energy for each of several thousand independent conformations of a molecule. When done, find the minimum energy |

This problem can be solved in parallel so that each of the molecular conformation is independently determined. The calculation of the minimum energy conformation is also a problem that can be parallelized.

2.2. Partitioning

One of the first steps in designing a parallel program is to break the problem into discrete pieces that can then be distributed in multiple tasks. This is known as decomposition or partitioning.

There are two basic ways of partitioning the calculating work between the parallel tasks: domain partitioning and functional partitioning. [3]

* Domain partitioning

In this type of partitioning the data related to the problem are decomposed. Each parallel task then work on part of the data.

![Figure 3. Domain partitioning](image)
2.3. Data dependencies

The data dependency is one of the key issues of real-time programming, and it includes sequential and parallel processing. [4] The data dependencies are the result of multiple use of the same location in the warehouse of various tasks.

The dependencies are very important for parallel programming, because they are one of the main inhibitors of parallelism. The analyses of data dependence are needed only for automatic detection of parallelism, but they are also essential for many other important compiler transformations, such as improving the memory location and load balancing. [5]

Although during parallel programs designing process it is important to identify all data dependencies, the dependencies in the loop are especially important because the loops are the most common target of the parallelism.

To deal with data dependencies we need:

- Distributed memory architectures - the necessary data communicate in synchronized points.
- Shared memory architecture - synchronized read/write operations between tasks.

2.4. Load balancing

Load balancing refers to the practice of distributing work among tasks so that all tasks are kept busy all the time. It can be considered as minimization of the assignment idle time. Load balancing is important for parallel programs because of its efficiency.

For example, if all assignments are subject to barrier synchronization, the smallest task will determine the overall performance.

In general the load balancing techniques fall into two categories: centralized load balancing and distributed load balancing. Centralized scheme usually has a main node that is responsible for load handling. As the cluster size increases, for a short time the node becomes a bottleneck and causes significant performance degradation. To solve this scalability problem, the workload can be sent to multiple nodes in the cluster, and these emerging the idea of distributed dynamic load balancing. [6]

The load balancing can be achieved in the following way:

- Equal work partitioning for each received task:
  - For array/matrix operations where each task performs similar work, the data set is evenly distributed among the tasks.
○ For loop iterations where the work done in each iteration is similar, the iterations are equally distributed among the tasks.
○ If a heterogeneous mix of machines with varying performance characteristics is being used, performance analysis tools need to be used in order to detect any load imbalances.
  – Use of dynamic work assignment:
    ○ Certain classes of problems result in unequal load imbalances, even if the data is evenly distributed among the tasks:
      * Sparse arrays - some tasks will have actual data to work with, while others will usually have a “zeros”.
      * Adaptive grid methods - some tasks will have to rewrite their network.
      * N-body simulations - some parts may migrate to / from the original task domain to another task domain, where parts of some tasks require more work than parts of other tasks.
    ○ When the workload that each task will execute is variable, or is unable to predict, then it would be useful to use a planner - thread pool approach. As each thread completes its work, it goes in the row in order to get a new job.
    ○ It may be necessary to design an algorithm which can detect and handle load imbalances, as it will appear in the code.

2.5. Granularity

The granularity of parallel programming is defined as a ratio of the time required for basic communication operation and the time required for basic computer operation. [7] In short, granularity is a qualitative measure of the calculations and communication ratio.

– **Fine-grain Parallelism** means that individual tasks are relatively small in terms of code and execution time. Data is often transmitted in a small amount of computer calculations. It makes load balancing easier.
– **Coarse-grain Parallelism** is reversed process of the previously mentioned. Here the data are transmitted less frequently after large amounts of computer calculations. This parallelism implies a greater opportunity for increased performance, and it is more difficult to establish a load balancing.

The most efficient granularity depends on the algorithm and the hardware environment in which this algorithm is executed. In most cases the overall costs associated with communication and synchronization are in large proportion to the execution speed so it is advantageous to have coarse granularity.

3. Limitations and Expenses of the Parallel Programming

The Amdahl’s law states that the potential program speedup is defined by a fraction of the code (P) which can be parallelized:

\[
\text{speedup} = \frac{1}{1 - P}
\]

If none part of the code can be parallelized, P=0 and speedup=1 (no speedup). If all of the code is parallelized, then P=1 and the speedup is infinite (in theory).

If 50% of the code can be parallelized, then maximum speedup =2, which means that the code will run twice as fast. Introducing the number of parallel processors, the ratio can be modeled by:

\[
\text{speedup} = \frac{1}{P + \frac{S}{N}}
\]

Where P = parallel fraction, n = number of processors and S = serial fraction.

It is obvious that there are limits to the parallelism scalability. For example:

<table>
<thead>
<tr>
<th>N</th>
<th>speedup</th>
<th>speedup</th>
<th>speedup</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P = .50</td>
<td>P = .90</td>
<td>P = .99</td>
</tr>
<tr>
<td>-----</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>10</td>
<td>1.82</td>
<td>5.26</td>
<td>9.17</td>
</tr>
<tr>
<td>100</td>
<td>1.98</td>
<td>9.17</td>
<td>50.25</td>
</tr>
<tr>
<td>1000</td>
<td>1.99</td>
<td>9.91</td>
<td>90.99</td>
</tr>
<tr>
<td>10000</td>
<td>1.99</td>
<td>9.91</td>
<td>99.02</td>
</tr>
<tr>
<td>100000</td>
<td>1.99</td>
<td>9.99</td>
<td>99.90</td>
</tr>
</tbody>
</table>
Problems that increase the percentage of parallel time with their size are more scalable than problems with a fixed percentage of parallel time.

4. Experiment Description

The purpose of testing and experiments was to check the performance of several different nVIDIA GeForce GPUs (Graphical Processor Units), in order to analyze the processing speed, the startup time, the length of processing time, etc. Some of the GPUs were part of the PC, and some part of the portable computers (laptops). Moreover, some of the machines worked on 32-bit and some of them on 64-bit operating system, so we were able to check whether these differences also play a role in getting different results during the tests. We must also mention that 4 of the computers worked on Windows 7 and one on Windows 8 Server operating system. We tested the same tests (Box Filter, Bilateral Filter and Mandelbrot) on all 5 GPUs that we used during the experiment:

- GeForce GTX 260 – PC – 64 bit Windows 7
- GeForce G105M – Laptop – 64 bit Windows 7
- GeForce GT 635M – Laptop – 64 bit Windows 7
- GeForce GTX 480 – Laptop – 64bit Windows 8 Server

During the experiment we obtained different results, so that certain GPU in a particular part of the test gives better results than the others.

4.1. GPU features

GPUs on which the testing was performed are of the same type, but they all have different features and offer a variety of options. Some of these features are the CUDA cores, graphics and memory clock, memory bandwidth, memory interface, supported technologies etc.

Table 1 shows the important features of the used GPUs, as well as operating system and type of computer.

5. Used techniques and programs

For the testing purposes CUDA platform and nVIDIA Visual Profiler program were used. CUDA platform is built on nVIDIA GPU processors, while nVIDIA Visual Profiler is a program in which parallel applications were made and tested on the GPUs.
5.1. CUDA (Compute Unified Device Architecture)

CUDA is a parallel programming platform created by nVIDIA and implemented in their processors (GPU). [8]

To understand CUDA, we must first know what GPGPU (general-purpose computing on graphics processing units) is. Simply put, it is the technique in which the GPU is employed to handle and perform computations that were previously handled only by the CPU. However, the GPU doesn’t have the same flexibility and calculation precision as the CPU that’s built for general purpose usage, and this is where CUDA comes in.

Table 1. GPUs features: GeForce GTX 260, GeForce G105M, GeForce GT 635M, GeForce GTX 480, GeForce 9400M

<table>
<thead>
<tr>
<th>GPU Engine Specs</th>
<th>GeForce GTX 260</th>
<th>GeForce G105M</th>
<th>GeForce GT 635M</th>
<th>GeForce GTX 480</th>
<th>GeForce 9400M</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUDA Cores:</td>
<td>96</td>
<td>8</td>
<td>Up to 144</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gigaflops:</td>
<td>396</td>
<td>38</td>
<td></td>
<td></td>
<td>54</td>
</tr>
<tr>
<td>Graphics Clock (MHz):</td>
<td>1600 MHz</td>
<td>Up to 675 MHz</td>
<td>1100 MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texture Fill Rate (billion/sec):</td>
<td></td>
<td>Up to 16.2</td>
<td>18.7</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>Processor Cores:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Memory Specs</th>
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<tbody>
<tr>
<td>Memory Clock:</td>
</tr>
<tr>
<td>Standard Memory Config:</td>
</tr>
<tr>
<td>Memory Interface Width:</td>
</tr>
<tr>
<td>Memory Bandwidth (GB/sec):</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Feature Support</th>
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<tbody>
<tr>
<td>OpenGL:</td>
</tr>
<tr>
<td>Supported Technologies:</td>
</tr>
<tr>
<td>Operating System and Computer Type</td>
</tr>
</tbody>
</table>

Figure 9. A flowchart showing how CUDA allows the GPU to work in tandem with the CPU
CUDA allows developers access to the virtual instruction and parallel computing elements memory in CUDA GPU. The GPUs have parallel architecture that allows execution of multiple segments going slower rather the fast, and subsequently performing of the segments.

CUDA program executes serial code on the CPU, which then calls a series of cores running on the GPU. [9]

CUDA provides low and high level API (Application Programming Interface). It works with all nVIDIA GPU G8x series onwards, including GeForce, Quadro and Tesla and it is compatible with most of the operating systems. There are several advantages that distinguish this platform compared to others:

- The code can read information from arbitrary addresses in the memory,
- There is a large shared memory (up to 48KB of multiprocessors) that can be used by all,
- Faster download from and to GPU,
- Full support for integer and bitwise, including text searches. [10]

5.2. nVIDIA Visual

The program that we used to perform GPU tests is nVIDIA Visual Profiler. This tool is a crossover platform that allows developers to get vital feedback for optimizing CUDA C / C++ applications.

The tool displays a timeline for the CPU and GPU activities while running the application and it includes automated analysis to identify optimizing opportunities. [11]

6. Use of abbreviations

This section shows the obtained results for all tested applications, as well as a comparison of these results.

6.1. Bilateral Filter

Bilateral Filter is a nonlinear smoothing filter that is implemented with CUDA and OpenGL rendering. It can be used for image recovery. [12]

![Figure 10. Bilateral Filter application](image)

Bilateral Filter has been tested on all five graphics cards. Table 2 gives the results for the startup time, the test duration, the GPU throughput and the number of instructions required to perform the test.

![Figure 11. Results obtained by Bilateral Filter testing](image)

Figure 11 shows the graph of the results of Bilateral Filter testing that has been done. From the graph we see that there is a big difference in the performance of these activities for all GPUs. From the comparison of the startup time, it can be noted that the GeForce 9400M (single computer

<table>
<thead>
<tr>
<th>Table 2. Results from the Bilateral Filter testing.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Startup time</strong></td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>GeForce G635M</td>
</tr>
<tr>
<td>GeForce GTX 480</td>
</tr>
<tr>
<td>GeForce G105M</td>
</tr>
<tr>
<td>GeForce 9400M</td>
</tr>
<tr>
<td>GeForce GTX 260</td>
</tr>
</tbody>
</table>
with 32-bits OS) has a far better startup time than other GPUs that have similar startup time. Furthermore, if we consider the time required to perform the test, it can be noticed that two of the five considered GPUs have significantly less execution time, which means that the GeForce GTX 480 and GeForce GTX 260 have a better execution time compared to the other graphics cards.

In terms of throughput, it is evident that it is approximately the same for almost all GPUs except GeForce G635M which has higher throughput than others. If we compare the values of the GPUs for required instructions, it can be noticed that there is a huge difference between the computer that has Windows 8 operating system, and other computers with Windows 7 operating system. GeForce GTX 480 (Windows 8) needs almost six times more instructions compared to all other graphics that need nearly the same number of instructions.

6.2. Mandelbrot

This is the second test that we performed in order to compare the GPUs, and obtained results are shown in Table 3. The principal activities which were of our interest are the same as in Bilateral Filter testing (startup time, duration, throughput and number of required instructions for execution).

![Figure 12. Mandelbrot application](image1)

![Figure 13. Results obtained by Mandelbrot testing](image2)

Figure 13. Results obtained by Mandelbrot testing

The figure 13 shows the graph of the values obtained by Mandelbrot test. From the graph we can see that the startup time of the GeForce 9400M differs compared to the other GPU, but now this time it is slower.

Regarding the execution duration, the graph shows a huge difference in the results. GeForce GTX 480 performs the test in less than 1ms, and it has the shortest execution time. Very similar results show the GeForce GTX 260, but the other three GPUs need a significantly longer time to execute the test. Throughput is approximately same for the first two cards, and it is about five times higher compared to the next three GPUs. The instruction issued are higher for GeForce GTX 480, and half of this instructions are enough for GeForce G105M, while the GeForce GTX 260 requires much less instructions.

6.3. Boxfilter

The last test is BoxFilter testing. As in previous experiments, here we had compared the startup time, execution duration, the throughput and instructions required for execution. Table 4 shows the results of this testing, and it is followed by a description of the resulting graph (Figure 15).

![Figure 14. Boxfilter application](image3)

![Figure 15. Results obtained by Boxfilter testing](image4)

Figure 15. Results obtained by Boxfilter testing

The last test is BoxFilter testing. As in previous experiments, here we had compared the startup time, execution duration, the throughput and instructions required for execution. Table 4 shows the results of this testing, and it is followed by a description of the resulting graph (Figure 15).
For this test, GeForce GTX260 has the longest startup, while the GeForce G635M and the GeForce 9400M have almost the same shortest startup time. The situation with the execution duration is again the same as with the previous two tests, confirming that the GeForce GTX480 has the shortest test duration, and again, GeForce GTX260 is close to it, while the other three cards need significantly more time to execute the test. The throughput is similar in all cards, and if we compare all results it can be seen that GeForce G635M has highest throughput, while GeForce 9400M shows worst results. For issued instructions we get data only for three of the five GPUs, and according to the obtained results the GeForce G105M needs most instructions.

### 6.4. Device Query

Device query lists the features of the CUDA devices in the system. We have tested four features: the total amount of memory bytes per block, the total amount of registers available per block, the maximum number of threads per multiprocessors and the maximum number of threads per block. The obtained results are given in Table 5. The Figure 16 shows a comparison of the obtained results for the different GPUs.

![Figure 14. Boxfilter application](image)

![Figure 15. Results obtained by BoxFilter testing](image)

### Table 4. Results from the BoxFilter testing

<table>
<thead>
<tr>
<th></th>
<th>Startup Time</th>
<th>Duration</th>
<th>Throughput</th>
<th>Instructions Issued</th>
</tr>
</thead>
<tbody>
<tr>
<td>GeForce G635M</td>
<td>55,828 ms</td>
<td>2,397 ms</td>
<td>1638,4 KB/s</td>
<td>516778</td>
</tr>
<tr>
<td>GeForce GTX 480</td>
<td>82,955 ms</td>
<td>1,079 ms</td>
<td>1075,2 KB/s</td>
<td></td>
</tr>
<tr>
<td>GeForce G105M</td>
<td>70,698 ms</td>
<td>6,467 ms</td>
<td>921,65 KB/s</td>
<td>963511</td>
</tr>
<tr>
<td>GeForce 9400M</td>
<td>55,694 ms</td>
<td>10,605 ms</td>
<td>793,07 KB/s</td>
<td></td>
</tr>
<tr>
<td>GeForce GTX260</td>
<td>111,635 ms</td>
<td>1,709 ms</td>
<td>1269,76 KB/s</td>
<td>120473</td>
</tr>
</tbody>
</table>

### Table 5. Results from the Device query

<table>
<thead>
<tr>
<th></th>
<th>Total amount of shared memory bytes</th>
<th>Total amount of registers available per block</th>
<th>Maximum number of threads per multiprocessor</th>
<th>Maximum number of threads per block</th>
</tr>
</thead>
<tbody>
<tr>
<td>GeForce G635M</td>
<td>49152 B</td>
<td>32768 B</td>
<td>1536</td>
<td>1024</td>
</tr>
<tr>
<td>GeForce GTX 480</td>
<td>49152 B</td>
<td>32768 B</td>
<td>1536</td>
<td>1024</td>
</tr>
<tr>
<td>GeForce G105M</td>
<td>16384 B</td>
<td>16384 B</td>
<td>1024</td>
<td>512</td>
</tr>
<tr>
<td>GeForce 9400M</td>
<td>16384 B</td>
<td>8192 B</td>
<td>768</td>
<td>512</td>
</tr>
<tr>
<td>GeForce GTX260</td>
<td>16384 B</td>
<td>16384 B</td>
<td>1024</td>
<td>512</td>
</tr>
</tbody>
</table>
From the results it can be noticed that the GeForce G635M and the GeForce GTX 480 have approximately the same results for all tested features, and the other three GPUs are similar to each other, but with slightly weaker features compared to the GeForce G635M and the GeForce GTX 480.

6.5. Bandwidth Test

We also made a comparison of the information bandwidth for the GPUs, for the cases of host to device, device to host and device to device communication. The obtained results are shown in Table 6 and Figures 17.

![Figure 17. Results obtained by Bandwidth test](image)

The results conclude that the highest bandwidth for host to device and device to host connection gives GeForce 635M, while during the device to device information exchange GeForce GTX 480 has a significantly higher bandwidth.

In some of the cases, some of the obviously weaker GPUs give better results than the GPUs with better characteristics. The main reason for this is that they skip some parts of the tests that are not compatible due to the lack of some features of these graphics, as for example less CUDA cores or less bits on the memory interface.

7. Conclusion

The parallel programming requires systems with good performances. From the obtained results during the experiments, it can be noted that the type of the GPU and the type of the operating system play a very important role in the parallel computing.

According to the tests on different GPUs for multiple applications created with parallel programming, we came to the results in which we cannot give the correct answer to the question which is the best GPU. This is due to the different graphics power, different number of CUDA cores, and different operating systems. However, we can see that every GPU is better than the others in different segments and in different parts of the test, which depends on the:

- power,
- number of cores,
- poor performances (what was the reason why all tests were not supported)
- bits of the memory interface
- memory bandwidth, etc..

Although the parallel programming requires expensive machines, however the number of users of this type of computing continues to increase due to performance for better and easier large problems solving that cannot or are hard to be solved by classic serial programming.

<table>
<thead>
<tr>
<th>Table 6. Information Bandwidth</th>
</tr>
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<tbody>
<tr>
<td></td>
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<tr>
<td></td>
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<tr>
<td>GeForce G635M</td>
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<tr>
<td>GeForce GTX 480</td>
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<tr>
<td>GeForce G105M</td>
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<tr>
<td>GeForce 9400M</td>
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<tr>
<td>GeForce GTX 260</td>
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</tbody>
</table>
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System for Quality and Risk Management - Managing on-site Courses Using Online Technology: A Study on Al Ain University of Science and Technology

Loay Alnaji
Al Ain University of Science and Technology, Al Ain, United Arab Emirates.

Abstract

Managing quality in on-site courses means you have to ensure that you need to provide quality education to all students regardless of who is teaching which course. This tends to be difficult when you have hundreds of teachers teaching hundreds of different topics using their own knowledge, skills, and their individualized teaching material. To ensure quality, universities use a set of program-learning outcomes (PLOs) that are approved by the ministry of education and renewed every 4 years. These PLOs are tied to course-learning outcomes (CLOs), which are specified for each course. Due to the different assessment techniques used (quizzes, examinations, projects, research paper, and presentations), it is becoming increasingly difficult to manage program learning outcomes and their effectiveness on students. In this paper, we shed light on the effort made in Al Ain University for Science and Technology to create a system that links, measures, and tracks student performance based on how well students score on assessment tools linked to CLOs (and in turn to PLOs). The research describes the process, findings, and improvements made from implementing the SQRM system through surveying faculty participating in the study.

Key Words: Online learning, Quality, Total Quality Management, Course Learning Outcome, Program Learning Outcome

1. Introduction

The importance of quality is evident in almost all organizations. Japanese managers focus on commitment to make incremental but continuous improvement, placing them ahead of American companies [1] forcing U.S. managers to move from short-term goals and fast profits to long-term goals, such as reductions in customers’ complaints, machine breakdowns, and defective products [2]. Many companies perceive total quality management (TQM) as a strategic advantage over competitors and a way to distinguish their products and services. Furthermore, many researchers and consultants persuaded organizations to focus on TQM to compete in a volatile marketplace where customer service is considered a competitive advantage [3].

Universities in the Gulf are no different. Providing top-quality service to their students as well as being able to measure performance and improve on it (the main definition of TQM) is key for their survival in a world where the number of licensed institutions in the United Arab Emirates alone is 75. One way to ensure that students graduate with the knowledge appropriate to enable them to compete in the market, as well as ensure license renewal from the department of accreditation, is to direct education toward a fixed set of program-learning outcomes (PLOs) that are reviewed by the ministry of education every 4 years.

2. Total Quality Management Definitions

TQM started with Shewhart in 1925. Since then, many researchers such as [4, 5, 6] contributed to it, making it a fundamental component in every organization. Since then, different researchers viewed TQM as a change that can make all the difference in an organization [8]. Other researchers viewed TQM as an analysis conducted on a rational and politically neutral entity, hoping to improve product quality and customer satisfaction [5, 9, 10].

The education field, like the industrial field, initiated TQM concepts in hopes of improving educational quality, beating competition, and
maintaining high standards. Developed countries such as the United States, the UK, and Japan have successfully implemented TQM principles. Many researchers explored the role of TQM in the education sector. [11] pointed to increasing teaching efficiency, reducing education costs, and strengthening the bond between institutions and students. The researchers also focused on four dimensions they believed support successful TQM in the educational field: students, faculty, employers, and community. Furthermore, researchers explored the use of TQM principles in schools in Yemen [12], the United Arab Emirates [11, 13].

3. First Steps

When I arrived at Al Ain University of Science and Technology in August 2013, I found that although the university had a strong engineering program, and qualified IT staff, they lacked a systematic approach to monitor, track, and evaluate students. More important, they did not have a mechanism to measure or improve education and faculty-performance quality. All systems were paper based including tests, assignments, grading, and evaluating students and faculty. After meeting with department deans and the university president, all agreed a system should be in place to properly measure faculty performance as well as student performance in classes. The system needed to provide services such as “student failing” alerts, give real-time screenshots of faculty and student performance in class, and generate “smart” reports to enable management to make decisions and improve the school’s education quality.

To start this, knowledge about the process of education in the Gulf was necessary, so time was spent understanding the needs and requirements of the Ministry of Education in the Gulf. Furthermore, the university had several departments applying for different international accreditations, making it important to create a system that also enabled faculty to provide reports needed by accreditation bodies.

4. Understanding the Current System

The system at that time consisted of paper-based forms filed at the end of every semester. The paperwork included forms that tied course-learning outcomes (CLOs) to PLOs (see Appendices A and B). Simply put, the form was a Matrix filled out by faculty to link what they taught in class, CLOs, to the department PLO. Because this was done individually, different faculty members filed the forms based on what they felt they did right, making them inconsistent and difficult to support.

Furthermore, by the end of the semester, student final grades are statistically analyzed to determine student performance, weak points in faculty performance, and suggest improvements to the course and the syllabus. This system was inefficient because courses offered in the second semester are usually not offered in the first semester, making it difficult to apply any modifications or improvements suggested in the meeting until a year later. Furthermore, no one monitored if suggestions were later implemented.

5. Tools used

Table 1 lists the tools used in the current system to assess the program learning outcomes. Table 2 demonstrates the link between the course learning outcomes, the program learning outcomes and the tools.

6. Problems with the Current System

The university operated like any traditional face-to-face university, offering educational material, courses, and examinations in paper format, conducting department meetings on a weekly basis as well as end-of-semester meetings to evaluate student performance and try to suggest improvements. This system was insufficient. In the current age, a university needs to act fast, detecting problems before they occur. For example, if more than 50% of students in a class are failing, this needs to be caught early to prevent it, either by providing more assignments, addressing weak topics in the course, or reviewing faculty activities in the course (how the material is being taught). These adjustments must be made not by the end of the semester (when it is too late), but at most 1 month after the course has started (courses are 3 months long). Furthermore, to stay competitive as well as gain international accreditation, and to
implement a full-quality system, managers need to provide evidence that they evaluated their programs, made recommendations, and implemented them. These steps can only be taken if modifications are documented and are easy to retrieve to show as evidence. Finally, faculty needs to be able to adapt to problems in the course, able to identify CLOs with which students are struggling, and able to provide them with more exercises or extra reading material to help boost their weaknesses. Simply put, educators need to do the following:

- Track student performance in class
- Properly link CLOs to PLOs
- Properly evaluate student strengths and weaknesses in CLOs
- Detect student-performance problems in class and suggest solutions

7. The Birth of the System for Quality and Risk Management (SQRM)

After the first semester ended, I realized a system was needed to facilitate the paperwork. Having more than 11 years of online teaching experience, as well as more than 20 years of programming, I built a system to automate these processes. The system is called System for Quality and Risk Management (SQRM). The system is dedicated to helping faculty manage and measure course quality as well as avoid (or detect) students at risk for failure or high attrition. Building such a system required three factors:

- Solid IT infrastructure including servers with more than 99% up time.
- A system to enable students to enjoy the learning experience without needing to build a new environment.
- A reporting system to help generate digital and paper-based reports.

To address the IT issue, the college purchased a space on the cloud. Simply put, the cloud is an emerging computing paradigm in which access to hardware, software, and data is available on demand over the Internet [7]. Next, the college needed a system that created an online class environment for students to use. Moodle was the best choice as it contained all necessary tools to create

<table>
<thead>
<tr>
<th>Program Learning Outcomes</th>
<th>Assessment tools (direct)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Demonstrate knowledge and skills of leadership required to</td>
<td>1. Quizzes</td>
</tr>
<tr>
<td>effectively and efficiently plan, organize, and control an organization</td>
<td>2. Assignments</td>
</tr>
<tr>
<td>for a competitive advantage</td>
<td></td>
</tr>
<tr>
<td>2. Demonstrate analytical and critical-thinking skills with direct</td>
<td>3. Midterm Exam</td>
</tr>
<tr>
<td>application to business environments</td>
<td>4. Computer assignments</td>
</tr>
<tr>
<td>3. Demonstrate capability to apply global multidisciplinary concepts in</td>
<td>5. Projects</td>
</tr>
<tr>
<td>business and industry</td>
<td>6. Interview</td>
</tr>
<tr>
<td>4. Demonstrate skills in the use of technology and computer software</td>
<td>7. Case studies</td>
</tr>
<tr>
<td>applications in business and industry</td>
<td>8. Presentation</td>
</tr>
<tr>
<td>5. Demonstrate capabilities to apply ethical and environmental values to</td>
<td>9. Term Papers</td>
</tr>
<tr>
<td>general business principles and practices</td>
<td>10. Team Work (Group Discussion)</td>
</tr>
<tr>
<td></td>
<td>11. Final Exam</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>#</th>
<th>CLOs</th>
<th>Program outcomes</th>
<th>Assessment tools</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5 6 7 8 9 10 11</td>
</tr>
<tr>
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<tr>
<td>6</td>
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<td></td>
</tr>
</tbody>
</table>

Table 2. PLO/CLO Matrix

Table 1. Tools used to assess PLOs
online classrooms as well as full access to code and database, enabling us to tap into it and create our own reports. Finally, a reporting system was manually built using PHP on the server side.

8. Implementation

To ensure reliability and ease of control, the system was installed and implemented on a cloud hosted by GatorHost.com. Moodle was installed on the cloud, giving faculty all the online tools they need. Course materials for five management courses were uploaded to Moodle. Students were introduced to the new system to clarify how to submit assignments, participate in discussion threads, and download course materials. All interactions were conducted through the online system. Students used discussion threads to answer questions and drop boxes to submit their assignments and complete quizzes and tests.

As demonstrated in Figure 1, our system, SQRM, runs in the background to monitor student performance, missing assignments, deadlines missed, work submitted, and objectives met (or not). All work was linked to course’s CLOs, which in turn were linked to PLOs. On the server side, the proper Standard Query Language commands were places to generate reports, enabling faculty to get real-time results on student performance.

Figure 2 shows a screenshot of the SQRM system. The system provides the following services:

- A digital means to connect CLO to PLO.
- Links all work, including examination questions, assignments, and any other measurement tools to CLOs.
- Tracks student performance and issues alerts about students who are not performing well in class
- Gives a clear overview of course performance
- Suggests improvements in certain weak areas. For example, if a class is not performing well under CLO 1, the system would suggest extra material, reading chapters, or assignments focused on that learning outcome.

9. Implementation Challenges

Once the system was built, we held several meetings with faculty to demonstrate the functionality and use of the system. Faculty were introduced to the concept of online environments and given training exercises to engage them in the system. Nevertheless, system implementation encountered several difficulties:

- Student willingness. When attending a university, students get used to the way process are implemented. Students had no experience using the online environment and were afraid it might cause them to perform badly in class. To help resolve this issue, we took several steps:
  ○ Course syllabi and materials were only posted online. No paper copy was given in class.
  ○ Students were taken to the laboratory in the first two sessions to train them on creating an account, logging in, and updating their online portfolio.
Bonus assignments (students are motivated by bonus assignments) were given online to anyone who wanted to participate in the online class.

Creating a social environment where a discussion thread was introduced in the online class encouraged students to communicate with each other, post fun information, and argue about topics not related to course material (called the FUN thread).

Faculty willingness. Although adequate training was given to faculty, and although many complained about the myriad required paperwork and were eager for something to help them focus more on teaching and less on administrative work, many still resisted change! To address these issues, the following steps were taken:

- University President Dr. Ghaleb Al-Refae explained the benefits the university could gain from using such a system. University managers issued an order that all courses needed to take advantage of the online environment as well as move course material to it.
- A faculty community page was created on SQRM with helpful tips, videos, and tutorials on using the system, shared with everyone.
- Faculty preferred using one source of information for the course: the book. They did not like the idea of having to use different resources to teach one course. When informed that a book should comprise about half of the teaching material, and the rest needed to come from external resources, faculty found it difficult to implement.

10. The Study

This research aimed to answer the following question: Can online technology be integrated into an onsite course to help faculty better manage the course? To answer the question, we created a system that links online tools (e.g., discussion threads, drop boxes, and online tests) to onsite courses. The system enabled faculty to use online tools to manage and measure course performance.

10.1 Study Environment

We created five business-management courses on Moodle, linking SQRM to them to enable faculty to monitor student performance. Four faculty members taught the four management courses; at the end of the course, we asked them to complete a short survey about their experience.

At the end of the course, we asked faculty who participated in the study to complete a survey to share their experiences. The survey asked them to rank their experience from 1 to 5, 1 being highly agree, and 5 being highly disagree. The questionnaire was divided into three sections:

- Faculty–technology interaction.
- Faculty–CLO interaction.
- Faculty–SQRM interaction.
- Comments and feedback

Survey results can be seen in Appendix D, Figures 1, 2 and 3.

10.2 Discussion

When it comes to using technology in class, none of the surveyed faculty used computers (before taking the survey) in class (see figure 3). Furthermore, 75% of the surveyed indicated having little experience with technology! To avoid any negative impact of faculty not using technology on our study (since it’s based on using an online system), the surveyed faculty were given training courses and workshops on using the system.

As for faculty interaction with CLOs, Figure 4, we were amazed by what we had taken for granted! Although it is very important for faculty to work on linking course material to CLOs, and to make sure CLOs are tied to PLOs, Figure 4 shows that none of the faculty surveyed focused on the
CLOs in class before using the system. Furthermore, none of the faculty surveyed used the CLOs as a measurement to evaluate their students. This is mostly due to the feeling that faculty needed to finish the book chapters in class, regardless of whether the book related to the CLOs. Furthermore, course outcomes were created by previous faculty with whom current faculty might not agree or determined the CLOs were outdated.

Figure 4. Faculty–CLO interaction

The benefits gained from using the system can be seen in Figure 5. 75% of surveyed faculty agreed that using the system enabled them to better manage their courses. Furthermore, the system increased faculty focus on CLOs to measure student performance changing the percentage from 0% to 50%. With 75% of surveyed faculty having minimal IT experience, we can see that 50% of them found the system easy to use, this tells us that more work needs to be made on the interface in hopes to make it more user friendly in hopes to increase this percentage.

Figure 5. Faculty-System (SQRM) Interaction

11. Conclusion and Future Study

SQRM enabled participating faculty to overcome their technology fears as well as improve course quality. Less dependence on one source and thereby including multiple sources for student education was the goal of the Gulf Ministry of Education, enhancing the chances the student will compete in the market after graduating.

The system not only enabled faculty to shift their focus on CLOs but also enabled them to get feedback and improve their course in real time, aligned with the TQM systems that use feedback to improve current systems. Real-time feedback given by reports generated by SQRM enabled faculty to identify weaknesses in their classes and address them immediately.

A future study exploring the student side of the study is being conducted to determine how students assessed the shift from a book-focused course to a more technology, CLO-focused course. The study will measure student “trust” in the system and any positive or negative effects that might have resulted.

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Introduction

The complication in socioeconomic relations, the transition we are in, crime growth and the general crisis of the legal system led to deterioration of interest among citizens and legal entities which is resulting in a growing number of litigation and various lawsuits.

It can be concluded that these lawsuits are getting more complex and require specific knowledge and expertise. In all of legal proceedings and state authorities, expertise has a special significance because it is used to determine facts, without them the law is not applicable therefore appropriate legal protection is not provided.

Furthermore, it is hard to determine the significance of expertise considering that the legal nature of it is still debated. There are different views on expertise, some consider it to be one of the less important tools, some see it as an immediate help on Court and others find that it directly affects the decision itself. We can say that none of these views is completely accurate.

To a large degree the significance of expertise and an expert witness depends on the quality of their work but also on the official (or judge) who is leading the proceeding and his judgement of the expertise importance.

Key words: expertise, expert witness, nonmaterial damage, bodily integrity

1. Basic consideration on expertise and expert witness

Violence as society phenomenon arises from the very beginning of the original human communities and along with it the need to suppress the same and to punish the perpetrators of the attacks on human life and bodily integrity. With the establishment of the first forms of state there was a need for legal re-
expert is a specialist doctor of forensic medicine who is invited (Court, prosecutor or defence attorney) on the basis of their professional knowledge and skills in the field of forensic medicine to provide testimony and opinion on the existence of certain facts which can be determined only by their knowledge and skills [3]. The testimony of a forensic expert is considered as evidence on Court, unlike other expertise which are only used to help the Court determining certain facts. By the provisions of the law on expertise, an expert witness is a person appointed to perform duties of expertise in accordance with the provisions of the law [4].

In judicial, administrative or misdemeanors proceedings, the expert witness is a neutral subject, and his impartiality is resolved by an institution exclusions and exemptions in the narrow sense. Specifically, the expert is in accordance with the same provisions like the disqualification of judges. In particular, it is determined that the expert can not be a person which can not be heard as a witness or a person who is exempt from the duty of testifying and if such person is still determined to be the expert witness a Court decision can not be based on his findings and opinion. A person who has been heard as a witness will not be determined for an expert witness. Also a cause for disqualification of an expert can be if that person is employed by the injured party or the defendant, or together with them, or if some of them are employed by another employer [5]. We can conclude that the expert is a disinterested person who has special expertise and was called on by the prosecutor or the Court to assist them in determining the important facts in criminal proceedings. In addition, the expert witness should assist the authorities on the criminal proceedings only in establishing the facts, and never when deciding on the application of legal norms. In addition to the personal and professional characteristics, to perform the duty of an expert is one needs to fulfill other legal requirements [5]:
- to be a citizen of Bosnia & Herzegovina,
- to have the appropriate experience and expertise in a particular area,
- to own an appropriate school degree,
- to have proven professional skills, a reputation of a careful, objective and expeditious expert in a particular field,
- and to be characterized with integrity and high moral qualities.

On the other hand, expert testimony is a procedural action within the framework of the expert, a person who has special scientific or professional knowledge, skills and methods and applies them to facts constituting the subject of his testimony. Expert testimony consists of two parts: findings and opinions. Findings (visum repertum) is a direct sensory observation or observation of subject of expertise. Opinion (Avis parere) is drawing conclusions in accordance to the rules of the profession or science from the established facts. In descriptive terms expertise is used to obtain an expert testimony as a source of finding out essential facts which are the subject of establishing in criminal proceedings, respectively expertise is used to obtain findings and opinion which can be used as evidence in criminal proceedings [10]. The process expertise goes through three phases:
- introductory phase, which is characterized by resolving procedural issues and the preparations for the expertise, and to which a reference is made to the expert to carefully study the expertise and accurately present everything he knows and finds, as well as to present his opinion without bias and in accordance with the rules of science [6].
- operational phase in which the expertise is conducted and managed by the authority that ordered the expertise and the expertise is conducted by the expert using his knowledge and methods but complying with the commands that the prosecutor or the Court ordered. During the expertise the expert may be given clarifications, may also be allowed examination of the files or questions during the crime scene investigation or reconstruction of events, but the expert may propose that evidence be presented or articles and data acquisition that could be of importance for his findings and opinion [6].
- final phase relates to the opinions and findings, along with the expert report and opinion, submitted worksheets, drawings, and notes to the authority who ordered the expertise. In addition, it should be noted
that the written findings and opinion will be admitted as evidence if the expert witness testified at the trial, and if he was cross-examined by the opposing party and the defense counsel [7].

Expert evaluation for the purposes of criminal proceedings are diverse, whereby legal provisions are more broad about certain types of expertise, which are the most common, the most important and most complex in practice. Mandatory types of expertise are expertise in case of:

- suspicion that the death was caused by criminal offense,
- suspected poisoning,
- bodily injury,
- suspicion that the accountability of the suspect or the accused is excluded or diminished [8].

The Criminal Procedure Code deals with the following special cases of expertise:

- expertise in case of suspicious death or forensic medical expertise (čl.117-120 CPC FBiH),
- toxicological expertise or expertise in the case of suspected poisoning (Art. 121 of CPC FBiH),
- expertise of bodily injury (Art. 122 of CPC FBiH),
- physical examination and other actions (Art. 123 of CPC FBiH),
- psychiatric examination in case of doubt on the exclusion or reduction of mental capacity (Art. 124 FBiH CPC),
- accounting expertise or expertise of the business books (Art. 125 of CPC FBiH),
- DNA analysis of art. 126-129 FBiH CPC).

In addition to this division of expertise, there are cases in which the legislator specifically addresses the distribution of expertise on the basis of the case and exhaustively itemizes all instances of expertise [5].

2. The concept of physical integrity and nonmaterial damage

Physical fitness is not only the absence of disease, but rather a set of physical resources and activities with which a human provides numerous and varied pleasures to himself. Thus, the body is (or it should be) a source of satisfaction and confirmation of its own values. Mental health is not only the absence of psychological problems and disorders, it is, above all, a collection of mental abilities that enable individuals to create spiritual growth and have a rich life experience. Finally, social welfare implies the establishment of a variety of communication between people, the possibility of meeting vital and social instincts, and equal rights and freedoms for all. Human health (physical, mental or social spheres) can be, in whole or in part, affected by the stress that comes from the outside. If the stressor affects the body, it causes damage to the tissue and thereby damage to the integrity of the organism. Due to the fact that humans are unique biopsychological systems, such lesions will also have psychological repercussions and possible social consequences. However, if the stressor acted only on the mental sphere of one's personality, then the physical damage will be absent. Physical and mental injuries inevitably disturb the biological and mental balance of a human being. Each lesion of tissue (especially if it is in a larger scale) causes physical pain, which is often accompanied by fear. Fear can persist even after the injury, during the treatment and rehabilitation. In addition, after the injury there can be difficulties in terms of mental pain and suffering. If the stressor is of psychological nature, there will be no physical pain, while fear and psychological distress may remain. Just mentioned categories - physical pain, fear and psychological suffering – make a medical substrate of nonmaterial damage.

3. Expert evaluation of nonmaterial damage

Expert evaluation of a nonmaterial damage requires a great knowledge in the area of medicine and a good professional foundation, as well as knowledge of medical facts about the course of treatment and rehabilitation. The expert needs to have an extensive experience in assessing the occurrence of permanent and temporary organic and psychological consequences, and their most common forms. In all of this, it is particularly important to provide a good analysis of specific circumstances in individual cases and avoid all un-
necessary patterns and generalizations. Expert testimony begins by examining the available medical and other documents in the case file, and continues with the history of illness and a clinical examination of the injured party, so based upon those the consequences of injuries are established. The local findings describe the current consequences of health damage, anatomically and functionally. In a nonmaterial damage case the subject of a forensic evaluation is not the weight of the bodily injury, but the kind, intensity and duration of the consequences that the injured party suffered, also the volume and intensity of physical, mental pain and fear, taking into account the individual characteristics of the injured party and the circumstances the injury occurred. The consequence of the injury is necessarily contained in the character of the injury itself. Unlike the result of the injury, a complication is a process which may, or may not derive from the injury itself, and it is not necessarily contained in the character of the injury and it also does not exist in all cases. The course and the development of complications can significantly be affected by the characteristics of an individual, among other things. The forensic analysis should explain that one and the same type of injury in the medical sense, does not have, to cause the same effects on two different individuals. Individual characteristics, overall health, mental constitution, intensity and duration of harmful agents, can be quite different to express with different people. Expert evaluation of nonmaterial damage is a very responsible task for the expert to assess because of the great variety of health damage and permanent consequences of injuries and illnesses and their impact on the habits with different people, also how subjective the manifestation of pain is, fear, impairment of life dynamics and damage of the aesthetic appearance, and to assess the severity of mental suffering of an injured person. Nonmaterial damage includes all the unpleasant subjective symptoms and dysfunctions caused to the body of the victim as a consequence of an injury or disease incurred. These consequences can be of a temporary or permanent nature and have a broad scope.

For forensic expertise a vast professional experience of the expert witness is needed because of the following reasons: It is a phenomenon which the injured person is subjectively experiencing with all the specifics related to the previous and the new status of their health in relation to sustained injuries, or occurring disease, age, mental status, lifestyle habits, status in society, profession, level of education, sea life, favorite hobbies, etc. There is no possibility to objectively consider the above mentioned types of damage due to lack of appropriate parameters, there is a frequent possibility that the injured party makes a false representation of subjective symptoms influenced by the expected profit; incomplete and inadequate medical records; ignorance about the essence of the problems with this kind of expertise, both by the authority conducting the procedure, and by the expert, with inadequate plea about the consequences for certain types of damages. Given the legally defined concepts “mental pain due to reduced life activities” and “mental pain because of disfigurement” it should be noted that the mental pain for these types of nonmaterial damages makes a substantial difference in relation to disability. However, the use of colloquial name “reduced life activity” and “disfigurement”, can frequently be seen in practice. Thus abbreviated use could not be justified by the fact that this discharges the essential definition of legal provisions “mental pain”. One of the main issues for compensation of these forms of nonmaterial damage is to determine if the injured party suffered emotional distress due to reduced life activities and disfigurement, the extent and the impact of suffering to the mental health of the injured party?

Failure of the Court to state the full name of legal provisions “mental pain ...” has the effect that the assessment of these forms of nonmaterial damage includes only experts with surgical specialty or forensic medicine, who are not fully competent to speak out on all the important elements, like mental pain. This gives cause for a legal complaint, on the basis of expertise competence. This does not mean that the experts of somatic specialty should not be determined for these forms of nonmaterial damage, moreover it is necessary because they are best qualified to assess the structural consequences of bodily injury and determine current functional state of organs and body. However, it is essential that an expert is included on the analysis of this kind to assess the mental anguish (psychiatrist and / or clinical psychologist).
Until a few years ago, doctors of physical medicine used to evaluate the fear suffered. This kind of expertise should be conducted by psychiatrists and/or psychologists. However, it remains the case that the courts entrust the expertise of fear suffered to experts of surgical disciplines. So we have cases that an orthopaedist by the decision of the Court, provides an assessment of the intensity and duration of the fear. An experienced expert with surgical specialties can declare a suffered primary and secondary fear, but has no knowledge whether the fear effected the injured party on a mental sphere and the percentage of reduced life activities. Therefore, it can be considered that when this type of nonmaterial damage is evaluated by experts in surgical branches, expertise does not meet the requirements of the Court. For the doctor-expert it is necessary to have additional education for the composition of findings and opinions in civil proceedings more than in criminal proceedings. Therefore, their further education comes into question, and so does the organizational form of such education.

Specialists in forensic medicine and forensic psychiatry, are educated in the course of specialization to obtain opinions as experts. However, they do not have the clinical knowledge. It would be necessary to provide additional education for clinical experts so they can deal with medical expertise. The current program of study in medical school does not provide the post-graduates to obtain training in this field. The initiative for such education would have to come from the justice department. Forensic expertise requires of a doctor-expert to be familiar with the legal regulations in this field, a high level of expertise and absolute respect for high principles and professional ethics, human dignity, integrity, freedom and personal rights and also keeping medical secrets. Due to lack of organized education for experts, the lack of standards, and lack of knowledge of elementary rules in procedural law and other legal norms, the courts have been displeased with the role of experts for a long time. In determining the nonmaterial damage in the lawsuit an expert in medicine is needed which the Court lacks. The role of a medical expert is that through their findings and opinions provide the Court the necessary explanation. Medical expertise is such an action in which the medical terms and regulations are translated into rules and categories set by law. It is a place of two different sciences - legal and medical.

4. Medical and legal approach to the expertise of nonmaterial damage

For reasons that when forensic evaluation can have certain irregularities and errors (whether intentional or not) the legislator has regulated that there is a three-level expertise:

- **Trial expertise** is performed by a doctor, usually a non-specialists in forensic medicine. In the trial expertise minor omissions are possible, so the assigned expert or a different one is required to add corrections or additions of disputed facts.

- The **expertise on appeal** is made, when there are substantial errors in the original trial expertise, whether that expertise was wrong, or even false, whereby making it unacceptable on Court, the Court requests the expertise on appeal. At this level of expertise, which can be done on a subject or on the basis of the case file, two experts are required, specialists in forensic medicine [9].

- **Tertiary expertise** or supervised expertise is conducted by the Board of Medicine, determined by the Court. This kind of expert testimony is set in all dubious cases, incompletely established or misinterpreted facts, or, when there is a large difference between the trial and appellate expertise, so the expertise on appeal itself can not clarify some crucial facts. Tertiary expertise is irrevocable and, as such, final.

The Court requires from an expert an active approach to the quality of medical expertise.

Therefore, the expert has to present important facts, such as: qualifications of bodily injury, a cause and harm of the injury, the impact of the previous injuries of the injured party, the impact of the treatment method applied, then perform an objectification of the permanent consequences and in the end apply all the data to the forms of the nonmaterial damage required. An examination of the injured party is mandatory in civil proceedings. It is performed to learn the time when the injury occurred, the type and severity of the injury, the
method of treatment, the completion of treatment and the evaluation of the consequences caused to general health, anatomically and functionally. It can be indicated to the injured party to conduct additional tests (X-ray, ultrasound, EMG, laboratory evaluation, etc.) before the expert evaluation which can be of importance to have a clear insight into the state after injury or disease. The examination of the patient should be done in a room that is intended for it, not in counselor’s office or in the apartment of an expert. An expert physician must have knowledge of the anatomy and function of all organs in the skeletal and muscular systems, blood circulation, nervous system and sense organs. All of this is a starting point for finding, identifying and understanding the acceptable medical criteria.

After reviewing the medical history, the subjective symptoms and data on the current condition are described. On completion of the medical examination, a short status of general physical and mental condition of the victim is given, with the assessment of: whether the calendar and biological age are balanced, whether the posture and movements are striking or not, with or without the use of orthopedic devices; entries on other special observations are made, and then the findings system by system. The local medical findings describe the current consequences of health damage in anatomical and functional sense, all in the context of expertise: the suffering of fear and its consequences, suffering of physical pain, aesthetic changes, ie. disfigurement, impairment of daily activities, suffering because of the severe disability of another person close to them and other.

The cause and effect connection between the injury and the resulting consequences must be established in all the injuries in which the subjective symptoms prevail and are difficult to medically objectify. It is not seldom for medical records that are not authentic to appear, also a long duration of sick leave for a light bodily injury, subjective symptoms that are not proven by objective methods, as well as other unreliable data in the files. The duty of an expert is to truthfully and completely answer whether the consequences of the injury are in a direct cause-effect connection with the present infringement.

The existence of an injury is a medical fact. For a medical fact to have probative value in Court, it must reflect in complete and equitable management of medical records. Probative value depends on all elements in the findings of the doctor: exactly specified type of injury, description of the injury, stating the location, size, shape, number, etc. If these rules are not followed, then the medical fact has no probative value.

Previous injuries and diseases, i.e. poor health condition before the injury in question should always be described in detail. Each person enters the harmful situation with their personal condition and possible previous injuries that need to be determined in civil proceedings, in order to separate the influence of the trauma, specific health condition or previous injuries in a different time before that. In practice this is carried out by reviewing the injured party and examining their medical records. If there were previous injuries of the same body part or organ an expert should determine the impact of those injuries and their lasting effect, all in relation to the new event. Also, all congenital pathology, acquired degenerative and inflammatory diseases, as well as metabolic and neoplastic diseases need to be excluded [10].

An illustrative example of this practice is an injury of the cervical spine, where the expert has to determine the degree of degenerative changes that the injured had before the traffic accident. At the request of the Court, expert neurosurgeons and orthopedic surgeons, can reliably determine the degree of degenerative changes of the cervical spine based on X-rays, and their share of lasting consequences. The injuries of ligaments and joints that occurred in a different time before the incident can be identified in the same way. Thus, with the expert testimony we can get reliable data on existing degenerative changes and separate them from the influence of the trauma that occurred.

It is very important to establish the data on curing of the injuries during the proceedings. An expert should explain whether the treatment was conducted under the rules of medical profession, does the length of the treatment have a medical reason, were the modern methods of treatment applied, were there any complications during the treatment and is the treatment completed?

Furthermore, it is necessary to determine how long after the injury did the injured party report for the examination, which injuries have been re-
received and whether or not they denied a proposed medical intervention or procedure, contributing to lasting consequences.

Expert testimony must be clear on whether the diagnosis was established by an objective medical method or on the basis of subjective symptoms. An expert should give information about the number of surgical procedures, the length of immobilization, and their physiological needs, development and intensity of the clinical picture and to chronologically list all the important healing data of the person injured. Therefore you should cite the doctor’s findings so the Court can follow the healing process, and then review the facts above. This way, the Court could explain its assessment of the compensation with much more objective data. In practice, the courts pay little attention to the presentation of evidence by an expert testimony and facts related to the treatment. This can lead to wrong conclusions about the length of the hospital treatment due to poor doctor – patient cooperation.

Objectification of permanent consequences due to injury is conducted with detailed clinical examination of the damaged party. With objective findings we establish the state of the organs and/or body parts in structural and functional terms. Expert assessments are often not based with an objective condition of the damaged party. There is a great need to find solutions and criteria to ensure equal medical evaluation of injury, and thus the irreversible effects that are normally expressed in the degree of disability.

Objectification of permanent consequences due to injuries can be used from the conclusions in the specialist’s findings who did the measurements of permanent consequences through application of modern medical and physiological methods. Such objective measurements conducted without the influence of an expert, are a sound foundation for the expert and courts so they can above all else describe in detail, the disfigurement of the body and reduced life activities. Logically, the role of an expert is to clarify to the Court all the measurement results from medical records.

Thus, for example, the condition of the knee can be objectified after the treatment using computerized dynamometer which measures the function of the joint, such as mobility, endurance and muscle fatigue. You must always compare the same two joints on paired limbs, i.e. the healthy and the hurt joint, which is always an important part of the objective findings in explaining the consequences of the injury (range of motion, joint volume, etc.). Also, measuring the mobility of the joint protractor is a commonly used method in the objective findings. If we do not measure the result and objectify the consequence, how can we know that we did not damage the person who has suffered the injury.

Modern medicine at this stage can objectify almost all lasting effects, especially the most common injuries in traffic accidents, such as injuries to the bones, joints and muscles. As an example the magnetic resonance imaging, can serve as a diagnostic method for injuries of the cruciate knee ligament, and can also be applied in the process of objectifying the success of the treatment, or an operation of these ligaments. The advantage of this approach is in the objectivity, it is not harmful, and it gives more information about the actual function of the injured body part.

All of these ways of objectifying the consequences of injuries are a Court polygraph that does not show the Court who has committed the violation, but the amount of damage caused to the

![Figure 1. The content of findings and opinion of an expert witness](image-url)
victim. Very rarely experts suggest an objectification of the injured parties health status with a new diagnostic method.

Application of objectifying method speeds up the process of expertise. In practice we are often faced with a variety of subjective assessments and findings of experts, which makes the work of courts very difficult. It is not rare for experts to superficially understand their role as helpers of the Court, or emphasize their academic position.

In civil proceedings an expert occasionally faces simulation (pretending) and aggravation (exaggeration), which represent an intentional presentation of false or exaggerated physical and psychological symptoms that are most often motivated be financial gain.

5. Types of nonmaterial damage

For harmful events that have a nonmaterial damage, we consider those who are referred to as physical pain, psychological pain (sorrow, sadness, melancholy, depression, gloom, and, directly caused by psychogenic factors) and fear. The emergence and / or intensification of such unpleasant feelings cause certain emotional disorders that doctors have to objectively analyze, describe and measure. In the health damage caused by an injury or disease an injured party suffers nonmaterial damage, which can not directly be compensated because it implies suffering related to the subjective feeling of pain, fear, various psychological discomforts to the level of mental suffering, change of life activities and the occurrence of impairment in aesthetic appearance.

It should be emphasized that the above mentioned concept and forms of nonmaterial damage can be the same or different. Thus, due to occurrence of some injuries all the mentioned types of nonmaterial damage can occur in a continuous chain (a serious body injury obtained in a traffic accident causes severe physical pain and mental anguish due to inability to achieve certain goals in life and also fear caused by circumstances mentioned). On the other hand, these forms of nonmaterial damage can be independent, in a specific case, the mental pain and fear can arise without somatic injuries, and some diseases can be a an expression of deep psychological changes (psychosomatic diseases - diabetes, angina pectoris, myocardial infarction, cerebral insult, etc.) at a later stage.

In assessing the consequences of injuries on which we determine mental pain, we start from the definition of the World Health Organization that health is a state of physical, mental and social well-being. In this regard, mental pain from the aspect of nonmaterial damage can be expressed in four categories:

1. The condition and function of internal organs, and thus the denial of satisfaction related to the function of these organs;
2. psychomotor skills that include ease of movement of body or limbs within the common needs and desires;
3. psycho-sensory function, used for the realization of the common life necessities and satisfaction;
4. psychosocial activities, by which is meant the ability to satisfy different needs at the micro and macro levels of social groups, which is appropriate to the individual characteristics of the victim.

In determining the mental pain in forms of nonmaterial damage experts in psychiatric-psychological profession should determine all the consequences because of which a normal activity of the injured party is limited or is difficult and why he is suffering mentally. This means that in the findings and opinion of an expert is not sufficient to state only the percentage of reduced life activities but is necessary to specify the circumstances in which the stated percentage of mental suffering is manifested. Also, it is not sufficient to indicate the degree of disfigurement, but to give its description and location, as well as the individual traits of the victim (gender, age, occupation etc.).

The consequences of injuries often do not manifest externally, but internally, subjective suffering of the victim (eg. suffered physical and psychological pain, a feeling of violation of honor, etc.) and they could not be measured with a full certainty and accuracy.

Therefore, a compensation for nonmaterial damage as a result of light injury comes to question. It is irrelevant how the injury is qualified (light or heavy), because it is important to mark the crimi-
nal act and criminal responsibility, and not to set the conditions for fee ad judgment. Here, the emphasis is on the duration of the physical and mental pain or fear and the intensity of suffering which led to mental balance disorder. Any suffering will not cause disturbances to the mental balance. It is believed that strong and medium physical pain with light bodily injuries, lasting for 4-5 days can cause disturbance in mental balance. Will there be a disturbance of balance depends primarily on the personality, age, health status and a number of other factors. Nonmaterial damage is in essence a violation of personal property of a human being, such as: life, physical integrity, health, mental and physical abilities, honor, name, shame, sexual integrity, freedom, personal and family peace and other personal goods. It is characteristic for these injuries that the subject feels them as damage, although they do not directly affect its property.

Expert testimony should explain the type of consequences of bodily injuries and its impact in terms of basic life functions.

The term end of treatment involves the treatment and medical rehabilitation when further non-invasive methods and procedures can not achieve a greater degree of health then the one already achieved. The assessment is possible based on the findings obtained by a control diagnostic treatment that is carried out at least three months after the completion of treatment, or when the condition is stabilized i.e. when according to the doctor’s prediction the condition will not worsen or improve. If this condition does not occur even after three years from the date of injury, the final condition after the expiry of that period is taken into account and then all the forms of nonmaterial damage are determined. For the evaluation of overall consequences of the injure or disease it is necessary to assess, on one hand, the anatomical or functional disorders, which can objectively be proven and quantified and, on the other hand, the consequences in psychological sense that manifest through mental pain or suffering because of the inability or limitations of satisfying basic needs and the denial of life joys. Psychological effects are subjective in nature, individually dependent and there is no reliable indicator for them.

The complexity of expertise actually comes from the fact that the effects of the bodily injury or disease are individually assessed in relation to earlier physical and psychological characteristics and the activity of the injured party.

The job of the expert doctor is to determine the extent of disorders occurred to the organism solely as a result of the injuries or disease due to which the common life activities have been disabled, limited or difficult. Then, to estimate the impact of the disorder on the injured party’s ability to perform ordinary life activities and consider the emotional pain the damaged party is dealing with.

Reduced life activity includes all limitation of activities which the damaged party achieved, or would certainly achieve in the future. Under limitation is performing activities with increased efforts or under special conditions is also considered.

Types of nonmaterial damage, for which the injured party may receive compensation, and which the law recognizes are:
1. incurred and future physical pain;
2. incurred and future mental pain due to reduced life activities;
3. incurred and future mental pain because of disfigurement;
4. incurred and future mental pain due to violation of reputation and honor;
5. incurred and future mental pain due to violation of freedom;
6. incurred and future mental pain due to violation of individual rights;
7. incurred and future mental pain over the death of a close person;
8. incurred and future mental pain due to severe disability of a close person;
9. incurred and future mental pain because of the criminal offense, against the sexual integrity, dignity or morals;
10. incurred and future fear.

Expertise of the above mentioned forms of nonmaterial damage is done on the basis of the Court records, the data obtained from the injured party, access to medical records, examination of the injured party and the data obtained during a hearing.

Various problems in the forensic analysis about the reducement of life activities are mainly due to lack of knowledge of basic principles in organizing and conducting expertise, both by the civil Court, as well as by the expert doctor. They are
also caused because of the practical problems related to this kind of expertise.

On the complexity of the problem indicates the fact that even in the countries of the European Union there is no unique criteria on this issue and that the law differs from country to country. In order of future harmonization of regulations, among the member countries, in the field of tort law an adoption of a single method for evaluating the degree of damage to health and its impact is being made. In this sense, a European integrative table for assessing impairment of mental and physical integrity was made on 2003.

6. Conclusion

It is obvious that expertise as evidentiary action in a variety of legal proceedings has a special importance, because without it we could not solve some decisive questions in evidentiary proceedings. Starting from this and from the fact that the expertise is one of the most common reasons for a long duration of criminal proceedings, there is a need for legislative intervention in this field of criminal procedure towards a faster and more efficient implementation of these actions, and in a practical application, leaving the former uncritical attitude towards evidentiary actions and expectations that the expert testimony can solve all even those unsolvable questions.

With the development of science, application of its achievements through expertise makes the job easier to determine the disputed facts in the criminal procedure, because of which all the existing obstacles must be removed, such as, inadequate criteria of evaluation of experts, inadequate way of collecting and providing the expertise material, omissions in practical management of expertise, uncritically and carelessly led evaluations, for is needed, not only in procedural law, but also in practical treatment of all bodies whose work has an impact on the quality of expert testimony.

For participants in the proceedings to achieve their rights within a reasonable time, and for the judiciary to achieve efficiency, it is necessary that the evidence in the expert testimony was found within a reasonable time by an expert, who will give its full contribution in judicial proceedings. In order for this to happen, it is necessary that experts have the full ability to exercise their rights, but on the other side also to fulfill their obligations. Only by creating conditions that will allow the achievement of equal rights and obligations, and that judicial, legislative and executive authority, each in its domain achieve prerequisites for the fulfillment of obligations in relation to the experts, judicial authority to bring adequate solutions in a reasonable time, legislative authority to ensure effective laws, and the executive branch to provide a sufficient budget, and on the other side that experts fulfill their obligations within a reasonable time and with required quality, only then will the full efficiency and quality required for making a proper Court decision be made.

When reporting, the expert on one hand has an obligation to keep the professional secrecy, but on the other hand, the law has prescribed the use of their expertise in the field of medicine for answering disputable questions in front of the Court. In addition to the findings and opinion, an expert usually encloses the medical documentation. Bearing in mind that the participants in the proceedings, and third parties have the right to inspect the files, except when the public is excluded, or the files are marked as government or official secret, inadequate storage of medical records can certainly present a violation of the right to respect a private life of a person, whose documentation is supplied by the expert. Therefore, it is obligated that all medical records relating to the party or other participants in the process, and can be made available to participants in the process or a third party be handed the Court in a sealed envelope, to ensure conditions that the right to privacies maintained. This also has to be taken into account by the Court. In preparing the material for opinions and findings, and in order to respect the right to private life, and to safeguard medical secrets, the Court expert will be legitimated in a medical institution designated by the Court in which he will obtain the necessary information.

To perform the work of expert witness, in addition to holding certain high degree of expertise and technical knowledge, it is essential that they meet other conditions and circumstances. First of all, a person engaged in an expert testimony must meet high personal and professional criteria, such as conscientiousness, responsibility, incorruptib-
ity, safety, and lastly honesty and ethics. Taking into account that the activities of an expert witness are done primarily because of the fact that in this way certain evidence materials are provided, it is certain that for the quality of this activity one has to have a certain tendency and affinity. All this makes one person, conditionally speaking, capable of being an expert.

Moreover, bearing in mind the objective that needs to be achieved in the conduct of Court proceedings, national courts should respect the content of the recommendation. R (81) 7, the Committee of Ministers of member states on measures that facilitate access to Court (Recommendation adopted by the Committee of Ministers May, 14th 1981. At the 68th session). In the act entitled “simplifying” in Chapter 7 it is provided that measures should be taken that the number of Court experts who are placed at the request of the Court be reduced to a minimum. This is consistent with the desired aim to make Court proceedings more flexible and efficient, and considering the increasing number of expertise that are required in civil and criminal cases, the number of expert witnesses should be kept to a minimum, in order to come to the opinion that requires the expertise of an expert witness, but in the most efficient and fastest way. In order to ensure the efficiency of Court proceedings and a reasonable timeline, without which there is no right to a fair trial, and as provided by the Article 6 of the European Convention on Human Rights, expert witnesses as specific participants in the process have provided obligations and rights. Therefore, national systems must by law determine the true measure of liability of an expert, and to determine their rights, so the Court with an appropriate application of these provisions can provide that expertise, as an evidence, contributes to quality of trial and achievement of reasonable time.

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Abstract

This study presents structural analysis of Bailey bridges consisting of different-spans-simple beams and different grid configurations. Combination of construction, needed to be used in order to make it compatible with transom spans, loaded in accordance with contemporary regulations for II category of bridges, is presented by tables. The procedure is conducted according to both analytical and numerical method, whereas results have been controlled in practise. Analytical and numerical results are presented by both tables and diagrams. Procedure of Bailey bridges analysis according to nonlinear contiguous load theory is presented by numerical example.

Key words: Bailey bridge, combination of construction types, plastic axial hinge, contiguous load.

1. Introduction

Bailey construction is mainly used for bridges in order to fastly overcome obstacles or because of temporary detour during building of a bridge. It was designed as a truss bridge by foreign engineer Donald C. Bailey in 1939 for the needs of the English army. The advantage of this construction is that it is easily and quickly produced in large batches, and easy to assemble for overcoming the obstacles. Both road and rail bridges can be mounted from Bailey constructions. Additionally, Bailey structures can be used as auxiliary structures in the construction of large buildings. The main purpose of this construction is that the road bridges can be built ranging up to 60.9 m, depending on the application of a combination of types of construction for loads up to 600 kN [1]. The design is most economical for medium loads up to 350 kN and spans from 30 to 50 m. Effective width of the bridge depends on the application of standard construction (S) which is a useful width of 3.277 m, the extended structure (P) with a useful width of 3.810 m or wide structure (W) with a useful width of 4.190 m. The literature describing the Bailey bridges of structural elements is given in tables in the span bridge function. Structural analysis that applies to the adoption of the structural elements of the bridge was made for loads of 3x90 kN if we have two transoms in the field of grid and load 3x160 kN if we have four transoms in the grid field.

Load of Bailey bridges to be endured is significantly less than the load that define the valid regulations in Bosnia and Herzegovina. Design of structures is based on the regulations for the load in defining the types and intensities of individual action. If we use the data from the available literature Bailey bridges would not satisfy the conditions required by applicable regulations. Thus scaling and adoption of the structural elements of the bridge needs to be adjusted to legal regulations in Bosnia and Herzegovina. The existing regulation in BiH bridge load is the Ordinance on technical standards for determining the size of bridge load (Official Gazette 001/1991) [2].

2. Basic installation structure parts and principal dimensions of bailey bridge

The Bailey bridge is a type of portable, prefabricated, truss bridge, which parts are assembled on the site of the bridge construction. Installation parts of the bridge are classified into main and other parts of the bridge. The main parts of the bridge consists of lattice girders with rhombic filling, transoms, bracings and stiffening elements.
Other parts of the bridge to be used for installation are [3]: pins for grid, bracing frame, bracing bolt, ribband bolt, clip, plain roller, rocking roller, wooden chess and launching- nose link. By the combination of these parts can be obtained different dimensions of the bridge along the length, height and width. Thus, single, double, triple and quadruple spans of bridges are formed. Abbreviations for combinations of the Bailey bridges are:

- SS – single-truss single-story,
- DS – double-truss single-story,
- TS – triple-truss single-story
- QS – quadruple-truss single-story,
- DD – double-truss double-story,
- TD – triple-truss double-story,
- QD – quadruple-truss double story.

Effective width of the bridge depends on the application of standard construction (S) which is a useful width of 3.277 m, the extended structure (P) with a useful width of 3.810 m or wide structure (W) with a useful width of 4.190 m, Figure 2.

Table 1 shows some of the dimensions in cross-section [5].

*Table 1. Dimensions of the cross section of the bridge*

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>A [mm]</th>
<th>B [mm]</th>
<th>C [mm]</th>
<th>D [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard (S)</td>
<td>5486</td>
<td>3277</td>
<td>3759</td>
<td>1448</td>
</tr>
<tr>
<td>Extended (P)</td>
<td>6096</td>
<td>3810</td>
<td>4343</td>
<td>1448</td>
</tr>
<tr>
<td>Wide (W)</td>
<td>6096</td>
<td>4190</td>
<td>4775</td>
<td>1448</td>
</tr>
</tbody>
</table>

Extension of the grid in length forms the bridge structure of \( L = 3.048 \) to 60.96 m.

**3. Load and adoption of structural elements of the bridge according to literature**

For static analysis Bailey bridge construction, it is necessary to calculate the impacts, bending moment and ultimate response only from the useful load. Construction Type calculated for maximum impact adopts the tables. Table 2 shows the permitted static size of Bailey bridges [1].

*Table 2. Permitted static values of Bailey bridges*

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>M [kNm]</th>
<th>Width S</th>
<th>P</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>JJ</td>
<td>1550</td>
<td>305</td>
<td>305</td>
<td>305</td>
</tr>
<tr>
<td>DJ</td>
<td>3100</td>
<td>610</td>
<td>610</td>
<td>610</td>
</tr>
<tr>
<td>DSO</td>
<td>6200</td>
<td>610</td>
<td>610</td>
<td>610</td>
</tr>
<tr>
<td>TS</td>
<td>4650</td>
<td>813</td>
<td>813</td>
<td>915</td>
</tr>
<tr>
<td>TSO</td>
<td>9300</td>
<td>813</td>
<td>813</td>
<td>915</td>
</tr>
<tr>
<td>QS</td>
<td>6200</td>
<td>1067</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QSO</td>
<td>12400</td>
<td>1067</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DD</td>
<td>6200</td>
<td>1016</td>
<td>1016</td>
<td>1016</td>
</tr>
<tr>
<td>DDO</td>
<td>12400</td>
<td>1016</td>
<td>1016</td>
<td>1016</td>
</tr>
<tr>
<td>TD</td>
<td>9200</td>
<td>1372</td>
<td>1372</td>
<td>1524</td>
</tr>
<tr>
<td>TDO</td>
<td>18600</td>
<td>1372</td>
<td>1372</td>
<td>1524</td>
</tr>
<tr>
<td>QD</td>
<td>12400</td>
<td>1728</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QDO</td>
<td>24800</td>
<td>1728</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Bridges that have two transoms in the field are designed for vehicle traffic which double axle has a maximum load of 180 kN, and the distance between the axles of not less than 1.22 m, single axle with a maximum weight of 90 kN which distance is not less than 1.52 m.

The bridges that have four transoms in the field are designed for vehicle traffic which double axle has a maximum load of 320 kN, and the distance between the axles of not less than 1.22 m single axle with four wheels with a maximum weight of 160 kN which is far from the double of not less than 1.52 m.

In recent literature, loads are divided by class 4-150 tons with designs of loads. According to these classes are made nomograms and tables spans for each combination of types of construction [5].

4. Effective load of bridges by applicable law in bih and adoption of constructive elements

The bridges on the roads are classified according to the importance of roads in three categories. Useful load consists of the typical load vehicles and surface pressure in the main and sub bands. Table 3 shows the computational load patterns for the three categories of bridges [6].

<table>
<thead>
<tr>
<th>Bridge Category</th>
<th>Calculation load patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Highways</td>
</tr>
<tr>
<td>II</td>
<td>Main, Regional and Municipal Roads</td>
</tr>
<tr>
<td>III</td>
<td>Other Roads</td>
</tr>
<tr>
<td></td>
<td>Roadway Width&gt;6 m</td>
</tr>
<tr>
<td></td>
<td>Roadway Width&lt;6 m</td>
</tr>
</tbody>
</table>

Table 3. Calculation load patterns for individual categories of bridges

The main strip load patterns with the main typical vehicle is located in the most unfavorable position for the calculation of certain elements of the structure. In front of and behind the vehicle main strip is loaded surface load \( p_1 = 5.00 \text{ kN/m}^2 \). In the main bar all loads are multiplied by the dynamic coefficient, which is calculated according to the formula:

\[
K_d = 1.40 - 0.008 \cdot L \quad \text{................. (1)}
\]

where \( L \) is the span in which the vehicle is located. If there are impacts for two or more directions \( L \) is the smallest span. If the minimum span of 0.7 from the largest span of \( L \) is required as the arithmetic mean of the span. Area of August off the main strip is loaded surface load \( p_2 = 3.00 \text{ kN/m}^2 \) without dynamic coefficient. At your local budget hiking trails, plates, crossbeams are done with traction \( p_3 = 5.00 \text{ kN/m}^2 \).

Figure 4. Type-vehicle W600

From these loads can be concluded that the burden of bridges according to the regulations in force in Bosnia and Herzegovina is greater in intensity than the load at which they performed static calculations Bailey bridges. In order to compare the results of the calculations should be carried out structural analysis of the bridge on the example of the simple transom with load according to the literature and according to current regulations. Dimensions cross-section has been taken for a wide bridge type.

The results of calculations of static impacts and selection of a combination of the bridge structure to load the type W600 vehicle are shown in Table 4, vehicle 2x90 kN + 90 kN in Table 5 and the vehicle 2x160 kN to 160 kN in Table 7. Table 4 shows that the maximum span of the bridge according to the regulations in force in Bosnia and Herzegovina \( L = 48,768 \text{ m} \), ie. to the main roads can not apply data from the literature that describes Bailey bridges.
Existing data can be used for approximate measures and combinations of the bridge structure, and for each different case width and span bridges should carry out a structural analysis of the same. Tables 5 and 6 specified loads for two four transoms in the field of grid data from literature agree that spans and bridges can be increased up to $L = 60.96$ m. From the time when patented Bailey structures until now loading bridges are increased significantly, as can be seen from the comparison of the calculation results. Comparison of the results obtained from the linear theory is shown in Figure 7.

For the justification of the analysis is an example to break down one Bailey bridge on the R467 regional road Zavidovići-Lead in Podkamensko shown in Figure 8.
Combination of the construction of this bridge is made of two transoms in the field of grid. Thus to select combinations of structural elements (grid) worth Table 5. From Table 5, number 10 for the load vehicle 2x90kN + 90kN tells that it is the combination of DD – double-truss double-story. It is obvious that in this case such a structure, using the selected literature for Bailey bridges, could satisfy the existing load. Collapsed bridge was removed and in the same location the new Bailey bridge of span L = 30.48 m was mounted. The new bridge was made in structural analysis according to the regulations in force in Bosnia and Herzegovina for the II category bridges (regional), vehicle load W600.

From Table 4 under number 8 for the new span of the bridge is read to require a combination of TD – triple-truss double-story. At this location the bridge with three rows and two floors with four transverse beam in the field grid which is shown in Figure 9.
5. Mechanism of conduct of axial load section

One of the basic assumptions of the theory of linear structure is linear elastic behavior of the material. However, most of the material does not act in accordance with the assumptions of linear theory. The behavior of materials is generally non-linear, which is necessary to know the nonlinear relationships stress and strain. Non-linear stress-strain relations in the design of structures introduce material or physical nonlinearity. In the calculation of material nonlinearity actual diagram of material behavior approximateS computation diagram for more simple calculation. Figure 10 shows the actual and approximated diagram of steel; behavior.

The simplest design of structures’ analysis according to plasticity theory is if the diagram of material behavior is approximated as a bilinear elastic and ideal plastic part. In the area before the yield point, the material behaves as in the linear theory (ε < abs). After the voltage of yield remains constant and the deformation increases fracture section. In the axial deformation of structural elements in the intersection of force at which performances give material can be calculated on the basis of the expression:

\[ F_y = \sigma_y \cdot A \] .......................... (2)

where \(\sigma_y\) is the voltage at the yield point, \(A\) cross-sectional area. The distribution of forces and strain in axially tensioned element is shown in Figure 11.

Shifting on the borders of release is calculated as:

\[ \delta_y = \varepsilon_y \cdot L = \frac{\sigma_y \cdot L}{E \cdot A} \] ........................ (3)

The force required to element length \(L\) stretched to the unit’s rigidity which follows from the expression (4) when \(\delta_y\) is equal to one, in the form [7]:

\[ F = \sigma_y \cdot A \]
\[ k = \frac{EA}{L} \] ................................ (4)

After reaching powers the yield section (Figure 11b) in the element is formed plastic hinge in which it appears force \( F_y \) (Figure 11.c) no matter what the load increases. This calculation method is called the method of plastic hinges. According to the method, the plastic hinge analysis of structures is carried out by first-order theory of plasticity. Advantages budget by plasticity theory are the following:

- Reasonable capacity of the structure;
- Cost-effective scaling;
- Knowledge of structural behavior at load limit;
- Ease budget.

When calculating according to the theory of plasticity is necessary to find the stress level for that structure remains stable kinematic free. This means that for kinematic simply fixed systems after the occurrence of only one plastic hinge occurs fracture of structures.

The force \( F_y \) will be constant in the \( \varepsilon_y < \varepsilon < \varepsilon_{gr} \), since within these limits is provided ductility section. After reaching the limit deformation \( \varepsilon_{gr} \) in plastic joint is necessary to put that \( F_y = 0 \). Limit strain is calculated using the formula:

\[ \varepsilon_{gr} = \frac{\delta_{gr}}{L_{global}} \] ................................ (5)

where \( \delta_{gr} \)-border movement in the direction of the axial hinge, \( L_{hinge} \approx (1/3) L - \) Length hinge is approximately equal to one-third the length of the rod. For Centrally pressed rods with calculated forces of yield of materials it is necessary to take into account the slenderness. In reference [8] are given the various curves buckling elastic and plastic range which are plots of the critical buckling stress, slimmess shown in Figure 12.

In practice, the European buckling curves (Figure 13) resulting from many years of theoretical and experimental research are used. These curves buckling over dimensionless coefficient \( \chi \) define the resistance element buckling as a function of the relative slenderness of the rod and the rod imperfections.

\[ F_{y,p} = \sigma_y \cdot A \cdot \chi \] ................................ (6)

The relative slenderness is calculated on the basis of the expression:

\[ \chi = \frac{\lambda}{\lambda_1} \] ................................ (7)

where \( \lambda_1 \) slenderness is at the border of yield material forms:

\[ \lambda_1 = \pi \left( \frac{E}{\sigma_y} \right)^{1/2} \] ................................ (8)
6. Numerical Example

For Bailey bridge DD (double-truss double-story) span \( L = 36,576 \) m do budget by plasticity theory and make a comparison with the load under current regulations. In this example, the bridge was analyzed with the same geometric and material characteristics as specified collapsed bridge. For the purposes of the budget by the theory of plasticity is used diagram of steel behavior shown in Figure 14 [9]. Diagram is obtained by testing samples of steel truss of the Bailey bridge.

![Figure 14. Diagram of behavior of materials [9]](image)

From the diagram, behavior of materials, the voltage value \( \sigma_y = 41.46 \) kN/cm\(^2\), the marginal deformation \( \varepsilon_{gr} = 11.81\% \) and secant modulus \( E = 2,47 \times 10^8 \) kN/m\(^2\).

Based on the voltage force \( \sigma_y \) the yield:

- Tightening:
  
  Cross section 100 2U (cord members):
  \[ F_y = 41.46 \cdot 13.5 \cdot 2 = 1119.42 \text{ kN} \]

  Cross-section and 80 (diagonal bars):
  \[ F_y = 41.46 \cdot 7.57 = 313.85 \text{ kN} \]

  Cross section 100 2U (cord members), buckling curve B:
  \[ \chi = 0.681 \]
  \[ F_y = 41.46 \cdot 13.5 \cdot 0.681 = 889.83 \text{ kN} \]

  Cross-section and 80 (diagonal bars), buckling curve A0:
  \[ \chi = 1.434 \]
  \[ F_y = 41.46 \cdot 7.57 \cdot 1.434 = -134.96 \text{ kN} \]

When the force of 1119.42 (-889.83) kN suffers from the axial plastic hinge in the band sticks to the truss, while the power of 313, 85 (-134.96) kN plastic hinge appears to fill members.

Load corresponding to regulations is:

- On the place of vehicles W 600:
  \[ F_{W600} = 1.11 \times 600/4 = 166.50 \text{ kN} \]

- on the other parts:
  \[ F_q = (1.11 \times 5 \times 2 + 3 \times 1.69) \times 1.44 = 23.28 \text{ kN} \]

Calculation of bridge span \( L = 36,576 \) m was made by the theory of plasticity. The loads are reduced to act as concentric load on the main carrier and gradually inflicted to the threshold. An analy-

![Figure 15. Scheme of the load of the bridge [10]](image)

Table 7. Results of calculation of a grid in Figure 15
ysis of limit load in linear elements carrier in which open plastic joints respectively.

Figure 16. Path of balance and order of formation of plastic hinges

Figure 17. a) The ratio of power-deformation of the lower belt

Figure 18. a) The ratio of power-deformation of the upper belt

The combination of DD grids for span \( L = 36.576 \text{ m} \) bridge under current regulations do not meet the limit state design and usability. The load to which the analysis of the \( F_q = 18.00 \text{ kN} \) and \( FW600 = 156.78 \text{kN} \) (Table 7), while the load corresponding regulations significantly higher of \( F_q = 23.28 \text{ kN} \) and \( FW600 = 166.50 \text{kN} \).

7. Conclusion

Structural analysis and building of bridges is a complex problem that requires some understanding of the broad subject matter of the construction, building materials, hydraulic engineering, geotechnical engineering, construction technology, organization and construction of roads. Bridges are expected to be long life in a variety of settings and effects of static and dynamic loads. Such complex objects is not easy to build because obstacles to be overcomed are usually demanding. Use the Bailey bridge structure is very easy to install on-site, and so for a short time overcomes obstacles.

Bailey bridges are mainly used as a temporary structure for the transition of military materiel and technical equipment in the military actions and the reconstruction and repair of existing bridges, and as permanent structures with certain modifications and finishing construction.

In Bosnia and Herzegovina, many bridges were destroyed and worn out because they were built over decades. The use of Bailey bridges as temporary structures is justified. But since 1939, this type of bridges were increased in traffic load, so the structure necessary had adapt to today’s regulations for bridge construction.

In this paper, such an attempt has been made in the allocation of a small administration referential combination of various spans, as well as limitations in terms of passing over an obstacle. Load is taken for Category II bridges because usually this type of construction is used as temporary or permanent structures on the main and regional roads.

From the calculation results can be concluded that the existing literature that describes Bailey bridges is not adequate for the use of these bridges in order to meet existing regulations that are stricter than the former regulations. Therefore, preliminary structural analysis of the useful load for the various spans of bridge of simple transom, and in
Table 4 below shows the approximate combinations of a type of construction which is required for bridging the specified span of the bridge.

In emergency situations in temporary structures data in Table 4 can be used. For each concrete barrier and span, as in the case of permanent bridges is necessary to make a detailed static-dynamic analysis, local and global check of all components of the bridge. For a concrete example of such a shortened analysis is done, as well as the results of such calculations. For justification of this approach to calculations of Bailey bridges is given specific case of collapsing bridge under load. Be sure that the bridge is not adequately dimensioned to the actual load for a specified period tolerate such a burden and that after more than fifteen years collapsed, opening new questions about the durability of these structures. The above calculation procedure of Bailey bridge is a contribution towards harmonization of literature on this subject with the applicable regulations and guidelines for designers who will deal with this area.

References

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Abstract

The aim of the study was to analyze testing results of posture status recorded with different kinematic methods and with different assessment methods to create a matrix. Posture status of respondents, for both methods, is estimated for the same group of children, aged 5-11 years, during the IPA “SpineLab” project implementation granted by the European Commission.

The samples of 12 variables are 2D – one camera view for frontal and sagittal position, calculates higher mean values for variables: legs frontal 2.88 / 3D =1.51, Lorenz’s triangle asymmetry 1.85 / 3D = -1.49 and shoulders displacements 1.83 / 3D = -0.79 as well as spine frontal view for girls 1.93 / 3D = -0.45 (all negative score value). 2D method is used like controlling variables set in research.

The samples of 17 variables are the main method in research with “Contemplas 3D posture compact” variables recorded by following a precise protocol. According to the deviation result in correlation to vertical zero line, an displacement of the mean values for most variables is noticeable, which is making the situation in a researched groups worse, except for the thoracic part of the spine in sagittal plane, which according to the physiological curve in this part indicates that from the fifth to the eleventh year of age, number of children with kyphotic deviation is more than 50%. In addition to the status of the spine there is a very common in the shape deviation of legs in correlation to the zero line value, which is a noticeable bad result in children with compromised leg angle, thigh and lower part of leg with a noticeable incline towards valgus position, as well as the knee joint hyperextension.

Key words: Posture screening, Body deformities, Human pose estimation

Introduction

Contemporary civilisation is characterised by a specific lifestyle. From ecological and kinesiological perspective, living in cities is not a favourable circumstance. It is a generally known fact that young people still at an early adolescent age start accepting contemporary lifestyle imposed upon them. Contemporary life styles result in an increase of irregular body posture in children and youth. The problem of today is hypokinesia (decreased bodily movement) which leads to unbalanced development of certain muscle groups [1]. Deformities and the present illnesses- overweight and nervous tension are frequent occurrence among the children and youth, who use their free time for the activities which require little or no muscular effort [2]. Computerisation and the growing impact of internet have taken their toll on the health status of every individual. Childhood and adolescence has been recognised as the critical age for adopting and maintaining the habits of performing physical exercise [3].

Present generations live their lives in a virtual world which affects their health (mental and physical) negatively. Imagination and Virtual Reality is formulated so as to respond to the needs of mass application, it decreases the possibilities of personal creativity and separates an individual from real life and personal initiative by developing unified mentality stereotypes [4].

Posture is a descriptive term for the relative position of the body segments during rest or activity. The maintenance of good posture is a compromise between minimizing the load on the spine and minimizing the muscle work required [5]. Muscles of the leg, pelvis, abdomen and back along with bones, ankles and ligaments participate in maintaining proper posture. If the muscles are strong enough to overcome Earth’s gravitational force than the body will remain in the upright posi-
tion, however if the muscles are not strong enough one would experience fatigue and the body would relax. In regards to the aforementioned, positive impact of any physical activity along with other healthy life habits, first and foremost adequate nutrition should be promoted through the physical and health education classes in schools.

If one wants to significantly affect the anthropological dimensions of younger school-aged children it is necessary to select physical exercising modes characterised as general, and their application should run with optimum intensity [6].

The results of annual medical examinations indicate the unsatisfactory status, especially regarding the data attesting to the status of feet, spine, frequent bad posture and increasing percentage of overweight children. At the same time, expert analysis and the results of numerous numbers of research papers demonstrate growing preferences in children practicing sedentary way of life and lacking the habit of performing regular physical exercise. Skeletal system in this age, especially spine and feet demand special attention during education: straightening of the spine, insufficiently developed musculature, irregular sitting position in school benches, easily lead to premature deformations which should be treated on time [7, 8].

Human upright position is conditioned by maintaining constant balance between paravertebral muscles and gravity’s centripetal force. This game in maintaining the upright position during the human evolution has contributed to the following physiological characteristics: lordosis of the cervical and lumbar region of the spine and kyphosis in thoracic spine section. If these curvatures appear within physiological norms, they are considered regular feature, however if their increase or decrease is noticed, that is regarded to be abnormal [9].

Postural deformities are frequent in children and adolescents. In preschool and early school-aged children functional postural disorders are most common, while in adolescent age structural deformities of spinal column are a characteristic feature [10, 11]. The influence of internal and external factors the musculoskeletal system of children in development is susceptible to deformities. The most common deformities during children’s development are: kyphosis, scoliosis, lordosis, protuberant and sunken chest, flat feet, winged scapula, “x” (genua valga) and “o” (genua vara) legs.

During one’s lifetime there are three significant stages when different samples may lead to posture deformities: Pre-school stage – during the first year a child gradually takes the upright posture and forms physiological spinal curves. If this phase occurs earlier, postural deformity might occur. School stage – starting school a child undergoes great changes, spending a lot of time sitting, carrying heavy school bags may lead to posture deformities. Some of the factors which can contribute to postural disorders are: school bag which weights more than 10 % of child’s body weight, carrying school bags over one shoulder, irregularly placed schools bag, etc.

Connection between growth and progression of the spinal curve is the most common starting point when describing the occurrence and development of spinal abnormality. Between the ages of 5 and 10 when the growth slows down there is a less occurrence of postural problems, but when they enter the puberty stage, a rapid deterioration of existing postural characteristics is to be expected, along with the detection of new cases. Therefore, it is very important to detect postural problems and keep them under control in early years [12].

The aim of this work is to compare different posture status, recorded for 3D analysis, in regards to a relatively heterogeneous group of children with trend projection of physical deformities development between the ages of five and twelve.

**Methods**

**Sample**

Sample consisted of children from 5 to 11 years of age selected from kindergartens and primary schools located in Sarajevo Canton. The sample group comprised of n=480 boys and girls, recorded for 2D and 3D kinematic analyzes.

**Variable sample**

First group of variables used for the purposes of this research provide main information regarding the posture status, Contemplas 3D posture compact mode. Variable sample consists of 17 variables acquired by “3D posture compact” testing protocol. The parameters indicate possible offsets from the
zero posture value for all three levels, in which case the deviations of the neutral axis are expressed in centimetres and degrees. Higher values of provided displacements, whether negative or positive, represent the higher level of deformities in subjects.

### 3D Variables description:

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder displacement</td>
<td>Variable expressed in centimetres indicates elevation/depression of the left/right frontal plane. Results with the positive values are in regard to the right shoulder elevation, while the negative values indicate a left shoulder elevation.</td>
</tr>
<tr>
<td>Pelvic obliquity</td>
<td>Variable expressed in centimetres displays elevated/lowered left/right pelvic side in frontal plane. Results with positive values indicate the elevation of right pelvic side, and results with negative value indicate the elevation of left pelvic side.</td>
</tr>
<tr>
<td>Shoulder rotation</td>
<td>Variable expressed in degrees indicates the rotation in longitudinal axis (transversal plane) of the left/right shoulder. If the results are positive it indicates a rotation of the upper body in which case the right shoulder is placed forward, while negative results indicate a rotation of the upper body in which case the left shoulder is placed forward.</td>
</tr>
<tr>
<td>Pelvic rotation</td>
<td>Variable expressed in degrees indicates rotation in longitudinal axis (transversal plane) of the left/right pelvic side. If the results are positive it indicates the rotation in which case the right side of the pelvis is placed forward, while in negative results the rotation of the left side of the pelvis is placed forward.</td>
</tr>
<tr>
<td>Trochanter rotation</td>
<td>Variable expressed in degrees indicates rotation of the left/right tronchanter in longitudinal axis (transversal plane). If the result is positive it indicates the rotation of the lower body in which case the right side of pelvis is rotated towards front, while the negative results indicate the front rotation of the left side of pelvis.</td>
</tr>
<tr>
<td>Condylus rotation</td>
<td>Variable expressed in degrees indicates the knee rotation in longitudinal axis (transversal plane). If the results are positive, it indicates the front rotation of lateral condylus of the right leg, while the negative results indicate the front rotation of the left lateral condylus.</td>
</tr>
<tr>
<td>Malleolus rotation*</td>
<td>Variable expressed in degrees indicates the rotation of the axis which runs through malleolus of ankle joint. If the result is positive it indicates the front rotation of the lateral malleoulus of the right foot, while the negative result indicates the opposite rotation. *All the results are 0 according to proper screening position at the calibrated space.</td>
</tr>
<tr>
<td>Sag. Distance cervical spine – sacrum*</td>
<td>Variable expressed in centimetres indicates the distance of the most protruded cervical (neck) vertebra in regards to the vertical line projection of the sacrum (bone at the bottom of the spine) in sagittal plane. Positive result indicates the increased flexion of the cervical spine, while the negative results indicate the increased extension of the cervical spine.</td>
</tr>
<tr>
<td>Sag. Distance thoracic spine – sacrum*</td>
<td>Variable expressed in centimetres indicates the distance of the thoracic spine in regards to vertical line projections of the sacrum (bone at the bottom of the spine) in sagittal plane. Positive results indicate an increase of flexion in thoracic spine, while the negative results indicate an increase in other extension of the thoracic spine. *Higher values in the positive and negative offset do not apply for the variables “Sag. distance cervical, thoracic, lumbar – sacrum”</td>
</tr>
<tr>
<td>Sag. Distance lumbar spine – sacrum*</td>
<td>Variable expressed in centimetres indicates the distance of the lumbar (lower) spine in regards to the vertical line projection of sacrum (bone at the bottom of the spine) in sagittal plane. Positive result indicates an increase in lumbar spine flexion, while negative results indicate increase in the lumbar spine extension.</td>
</tr>
<tr>
<td>Varus/Valgus left</td>
<td>Variable expressed in degrees indicates the Varus-Valgus alignment angle of the left leg (medial/lateral) at the knee joint.</td>
</tr>
<tr>
<td>Varus/Valgus right</td>
<td>Variable expressed in degrees indicates the Varus/Valgus alignment angle of the right leg (medial/lateral) at the knee joint.</td>
</tr>
<tr>
<td>Flexion/Extension left</td>
<td>Variable expressed in degrees indicates the hyperextension and flexion of the left leg at the knee joint (sagittal plane). Positive result indicates the left leg flexion, while negative result indicates hyperextension of the left leg.</td>
</tr>
</tbody>
</table>
Second part of variables used for the purposes of this research provides secondary information regarding the posture status is 2D – one camera view variables for frontal and sagittal position. Posture status is estimated by modified method of lattice projection with 2D snapshots (one camera) and valorisation according modified Wolanski method graded form 1 to 5 negative score, measured displacements from “ideal” posture.

Body posture constitutes a motor habit that is typical for an individual. For that reason, it is difficult to specify only one pattern of body posture, especially if it is change through ontogeny. Researchers are still looking for a pattern of correct body posture, and the first typologies were introduced at the end of the 19th century [13]. At present, the size of physiological spinal curvatures, as well as abnormalities along the cephalocaudal axis, can be assessed by means of visual inspection, used as Wolanski method and improved by use of camera and added horizontal and vertical lines on screen. Testing protocol is modified for mobile laboratory assembled in those primary schools and kindergartens whose children were tested.

2D variables are:
- Head – one estimation by two views;
- Shoulders – one estimation by two views;
- Scapulas – one estimation by two views;
- Stomach – one estimation by two views;
- Chests – one estimation by two views;
- Spine frontal – one estimation by one view;
- Spine sagittal – one estimation by one view;
- Lorenz’s triangle asymmetry – one estimation by one view;
- Hips – one estimation by one view;
- Spine frontal in bend position – one estimation by one view;
- Legs frontal view – one estimation by one view;
- Foot status – estimation by foot print.

Testing protocol for 3D Contemplas compact mode

Mobile laboratory was assembled in those primary schools and kindergartens whose children were tested. In regards to the testing protocol the Contemplas testing equipment required and ideally flat surface. After acquiring an adequate surface Contemplas testing instrument was position on top of it and fixed to the surface so as to avoid displacement during children positioning and to avoid additional space calibration.

3D calibrator was placed on the surface with fluorescent markers attached to it. 3D Calibrator must be exactly placed in the centre of the measuring board (figure 1) and its upper and lower beams along with the vertical beam must be ideally aligned and levelled by the spirit level. The next step is to position a “V” frame supporting three cameras enabling 3D analysis. The camera’s distance from the centre of the measuring board must be at least 2 metres and 15 centimetres (figure 2).

Next is the preparation and placement of fluorescent spherical markers (3D) and point markers (2D) on the subjects. Markers are placed on specific points of the subject’s body which only need to wear their underwear. Considering that this testing protocol was the one specified by the „3D Posture Compact“, it was necessary to apply 14 markers for each subject (figure 3).
The following represent the body points of marker placement: acromion (left and right), cervical spine, thoracic spine (kyphosis), lumbar spine (lordosis), crista iliaca posterior superior (left and right), sacrum, trochanter major (left and right), condylus lateralis (left and right), malleolus lateralis (left and right). The subject is placed on the measurement board so as to have his/her back to the cameras, with feet placed parallel and in hip width apart, where the axis along the centre of the malleolus must be paralleled with the horizontal line at the measuring board (frontal plane). One can emphasise that the removal of ambiguous 3D poses related to a single image is the main focus of posture analyses [14]. The process of assembly and testing instrument calibration is repeated every time the location is changed, specifically with each new schools and kindergarten where the testing is to take place.

Data analysis method

Results were processed in „SPSS 22“ software package. Descriptive indicators were calculated for the separated groups 2D boys and 2D girls as well as 3D boys and 3D girls. In order to determine the difference of each variable for the observed children groups, ANOVA test was applied,
according the different methods in posture screening. At the final was calculated a mean value for all 480 kids in 2D as well as 3D screening, so the results can be compared.

Results

Each group is assigned with an individual mean value of results. The parameters indicate a posture image offset from zero value for which purposes the horizontal, vertical and rotational offsets represented in centimetres were valorised and illustrated in degrees as offsets from the neutral axes in the observed plane. Considering frontal plane only, analysis reveals no differences between groups but ‘3D deformity’. On the contrary, transversal plane analysis, which combines sagittal and frontal information, delivers more relevant information than only an analysis of sagittal plane [15].

Higher negative and positive offset values assume a higher degree of deformities in subjects given by 2D and 3D screening. The samples of 12 variables are 2D – one camera view for frontal and sagittal position, calculates higher mean values for variables: legs frontal 2.88 / 3D =1.51, Lorenz’s triangle asymmetry 1.85 / 3D = -1.49 and shoulders displacements 1.83 / 3D = -0.79 as well as spine frontal view for girls 1.93 / 3D = -0.45 (all negative score value).

The sagittal values are conditioned by the physiological curves of the cervical, thoracic and lumbar spine in regards to the distance from the most protruded part of the sacrum. Results for this posture are observed separately along with the designated criteria attesting to the spinal status in sagittal plane. According to the statistical result analysis, a status of physical deformities facts was projected for children between the ages of five and eleven. Concerning the identifiable indicators „0“ vertical line offsets for all segments are in regards to the frontal plane.

Discussion

Analyses of offsets and rotations which are expressed in centimetres for offsets and degrees for rotations, did not reveal high degree result if compared to the physical height of the subjects. In the screening records all the segments include offsets, indicating that all the kids have offsets in relation to the proper posture status.

Entire research was conducted focusing on the spinal column and leg status of the subjects, for that reason the results emphasize the frontal and sagittal perception of the spine. If we follow the increase trend of zero vertical offset, the increase of mean values is noticeable for all the variables, apart from sagittal perspective of the thoracic spine, which according to physiological curve in that spinal section indicates that the number of children with kyphotic offset between the ages of five and eleven is more than 50%. The Scoliosis Research Society has recommended annual screening of all children age 10–14 years; the American Academy of Orthopaedic Surgeons has recommended screening girls at the ages of 11 and 13 years and boys age 13 or 14; and the American Academy of Paediatrics has recommended routine screening at ages 10, 12, 14, and 16 years. The Bright Futures guidelines recommend noting the presence of scoliosis during the physical examination of adolescents and children who are at least 8-years-old [16]. This research was conducted with children of younger age (5 – 11 years) since in their case it is possible to greatly affect the postural status corrections. The calculated trend projection of postural deformities development increases as the subjects are older, regardless of the growth of negative or positive offset values in regards to zero values. The analysis results regarding the scoliosis of the spinal column are particularly important. Scoliosis is a complex three-dimensional (3D) deformation of the spine and rib cage that produces cosmetic asymmetries of the trunk, which represent the main complaints of patients [17]. Apart from the spinal column status, there is a significant offset increase in regards to zero value of leg shape, with an big number of subjects with a disturbed relationship angle between upper leg and lower leg, in which case there is an incline towards the valgus position, as well as hyperextension in the knee joint. Children with such diagnosis have potential difficulties when walking and that segment is very important for the overall postural analysis. Scoliosis patients and patients with valgus legs deformities showed significant but slight modifications in gait, even in cases of mild scoliosis. With the naked eye, one could not see any difference from controls, but with powerful gait analysis technology, the pelvic frontal motion (right–left tilting) was reduced, as was the motion in the hips and shoulder. [18].
Once the matrix consisting of all research data was created, it became evident that the applied testing protocol consisting of computer outputs if reversed for the purposes of explaining someone’s posture status excluding specific physical deformities by data valorisation, would not produce a precise insight in all the deformities from the sagittal perspective. For that reason 3D result outputs consisting of rotations and offsets were discussed along with necessary insight into the posture result imagery, clustered as numerical data. That is the reason for rescreening using 2D protocol in exact calibrated space with different data valorisation.

Conclusion

It is evident that the result projection of body deformities status is significant for the parameters of the spinal column results in relations to scoliosis, kyphosis and lordosis with a big number in offset from the “proper” posture for children 5-11 years of age. In addition, such score was recorded for the angle status of upper leg in relation to the lower leg, reflecting in big number of children with “x” legs. When a child/parents, starts attending first to fifth grade primary school his/her posture status can become a bad posture status.

Therefore, the scientific contribution of the research conducted in Sarajevo schools and kindergartens made possible due to European Commission funding, is reflected in the possibility of clear and concise physical deformity valorisation, assisted by modern kinematic 2D and 3D procedures with the purpose of designing the total results matrix indicating the postural status of the assigned population. The possibility of future predicting the deformity occurrence trend, represent the baseline for gaining direct benefits in a form of potential, individual programmes for treating or decreasing registered physical deformities. Application of technological solution for assessing the posture status (“Contemplas 3D posture compact” and ”Modified Wolanski 2D screening”), for examines is extremely adequate for obtaining the individual analysis results which will serve as a baseline for planning and programming corrective procedures for the purpose of treating and decreasing physical deformities. More data is offered by 3D screening and more precise is measuring in one plane of recording at the time.

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Abstract

The Aladza Mosque in Foca was built in the middle of the sixteenth century and it was destroyed during the war in Bosnia and Herzegovina. Considering that it is a monument protected by the state and included in the World Heritage by UNESCO, it is necessary to carry out its rehabilitation. It is essential to construct this religious building of the same materials, dimensions and exterior form.

With the destruction of the object in its entirety, there has been damage to some original stone fragments that the mosque was built of. Therefore, it is necessary to provide new supplies of the stone matching the original.

For the purpose of examining new borrow pits of the stone, it was necessary to determine mineralogical-petrological and geomechanical properties of the original fragments. All stone types built in the former Aladza Mosque were examined thus providing the guidelines for the investigation of new borrow pits.

Key words: the Aladza Mosque, original stone fragments, mineralogical – petrological analyses

1. Introduction

The Aladza Mosque in Foca was built in the middle of the sixteenth century and belongs to the category of objects of cultural heritage of Bosnia and Herzegovina. The mosque has been included in the World Heritage List by UNESCO. It is characterized by an Ottoman style of the construction that was later reflected in building of new mosques. It was built of materials resistant to the passage of time, and a manner of the construction and settings of the structure are interesting even for contemporary builders.

During the war in Bosnia and Herzegovina this religion building was demolished whereby a part of its construction material was damaged, part missing and the most of it remained close to the object.

Initiation of the activities on rehabilitation of the Aladza Mosque required the assessment of an actual situation in the field. The object was built of several types of rocks applying specific methods for foundation and construction. Within preparatory works, a listing of all types of original fragments of stones located near the mosque was made. It was followed by a conclusion that a certain part of material needed for the construction of the object in its previous form, was missing.

In order to be able to search for borrow pits in immediate vicinity, all types of stones built in the Aladza Mosque [1, 2] were tested.

Mineralogical-petrological and geomechanical properties were determined, which presented a basis for exploration of new stone deposits.

2. Review of original fragments – stones at the site of the mosque

The presence of original fragments of the structure elements provided the opportunity to overview their characteristics starting from mineralogical-petrographic to physical-mechanical properties.

Six (6) original samples were selected from typical structural elements for the purpose of laboratory examination of mineralogical-petrographic to physical-mechanical properties.

Six (6) original samples were selected from typical structural elements for the purpose of laboratory examination of mineralogical-petrographic to physical-mechanical properties, Table 1. The appearance of samples is given in Figure 1.

Samples were transported to the laboratory of the Technical Institute Bijeljina for determination of physical-mechanical properties. Part of the original fragments samples was sent to the Faculty of Mining and Geology in Belgrade for determination of mineralogical-petrographic properties.
Table 1. Sites where original samples were taken

<table>
<thead>
<tr>
<th>No.</th>
<th>Sample label</th>
<th>Structural element of the building</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>T – 1</td>
<td>Minaret</td>
</tr>
<tr>
<td>2</td>
<td>T – 2</td>
<td>Wall</td>
</tr>
<tr>
<td>3</td>
<td>T – 3</td>
<td>Wall</td>
</tr>
<tr>
<td>4</td>
<td>T – 4</td>
<td>Foundation</td>
</tr>
<tr>
<td>5</td>
<td>T – 5</td>
<td>Minaret</td>
</tr>
<tr>
<td>6</td>
<td>T – 6</td>
<td>Corona</td>
</tr>
</tbody>
</table>

Figure 1. Original samples taken from the site

Mineralogical – petrographic investigations included:
- Macroscopic examinations with the use of magnifier, cold and diluted (1:3) hydrochloric acid and photographing
- Microscopic examinations of petrographic items prepared by using polarized microscope for passed light, type Leica DMLSP, with a digital camera Leica DC 300 and a software Leica IM 50, thus enabling the image to be displayed on a monitor and photographing of the samples too[3].

All samples were previously photographed, and photos were taken also during the microscopic examinations. Their appearance is shown in figures 2 and 3.

Figure 2. Appearance of the samples observed macroscopically

Figure 3. Appearance of the samples observed microscopically

Macroscopic examination defined the external appearance of each rock noticing the color, structure and texture, degree of homogeneity, the presence of porosity and reaction to HCl [4]. Microscopic examinations have more clearly defined the presence of particular minerals, their crystal-line form, the presence of porosity in a certain percentage as well as large pores, possible presence of various oxides and hydroxides occurring in different colors [2]. Results of the examinations are presented in Table 2.

Table 2. Results of laboratory testing of rock samples

<table>
<thead>
<tr>
<th>No.</th>
<th>Sample label</th>
<th>Structural element of the building</th>
<th>The name of the rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>T – 1</td>
<td>minaret</td>
<td>limestone</td>
</tr>
<tr>
<td>2</td>
<td>T – 2</td>
<td>wall</td>
<td>tufa</td>
</tr>
<tr>
<td>3</td>
<td>T – 3</td>
<td>wall</td>
<td>tufa</td>
</tr>
<tr>
<td>4</td>
<td>T – 4</td>
<td>foundation</td>
<td>micritic organogenic limestone</td>
</tr>
<tr>
<td>5</td>
<td>T – 5</td>
<td>minaret</td>
<td>micritic limestone</td>
</tr>
<tr>
<td>6</td>
<td>T – 6</td>
<td>corona</td>
<td>micritic limestone</td>
</tr>
</tbody>
</table>
Physical-mechanical examinations were carried out with the same samples, Figure 4.

Figure 4. Samples prepared for laboratory testing

Results of the examination of mineralogical-petrographic and physical-mechanical properties of rocks are presented in Table 3.

Table 3. Mineralogical-petrographic and physical-mechanical properties of rocks

<table>
<thead>
<tr>
<th>Sample label</th>
<th>Structural element</th>
<th>Mineralogical-petrographic provision</th>
<th>Volumetric weight</th>
<th>Water absorption</th>
<th>Uniaxial compressive strength</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>with pores $\gamma_s$</td>
<td>with no pores $\gamma_s$</td>
<td>$u_v$</td>
</tr>
<tr>
<td>T – 1</td>
<td>minaret</td>
<td>limestone</td>
<td>27.77</td>
<td>29.20</td>
<td>5.02</td>
</tr>
<tr>
<td>T – 2</td>
<td>wall</td>
<td>tufa-travertine</td>
<td>17.80</td>
<td>20.05</td>
<td>5.02</td>
</tr>
<tr>
<td>T – 3</td>
<td>wall</td>
<td>tufa-travertine</td>
<td>17.10</td>
<td>20.01</td>
<td>17.10</td>
</tr>
<tr>
<td>T – 4</td>
<td>foundation</td>
<td>micritic organogenic limestone</td>
<td>34.10</td>
<td>34.15</td>
<td>0.19</td>
</tr>
<tr>
<td>T – 5</td>
<td>minaret</td>
<td>micritic limestone</td>
<td>25.10</td>
<td>26.10</td>
<td>7.57</td>
</tr>
<tr>
<td>T – 6</td>
<td>corona</td>
<td>micritic limestone</td>
<td>28.20</td>
<td>29.60</td>
<td>4.97</td>
</tr>
</tbody>
</table>

Based on the field investigation of samples and laboratory testing of mineralogical, petrographic [5, 6], and physical-mechanical properties of original fragments [7, 8], types of rocks used for the mosque construction were determined.

**Sample no. T – 1 – Minaret**

It is an ocher-colored rock of crystalline structure and massive texture.

Macroscopically, the rock mass shows a large degree of homogeneity and is made up of grains of relatively uniform size. The structure of the rock comprises calcite that expresses anisotropy and is present in crystalline forms that are, by their size, between the grains of micrite and sparite characteristics. Aggregations of fine grains of iron hydroxides and oxides are noticed. Significant place in the rock structure is taken by the porosity; pores occupy up to 30%. According to the characteristics of the complex and mineral composition, investigated rock is limestone.

**Sample no. T – 2 – The wall**

It is a light-ocher-colored rock, of cryptocrystalline structure and porous texture. It is characterized by the presence of numerous caverns of irregular shapes and various dimensions. It is built of aggregates of cryptocrystalline to microcrystalline calcite. Some of them are of tabular form with a diameter up to 1 mm. Coarser crystals clearly express pseudopolychroism and traces of two cleavages. A clastic form in the shape of isolated grains is rarely observed. Rock porosity is up to 45% and the size of pores fluctuates widely from submillimeters dimensions to the cavities whose length reaches 2-3 cm. Banded structure of calcite aggregates can be noticed around individual cavities due to different grain sizes in some areas. Hydroxide and oxide membranes of iron often occur on the edges of cavities. According to the characteristics of the complex and mineral composition, the examined rock is tufa – travertine [9, 10].

**Sample no. T – 3 – Wall**

According to its macroscopic characteristics, the sample is very similar to the sample no. T–2. The rock is of light ochercolor, cryptocrystalline structure and highly porous texture. It is built of calcite and has more distinctive stripes wedging
out and coating the cavities than the sample T–2. In accordance with the properties of the complex and its mineral composition, the examined rock is tufa-travertine.

Sample T – 4 – Foundation

The rock is grey, having crystalline structure and massive texture. The composition comprises micritic calcite components, fossil remains and crystalline calcites. Cracks that extend in two directions are present, containing deposited coarse-grained calcite. The rock mass contain tiny brown dolomite crystals of less than 0.1 mm in diameter, then sections of different types of microorganisms shells. Properties of this complex reveal that the examined rock is micriticorganogenic limestone.

Sample no. T – 5 – Minaret

The rock is of grey-ocher color, crystalline structure and massive homogeneous texture, and appears homogeneous in color and the size of ingredients. According to its microscopic properties the rock resembles the sample T–1, it is built of micritic calcite of uniform size and porosity. In accordance with the properties of the complex and its mineral composition, the examined rock is a micritic limestone.

Sample no. T – 6 – Corona

The sample highly resembles the sample no. T–1. The rock is ocher, of crystalline structure and massive texture, homogeneous with slightly observable elements of banded texture, cryptocrystalline structure and porous texture. The bas of the rock is presented by micritic component with tiny pores that are less common. Properties of the compound and its mineral composition show that the examined rock is a micritic limestone.

3. Discussion

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
  - micriticorganogenic limestone, used for the foundation.

For these type of rocks it was necessary to find smaller deposits in immediate vicinity, in order to build the object entirely of stones which had previously been used for its construction. Detailed investigation of the field were performed in the surrounding and a number of rock samples matching the original fragments were analysed. Considering that the quantity of rocks needed for the completion of the construction of the mosque is small, only samples approachable for the exploitation were analysed, namely the places where the exploitation can be carried out without special preparations. In order to provide the most original fragments, additional investigation of rock characteristics will be performed during the exploitation phase, that is the selection of certain parts of rocks for the construction.

4. Conclusion

Investigation of original fragments – stones at the location of destroyed Aladza Mosque in Foca were carried out in order to determine their mineralogical – petrological and geomechanical properties. By these investigations, it was observed that for the construction of previous object two types of rocks were used. These are: tufa–travertine and limestone of different varieties.
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Abstract

One of the most important moments of the total economic reforms in the Republic of Serbia is based on the privatization process of the social and state capital and assets. The main objectives of the privatization as the major reform process have been set as the targeted increase in the overall business efficiency and competitiveness of the economy, as well as the harmonization of its structure to the world market condition.

Instead of the private property, as was clearly ungroundedly expected in the concrete case, showing all of its references in the field of supposed benefits over the social and state capital through the ownership transformation, in Serbia, it resulted in the drastic reduction in production, the shutting down of a large number of business entities, constantly rising unemployment, the culmination of the worker discontent expressed through strikes and road blockades, the violation of the basic rights of the employees, growing poverty, which is just the opposite of the set objectives of this entire transition process.

Objectively perceived, the complete failure of the privatization in Serbia, among other things, is reflected in a large number of terminations of the sales contracts in order to abuse and disrespect the assumed obligations; in the fact that the primary goal of the investor – buyer in the privatization was most commonly to obtain the ownership over the construction land and buildings for their future resale; in the shutting down of the mass production, even in those fields where it had the sustainable potential; in a great number of strikes in the privatized enterprises; in the fact that the restructuring of business entities in the privatization process for the purpose of the obstruction of the processes lasts for unreasonably long time followed by great abuse, which shows that the privatization was not, nor it ever will be “a magic machine for creating profit, driven by an invisible hand of the market as its regulator”, and therefore there is no doubt that the privatization will not lead to the increase in efficiency of the existing companies, because many of them “the rescuers” did not manage, nor they ever will, to rescue.

Therefore, the change in ownership or the ownership transformation has never been the precondition for it. It is just a nicely packed phrase that was supposed to, and it did, seduce those who doubted in the beautifully packed concept, which was only supposed to enable the speculative capital and speculators as its owners to provide an opportunity and unobstructed path to what they wanted, and what they wanted was not the social prosperity and economic growth, but the assets and their personal enrichment as the main goal of the neoliberal concept.

Key words: privatization, restructuring, social and state companies, bankruptcy proceedings, strikes and social problems, unemployment etc.

Introduction

One of the basic characteristic of the present stage of the privatization process in the Republic of Serbia is that it is only relatively successful, which is primarily related to the observed period (from 2001 to 2011), because this privatization period has not taken place in the negative conditions of the war and sanctions, but in the period of the full international support and according to the internationally accepted model and principles.

The private property in Serbia, instead of showing its advantage over the social and state property through the privatization, due to the manner of its implementation, resulted in the decrease of
the production, shutting down of a large number of the enterprises, rising unemployment, violation of the fundamental rights of the employees and increasing poverty, and all this against the objectives set in the process. [1]

The failure of the privatization in Serbia, among other things, is reflected in a large number of the termination of the sales contracts (until the mid 2011 26% of the total number with the tendency to grow further); the fact that the goal of the buyer in the privatization process was to obtain the ownership over the construction land and facilities for the purpose of their future sale and use for the purposes that have nothing to do with the activities of the privatized enterprise (rather than the further development of the existing production); the fact that the revenues of the state, more correctly, the filling of the state budget was the primary objective of meeting the uncontrolled current spending (rather than the overall economic development and investment); the fact that the restructuring of business entities in the privatization process takes a long time and is done with great abuses; in the existence of a great number of business entities which, even after more attempts to privatize, did not find the strategic investors and therefore have entered the bankruptcy proceedings etc.

After a long period of a complete domination of the social ownership, the privatization process in Serbia was initiated by the adoption of the federal Law on Social Capital of SFR Yugoslavia in 1989. That process was then slowed down by adverse economic and financial conditions as well as the unfavorable political and legal situation in the country together with the institutional constraints.

There were numerous laws that relate to this area as well as the concrete projects that were guided according to the mentioned laws. The laws have changed, allegedly for the best, but no major fundamental reconstruction of the domestic economy and organizational and technological restructuring in the direction of health and efficient market economy have been realized.

The Law on Privatization under which the privatization process is implemented in Serbia today promotes the model according to which up to 70% of the social capital is sold through public bidding of the potential buyers (public tender) or through the public auctions in accordance with the specific terms and conditions of sale, and the rest is freely shared among the employees and citizens. [2]

The process is designed in such a way that it secures the new majority owners of the social property making them by definition the ones who possess the interest, knowledge and the capital to constantly improve their business enterprises. In case there are no interested buyers (due to the poor financial situation and insolvency of the company, or a large number of subsidiaries and employees) the enterprise shall be first restructured in the privatization process (statutory, more correctly organizational changes, will be carried out, the alignment of the debtor – creditor relations will happen and so on), and then it will be brought into a situation in which it can be strategically privatized. [3]

One year after the current Law on Privatization started to be implemented only 15 enterprises were sold. That was the reason why already the next year, 2002, some corrections were carried out for the purpose of speeding up the privatization, primarily through the changes and amendments of the Regulation on the auction sale (3 times), then through the changes and amendments of the Law itself (2 times), the amendments of the Regulation on tender sale (3 times) and the adoption of the new regulations on the procedure and the method of restructuring process and the sale of the capital by using the method of the public auction, as well as adjusting other legislation (Law on Business organizations, Law on Securities Market, Law on the Takeover of Joint Stock Companies etc.). As the number of privatized enterprises under the new law at one point reached the enviable figure of over 2 000, the public attention focused on the activities in them after the changes in the ownership. [4]

1. Strikes and social problems as a consequence of the applied model of the privatization

Based on the data obtained from the Union of Autonomous Trade Unions of Serbia, in strike or protest in the Republic of Serbia, in August of 2009 were 49 enterprises which employ over 20,000 employees. The reasons for strike are interconnected. If the employees do not get their salaries, they are not paid the contributions for the social insurance as well. This situation, in most cases, is followed
by the bad implementation of the products on the market, the lack of production, the bad privatization etc. As far the most common reason for strikes is that the owners of the company do not pay salaries to their employees (36 companies, or 73% of cases). The second place belongs to the bad privatization process, lack of the implementation of the sales contracts (5 companies), and then comes the failure to implement the legal rights of the employees in the social program (2 companies). The other reasons are the unpaid taxes and contributions, the issue of security and safety at work, the issue of wages etc. (per 1 case of the listed companies).

In the early 2001, the Government of the Republic of Serbia has launched a comprehensive reform program which was aimed at the restructuring the economy, the privatization of the enterprises, with the goal to increase the competitiveness and income opportunities of the economy. In the privatization process, among other things, there was a change of the structure of economy of the Republic of Serbia.

As a result of the strikes, the bad privatization and the bankruptcy in the real sector, there happened significant layoffs. Only in the period from 2001 to 2008, the number of job opportunities decreased for 400 841 job positions. At the same time, the number of job opportunities in the areas of insurance, pension funds and other intermediary positions, real estate and renting positions, administration and social security, education, community, social and personal services increased. In these services the number of employees has increased by 82 567. If we correlate 1 999 476 employees in 2008 to 2 101 668 employees in 2001, we see that the decrease of job opportunities is 102 192 which is 4,9%, and that is a relatively acceptable price of the restructuring and transition. However, the analyses show that the real sector is practically missing 400 000 employees and the Republic of Serbia has become considerably de-industrialized. On the other hand, all of the fired employees, due to the restrictive policies of the employers on the admission of the employees, their age, qualifications and other factors, in most cases are not able to find a new job.

The percentage of the unemployed of persons aged 55 to 64 years, was 7,4% in 2008, while in 2009 it increased to 9,1%. When it comes to persons aged 45 to 55 years, the percentage of unemployed rose from 19,6% in 2008, to 20,9% in 2009 and 2010”, while the ungrounded economy, according to the official statistics hires 18,2% of the working – age population, and according to the estimates this informal economy accounts for 35% of GDP.\footnote{This is a fairly high share of the ungrounded economy in GDP when compared to any other EU country.}

The metal industry of Serbia has lost 90 000 of its employees. The textile industry has more than halved the number of employees and has remained without more than 66 000 of employees, while the agricultural industry has lost a third of its staff (over 62 000 of employees), even though the agriculture together with tourism and transport should be one of the main sectors of development. Some of the reduction of the number of employees in the certain industries and sectors may be justified to some extent by the fact that it had led to an increase of the competitiveness of our economy in the world market, i.e. that we have achieved a wider range of goods and services that we offer in a particular class of the market quality, or by the price competitiveness.

In the textile industry, “Sintelon” (which was privatized before 2001 by insider model together with a couple of other companies) is competitive. The textile industry is practically decimated, with the exception of a few examples which are on the edge of poverty.

Numerous enterprises which had a brand in the food industry no longer exist in their production capacities. In contrast, 221 000 people are employed as entrepreneurs in their stores. However, the range of their services and products simply cannot offer a high-quality and a stable export potential considering the fact that they are not related to the structure of a strong industry. Amongst the activities which are represented the most with the private entrepreneurs, trade with small shops and services of repair and maintenance dominates (45%), then comes the private catering industry (11%), the production of food and beverages (7,4%), the construction industry (9,5%), activities related to renting and brokerage of the real estate (5,6%) etc. Thus, the majority of services that are offered through these activities are on the local level, intended for the narrow local market and they do not represent any expansion potential that
can balance the negative balance of foreign exchange, nor can it compensate for the import and export performances and the dynamic increase of the declining GDP.

Revenues generated from the privatization are spent within the public sector, as illustrated by the fact that the administration has grown disproportionately as compared to the other sectors, although each consecutive government shows new data about alleged reduction of the number of employees in the public administration, while the actual situation is exactly the opposite.

The development which is primarily composed to rest on the services sector, in the particular constellation of factors, can be the solution for Belgrade, Novi Sad or some other area that possesses the potential for highly educated and professional staff, technological resources etc., but for the most part of Serbia that is not the solution because the process of the constant deindustrialization has affected the areas of Serbia which are out of the listed cities.

Despite some methodological difficulties to accurately determine the change of the number of employees by regions in terms of consequences of the implementation of the privatization process (because the State Institute of Statistics and Informatics conducted the amendments of the covered set of employees in the period between 2000 and 2003), it is certain that, when it comes to layoffs, the most affected areas are the area of the Bor district – Bor, Kladovo, Majdanpek, Negotin, where the number of employees in the enterprises, institutions and other organizations decreased by 37.6%; the Toplica region – Blace, Žitorađa, Kuršumlija, Prokuplje, where the number of employees in the enterprises, institutions and other organizations decreased by 36.7%; the Jablanica region – Bojnik, Vlasotince, Lebane, Leskovac, Medveda, Crna Trava, where the number of employees in the enterprises, institutions and other organizations decreased by 35.9%; the Mačvanski – Pčinjski, Mačvanski, Srednje – banatski, Nišavski, Sremski, Pirotski and Zapadno – bački districts, which is a consequence of the privatization and the persistent strikes and confrontations of the new owners and the employees in the privatized enterprises.

In 2007, the relationship between the most and the least developed districts in Serbia, according to the actual employment rates was 4:1. The unemployment rate higher than the national average has been recorded in Toplica and Jablanica districts, then come Pčinjski, Mačvanski, Srednje – banatski, Nišavski, Sremski, Pirotski and Zapadno – bački districts, which is a consequence of the privatization and the persistent strikes and confrontations of the new owners and the employees in the privatized enterprises.

The mere fact that the Decision on the maximum number of employees in the public administration has been alternated and amended 20 times in the period of one year [5], each time moving the number upwards without it being presented to the public, clearly shows the attitude of the government towards the citizens and their irresponsible behavior in the given situation. However, the fact that the IMF did not warn the government, even though it was the IMF’s demand to do so as an excuse for savings and reduction of the state administration, clearly shows that the real reason for the above mentioned actions of the government lies elsewhere. This situation still favors only the brain drain and the trend that a large number of highly qualified staff continuously leaves the country and offer and realize their potential in some other countries, so this is some kind of a conscious professional depopulation, because of which we are according to the WEF at the 4th place in the world [6].
and Kosovska – Pomoravski district, where, according to unofficial data one can reach, the unemployment rate is around or over 80%.

Of the total number of districts on the territory of the Republic of Serbia (without Kosovo and Metohija), in 22 administrative districts, the unemployment rate is from 25% to 50.8%, while only in two administrative districts out of 25, the unemployment rate is 20.2% and 14%.²

2. The politicization of the poor results of the privatization (false presenting of the effects of the privatization for the sake of political success)

Simply put, nowadays even the employees in the privatization subjects perceive the privatization as something they cannot see their benefit in, but they feel they are losing and this syndrome is slowly and inhumanely transferred to the state administration, which, instead of being defined as a professional and expert entity, is defined by party affiliations at all levels of working places, starting from the unskilled workers all the way to the management.

This ensures that the people who implement the privatization need to ask themselves what the perception of this process is, not only by the IMF and the World Bank or some other international organization, but also by the citizens, employees, voters – if they are not guaranteed their legitimate interests, such as the right to work, family and offspring.

This poses the question of uncertainty and risk of where this political process will lead Serbia in the near and distant future. Despite all this, as well as the objections of some analysts that so far the privatization has served only for filling the state budget for consumption, that there are many irregularities in the implementation of the privatization processes and that there are no adequate mechanisms of its control, it would be wrong to “demolish everything that was done and start from the beginning”. The effort should be devoted to the correction of the fundamental errors and further affirmation of the elements necessary for the creation of the efficient market economy.

The problem is that this type of the privatization is presented as successful and of a good quality, so it is logical to raise the question: Why somebody does not explain the paradox of presenting our privatization as successful to such an extent that the world admires us, while its results are surprising?

The presented results can point to the urgent need to understand the importance of a quality implementation of the privatization process and the necessity of timely and active involvement of all social partners, including trade unions, so that the Republic of Serbia does not enter deeper into the vortex of a non–refundable process. The privatization model that is being implemented in Serbia has long been on the spotlight of experts. In scientific circles the disadvantages of this privatization process have been described and the possible solutions have been offered, but not in life nor in politics there are consequences of such explanations. The privatization is thus carried out consistently, faster or slower, but with the consequences which look like the result of the deliberate strategy for the destruction of the Serbian economy and society. “The privatization in Serbia was carried out in such a way that the companies were often sold to the owners with suspicious capital and insufficient business competencies.”

“In sight of all of us ‘the development model’ in Serbia predominantly referred to the opening of banks, shopping malls, sports betting and the construction of the luxury offices and residential buildings” so in our structure of the gross added value, almost 60% comes from the services, and only 29% from the industry and construction.

From the beginning of the implementation of the current privatization concept, it has been recommended that the model of the privatization should continue on diversifying and that some alternative models should be included in order to speed up the process and decentralize it. That did not happen but the model of sales continued to be used, so the question is whether it was better to move onto some decentralized model of the privatization by which the employees, and partly the citizens, would become the owners of the shares [8]. That
would allow the recovery of the companies or the further sale or liquidation if there were no other solutions. The strategic partnership (proclaimed but very rarely realized), the corporate ownership, consortium ownership, cooperatives or various other models of participation and co-management could be the alternative – but they are not enabled, so this, among other things, causes the strikes and destruction of the companies because of the bleak perspective of the employees.

The creators of the current situation in Serbia still do not hesitate to praise their activities. A few years ago the representatives of one consulting company organized a panel discussion titled “The privatization or the nationalization” and assessed that in Serbia “the attitude towards the privatization is the same as in 1948”. Among other things, the director of that company boasted that his company, over the past eight years, has taken part in the privatization processes whose transaction value in Serbia was eight billion Euros and that he was the most frequent advisor of the state and the greatest buyers of the Serbian companies [9]. *Thus, during the sale it is not important how much the company is worth, it is important to sell the company, even for one Euro only*. Finally, if there has to exist a monopoly company, then it should be a private company [10]. It is clear that this leads to conflict, chaos and strikes, and then into the spiral of problems that usually end in agony of the bankruptcy proceedings.

The bad ratio of the number of employees, about 1.8 million, and the number of pensioners, about 1.6 million should be pointed out. This ratio shows that “Serbia enters the dangerous zone of equalizing the number of employees and pensioners.” This trend, if compared to blood pressure, clearly shows that when these numbers equalize it will result in collapse or a fatal outcome for the system [11].

**Conclusion**

Having in mind what the privatization process implies and what has been done so far, the overall results suggest that the privatization process is still far from over and that the privatization in Serbia has not given anywhere near expected results, on the contrary. From the stated, it is clear that the privatization is not “a magic machine for making profit” and that it will not lead to higher efficiency of all the existing companies – because many of them “the rescuers” did not manage, or will not manage to rescue.

The perception of the overall situation of employees in the companies after the privatization process is quite black. The discrepancy between the expected goals, i.e. the proclaimed principles of the socially acceptable transitions mover and the really achieved results is clearly visible, with the exception of a couple of rare instances where the positive effects have been achieved. The social picture of people affected by poor results of the privatization is grim and the growing dissatisfaction culminates in strikes and protests. All the governments of the Republic of Serbia from 2001 onwards have been faced with strikes, blockades of the roads and public protests due to all the possible reasons the privatization has caused.

The experience of other countries was obviously not a warning enough for us. Those who should not possibly, still forget that the privatization is not solely an economic matter, but that it is always the socio-political thing, and that the story that the negative consequences in that process do not exist is simply not correct, nor that there is an example in which it is so. This is best illustrated by many years of unemployment statistics which is even worse than it seems at first sight, because it does not encompass the statistic data about the unemployment for the Kosovo, Peća, Prizren, Kosovsko – Mitrovicki and Kosovsko – Pomoravski district, in which virtually the unemployment is 80%. *Without hesitation this can be called the catastrophic scale of unemployment and poverty which is predominantly caused by unemployment.*

Unlike many, who at the beginning of the privatization thought it was an easy and simple process, it is certain that today a small number of people would agree with such a reckless statement. Time has shown that the privatization is very expensive and that it inevitably leads to the reduction of labor rights, increased unemployment, social insecurity, and not only in our country, and the gloomy results and not so bright economic future raise the question whether there is potential in our society to go out of the economic and social collapse. Unless some concrete steps are undertaken in order to resolve the resulting economic problems caused
by the privatization, the further culmination of the social unrest and discontent is simply inevitable.

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6. WEF World economic forum.


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Abstract

Body composition plays a very important role for the competition success. Elite Karate athletes are characterized as ectomorph and mesomorph somatotypes with a low level of adipose tissue, while the morphological profile of young female athletes is unknown to authors. The research was conducted on a sample of nineteen (n = 19) female subjects (mean value ± SD: height 160.21 ± 10.34 cm; weight 52.67 ± 12.53 kg; age 13.74 ± 2.42 yrs.). High level of correlation with the OSI was detected at a level of significance (p < 0.05) for all the body composition variables including the APSI (p < 0.05), however excluding the body height. MLSI variable indicated the correlation between all body composition variables (p < 0.05) apart from FatMass%, TBWkg and BMI. One can conclude that all the changes in body composition contribute to the change in postural stability. Negative influence on postural balance is indicated by almost all variables, i.e. the increase of each variable distorts overall stability segments. Total water amount is characterized as positive influence in the increase of postural stability. An increase in any of the body composition elements leads to impaired postural balance in young female karate athletes.

Key words: balance, morphology, subcutaneous adipose tissue.

Introduction

Karate is traditionally characterized as a complex composition of martial arts and Budo philosophy of life. Karate is dominated by wide stances with low center of gravity, explosive hand and leg techniques, and explosive movements with opened kinetic chain. Karate contributes to the development of body functions, motor abilities, as well as to controlling the mental abilities [1].

Karate is the sport classified in accordance to the weight categories.

High level of energy expenditure during Karate trainings and sparrings can induce changes in basic body composition parameters [2], regarding the fact that the 78% of produced energy comes from aerobic processes which can result in reducing the overall level of adipose tissue [3]. The truth is that athletes wish to reduce the level of adipose tissue and increase the level of muscle tissue, so as to increase the situational efficiency by improving the correlation between body composition parameters. If one is not careful, every change in body weight can disrupt the performance strategy by changing the weight category.

Body stability is conditioned by maintaining the position of the body centre (PoC) in balance, and an ability in resisting the gravitational force as well as other external forces, depending on the mutual inter-coordination of the visual, proprioceptive system and vestibular apparatus [4]. The balance plays a significant role in Karate sport success, since it is dominated by endurance (statistical balance) and movement accompanied by change in direction (dynamic direction). Practicing Karate sport contributes to the reduction of the distance between the body centre and the ground which increases the postural stability and balance characteristics [5]. The difference in balance abilities is significant in regards to boys and girls, where in case of girls the level of balance abilities is higher. However, in preschool period this level is almost equal and in later age it is consistent to the level expressed by boys [6]. This type of transformational evolution can reduce the effects of biological development in regards to the increase of balance characteristics in girls during adolescent age.

Body composition can alter the level of balance abilities. Overall fat percentage and the amount of
Subcutaneous adipose tissue has a negative effect on strength, speed and balance performance [7], which is essential for the success of kick performance in Karate [8]. In relation to men, women have a greater percentage of fat tissue, due to their morphological and hormonal differences. Girls during puberty are characterized by the change and increase in their body weight and the level of fat tissue which can disturb the balance abilities as they are closely correlated to the situational efficiency. The data which express the fat tissue percentage for the adult karate athletes range from 12.6% [9] based on a sample of Polish Karate athletes, to 10.9% [10] based on a sample of American karate athletes, while in case of adult Japanese Karate athletes the percentage of fat tissue is 12.8% [11].

The aim of this research is to analyze the significance of the correlation between balance ability parameters and body composition segments, while attempting to explain their correlation and its contribution for the Karate success in this paper’s section dedicated to introduction and discussion. The age characteristics and long-term training effects shall be taken into account in case of female athletes. This study might be limited in regards to the number of subjects, and a few number of studies based on a sample of the same age subjects or those of similar age.

**Methods**

**Subjects**

Nineteen (19) female Karate athletes from the local karate club, aged 12-14 have been analyzed so as to determine their balance status. All the subjects are completely healthy, without any injuries or other diseases which might have affected this research. Sample characteristics are indicated as mean values ± SD: height 160.21 ± 10.34 cm; weight 52.67 ± 12.53 kg; age 13.74 ± 2.42 yrs.; time duration of practicing sport 2.6 ± 0.4 yrs. All the methods applied in this research are in accordance with the regulations and Helsinki Committee Declaration.

**Body composition**

All the female subjects have been personally informed on the testing protocol. Measuring was conducted in the morning, after refraining from eating all night (at least 6 hours). The subjects wore swimming suits, without any jewelry or any type of metal. The height was measured by Hotolin anthropometer under equal conditions for each subject. Body composition was determined by Tanita scale BC420SMA (Tanita Corp, Tokyo, Japan) which measures the body composition on a principle of bioelectric impedance (BIA) by foot-to-foot system [12, 13] and is medically approved and reliable. The scale determines body composition based on the reduction of bioelectric impedance [14] providing with the results which are precise up to ± 0.1 kg. Each subject was characterized as an athlete in regards to scale parameters. Measuring was conducted at a temperature of 22°C.

**Postural balance**

Prior to determining the level of balance ability, the subjects spent 5 minutes riding Cycle Ergometer under the pressure of 50 W for the purpose of warming up. The balance was determined by Biodex Balance System (BBS - Model 945-300, Biodex Medical Systems; Shirely, New York) set at a difficulty level 4, with a maximum gradient of 20° on balance board. Balance testing protocol of bilateral balance for the period of 20 seconds was applied [15, 16]. Each subject underwent identical protocol consisting of 5 trials in 20 seconds, with 30 seconds breaks between the measuring, so as to determine the overall balance level. Knee was placed in a slightly bent position, and the hands were placed in standard position.

**Variables**

Parameters measured by Tanita scale for the purposes of body composition analysis: Mass (kg), Fat mass % (FM%), Fat mass kg (FMkg), Fat Free Mass (FFM), Muscle mass (MMSS), Total body water kg (TBWkg), Total body water % (TBW%), Body Mass Index (BMI).

Regarding the gradient direction of the system’s balance board, three variables of the stability index were projected: APSI (anterior-posterior stability index) – calculated gradient direction front-to-back, MLSI (medial-lateral stability index) – calculated gradient direction left-to-right and an overall stability index (OSI) – the combination of APSI and MLSI [17]. All the numerically quantified balance abilities (stability indexes) have been inversely scaled.
**Statistical analysis**

Data have been analyzed by the statistical data analysis package SPSS 22.0 (IBM Corp.). All the data are expressed as mean values and standard deviations. The normal distribution of data has been confirmed by the application of K-S test. The variable correlation has been determined by bivariate cross-correlation analysis. The concluding level of statistical significance was set at \( p < 0.05 \).

**Results**

All the data were distributed within the scope of normal values, and the measurements of central and dispersion parameters, along with measurements of variables and distribution forms within the permitted limits. The results from Table 1 demonstrate that almost all body composition variables are correlated with stability indexes, indicating high level of statistical correlation between the three stability indexes.

OSI high level of statistical correlation \( (r > 0.70, p < 0.01) \) is indicated in regards to the body mass variable (Mass), total water percentage (TBW\%) and variables \( (r = 0.50 - 0.70, p < 0.01) \) FFM, MMSS, FMkg, Height, BMI and Age. The least statistical correlation is indicated in regards to variables: FM\% and TBWkg.

High level of statistical correlation \( (r > 0.70, p < 0.01) \) between APSI and body composition were not determined, while the inter-correlations \( (r = 0.50 - 0.70, p < 0.01) \) are indicated by the following variables: Mass, BMI, FFM, MMSS, TBW\%, FMkg and Age. The least statistical correlations are indicated by variables FM\% and TBWkg, while height is not significantly related with the balance offsets in frontal plane.

The highest level of statistical significance for MLSI and body composition has been determined for the following parameters: Height, FFM, MMSS, TBW\%. Significance is likewise indicated by the variables Mass, Age and FMkg. No relations between FM\%, TBWkg and BMI were demonstrated.

**Discussion**

The results indicate that there is a high level of correlation between body composition and the performance of balance characteristics. The methods applied in this research, including the measuring methods have been verified by personal metric characteristics which are, within the scientific scope, considered valid for the assessment of tested abilities and characteristics. Research results can be considered as reliable indicators of the correlation between body composition and balance abilities.

Based on the correlation level and statistical significance within the scope of three numerically quantified stability level parameters, one can conclude that the BBS apparatus possess suitable metric characteristics, confirmed by previous research regarding BBS reliability [18]. Therefore, balance abilities expressed by three stability indexes (OSI,

<table>
<thead>
<tr>
<th></th>
<th>OSI</th>
<th>APSI</th>
<th>MLSI</th>
</tr>
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<tbody>
<tr>
<td>Mean ± SD</td>
<td>2.29 ± 0.95</td>
<td>1.68 ± 0.62</td>
<td>1.49 ± 0.35</td>
</tr>
<tr>
<td>Height</td>
<td>160.21 ± 10.33</td>
<td>.615**</td>
<td>.434</td>
</tr>
<tr>
<td>Age</td>
<td>13.74 ± 2.42</td>
<td>.519*</td>
<td>.532*</td>
</tr>
<tr>
<td>Mass</td>
<td>52.67 ± 12.53</td>
<td>.720**</td>
<td>.628***</td>
</tr>
<tr>
<td>FM%</td>
<td>22.69 ± 5.26</td>
<td>.489*</td>
<td>.458*</td>
</tr>
<tr>
<td>FMkg</td>
<td>12.36 ± 5.37</td>
<td>.646**</td>
<td>.570*</td>
</tr>
<tr>
<td>FFM</td>
<td>40.31 ± 7.99</td>
<td>.695**</td>
<td>.601**</td>
</tr>
<tr>
<td>MMSS</td>
<td>38.25 ± 7.6</td>
<td>.695**</td>
<td>.601**</td>
</tr>
<tr>
<td>TBW%</td>
<td>56.6 ± 3.92</td>
<td>.700**</td>
<td>.580**</td>
</tr>
<tr>
<td>TBWkg</td>
<td>28.97 ± 6.09</td>
<td>-.492*</td>
<td>-.468*</td>
</tr>
<tr>
<td>BMI</td>
<td>20.28 ± 3.18</td>
<td>.585**</td>
<td>.621**</td>
</tr>
<tr>
<td>OSI</td>
<td>1</td>
<td>.745**</td>
<td>.810**</td>
</tr>
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</table>

**Statistically significant \( p < 0.01 \)  
* Statistically significant \( p < 0.05 \)
APSI, MLSI) measured by BBS, represent an actual state of balance abilities in girls.

Based on the results, one can assess that all the variables negatively affect stability indexes (inversely scaled results). These results mostly indicate that the increase in any body composition component results in an increase of the total body mass, which has negative effects on the performance of balance abilities. Further supporting this statement is the number of studies analyzing the negative effects of the subcutaneous adipose tissue on postural stability in obese teenagers [19, 20]. Increased body mass index likewise has negative effect on postural stability as well as influencing mechanisms which control body balance [20]. Overall fat free mass and muscle mass negatively affect the performance of balance characteristics in accordance with this study results. These results are contradictory to the current research which mostly bring the high level of balance characteristics in relation to the high level of muscle mass [21]. Muscle mass represents active mass which stabilizes body levers and performs mechanical corrections by applying movement so as to maintain stability level. Regarding that, the sample tested in this research was in a development phase, in which case central nervous system is not adopted enough to perform a great number of simultaneous tasks, and this might represent the reason why there is negative correlation between muscle mass and stability index. Positive low correlation level between water percentage in the body and total stability was determined in regards to the tested sample.

Following the training effects of Karate during the period of six months [22] between the group of subjects in the ages from 8 to 10 who practice Karate, and a group of subjects of similar characteristics who practice similar sports, Violan and co-authors [22] have confirmed the improvement in statistical body balance in a group which practices Karate. Results of the research likewise indicate that long-term Karate practice induces basic changes in regards to balance characteristics. Karate training has positive effects on the increase of postural stability, where training effects resulting from the specificity of the movement pattern allow for the increased level of body incline without the fear of balance impairment. Importance of balance is brought in connection with the Karate sport efficiency. Other combat sports, who are also classified by weight categories [23, 24], are influenced by body composition as well.

**Conclusion**

Balance plays a significant role in Karate efficiency. Body composition and balance are closely related, whereas total body mass has negative effects on the performance of balance characteristics, which includes muscle mass and other fat-free mass. Competition in an optimum weight category is very important since based on changes of body composition parameters, one can directly influence the balance abilities which ultimately can have negative effects on success in accomplished and planned results.

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Employee Attrition in ITeS Call Centers in Selected Clusters of North India: Need to have a Relook

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Abstract

The present study has been undertaken to get a deeper insight into the problem of employee attrition in ITeS call centers in selected clusters of north India. The problem of high employee attrition is demotivating the other employees of the organization. It also increases the recruitment costs for the ITeS call centers by impacting the profits. To tackle the problem of employee attrition, the study highlights eight factors that need to be focused carefully. These eight factors are: Managers attitude, Work culture, Customer handling interface, Personal growth opportunities/career prospects, Nature of the job profiles, Health hazards and stress problems, Performance management system, Salary structure and monetary incentives, Social recognition and employee engagement. The study highlights that employees of ITeS-BPO firms want more humane and friendly working environment with better career progression rather than just lucrative salary and swanky office places.

Key Words: attrition, outsourcing, ITeS call centers, India

1. Introduction

The Indian BPO (Business Process Outsourcing) industry is growing at a very good pace, coupled with key factors like labor pool, language proficiency, location attractiveness [1]. The BPO industry was growing at an annual rate of 40-50% since its inception [2]. The outsourcing industry accounts for almost $11 billion and employs slightly over 7, 00,000 professionals in terms of direct employment. The industry would account for nearly 2.5% of GDP (Gross Domestic Product) growth in 2012, generate direct employment of about 2 million [3]. Because of its impact, the Tier II and Tier III cities will emerge as fresh hubs for rightly skilled talent for this sector. India has 5-6% share of the total global outsourcing industry [4] whilst another researcher has studied that the Indian outsourcing sector accounts for at least 10% of the global ITeS-BPO industry [5]. On the other side, NASSCOM (The National Association of Software and Services Companies) has published in its latest strategic review of 2011, India has retained its position as the leading global offshoring destination with a 55% share of global ITO and BPO market in 2010 in spite of competitive challenges presented by the other emerging offshoring destinations. The industry is flourishing in India at a good average pace; more and more companies are establishing operations in the metropolitan cities to capitalize on the available human resource (HR). The main markets for Indian ITeS-BPO firms are US and UK which remains the largest export markets accounting for 60% and 31% respectively [3]. India will capture more than 50% of the market, if it overcomes the challenges it faces [6]. The world wide spending aggregate in ITeS-BPO sector has reached approximately USD 1.6 trillion, a growth of 5.6% as compared to last year [6].

The main functional areas of this sector are: customer care, such as remote maintenance, help desk and sales support; finance and administration which includes data analysis, medical transcription, insurance claims and inventory management; HR and payment services like pay rolls, credit card services, cheque processing, employee leasing and content development, i.e. digital content and application maintenance. About 70% of Indi-
an BPO industry’s revenue comes from ITeS call centers, 20% from high-volume, low-value data work and the remaining 10% from higher-value information work [7]. BFSI (Banking, Financial Services and Insurance) and Hi-Tech/Telecom continued to account for more than 60% of Indian ITeS-BPO industry [8]. Healthcare ITeS-BPO vertical is likely to witness increased investments due to increased focus on public health, making healthcare and insurance affordable to all. Other ITeS-BPO verticals that will see growth include telecom, retail and utilities.

Human capital is the most important driver for the success of any organization. It is essential to manage the human resources for the success of an organization [9]. Gone the days, when people believed in lifetime employment and a career within a one company only. In the late 1990s, the trends were changed drastically. It happened because the companies across various industries restructured their operations and headcount was reduced. People then started thinking about owning their own careers. They started collecting experiences and skills in various jobs at various companies to enhance their ongoing employability. By the year 2000, due to a growing imbalance between an expanding demand and limited supply, there was paradigm shift in the trend. Employees started thinking for their own employability and personal gain rather than their employer’s success [10].

Managing attrition is becoming increasingly important nowadays. It is not because of the knowledge professionals who have become the lifeline of a service industry but manpower costs are also one of the largest expenses regularly charged to the budget of a company in the ITeS call center industry. It increases manpower costs (related to recruitment, induction and training of new joiners), causes inconsistency in meeting the organizational deadlines [11]. It has become a prevalent problem in the Indian ITeS call centers. The people intensive nature of the industry has been facing problems in attracting and retaining the talented headcount [12, 13] and it is an issue of critical importance to human resource managers.

The current study seeks to address this challenge. The following section starts with a brief review of the existing research on the present study. Based on the literature review, hypotheses are developed and tested with empirical data collected for this study. The paper concludes with a discussion of the managerial implications and future research directions. This study specifically investigates the factors responsible for attrition in ITeS call centers. Section 2 develops the theoretical support from the previous outsourcing literature and justifies the need for the study. Section 3 briefly describes the research methodology adopted for the study. Section 4 presents results and findings after applying statistical analysis using descriptive statistics and factor analysis. The conclusion and future scope are discussed in the last sections of the paper.

2. Theoretical framework

The charm and glamour of the industry has started slipping the ladder because of the challenges faced by the industry since its inception. The challenges faced by the call center industry can be classified into two categories. These are known as internal and external challenges. The external challenge faced by the industry is the opposition from the US politicians and the UK labor unions against the outsourcing of jobs from their home countries to India [14]. The government of the US has already threatened to levy a basic minimum tax on foreign earnings of US firms that outsource jobs to other economies. The threat of fierce competition from other outsourcing players like Philippines, Ireland and Malaysia also exists, which should also be taken care of with proactive approach. There are many internal challenges which are also impacting the industry. These challenges include employee attrition, shortage of right talent for middle and senior level [13, 14], stress management, problem of finding quality human resources [13], problems of absenteeism, lack of motivation are some of the major issues of the industry [15]. A number of researchers have tried to get into the depth of growing concerns such as infrastructure issues, manpower costs, human resource aspects, cultural differences, twin identity hangovers, accents [14] and fear of reduced service levels [16]. But, majority of them have not felt accomplished at their research if they had not talked about the most hyped problem called employee attrition. Many of the researchers focus on the ever increasing problem of employee attrition [13, 14, 15, 17, and 18].
Despite high salaries, aesthetic offices, fancy designations, employee attrition rate is very high in the IT and ITeS call center industry. India faced an attrition rate of 18% in 2003 [19] and it had increased to around 50% in 2006 [20]. Further it had dropped down from 21% in 2007 to 16% in 2008 because of global recession [21]. According to a recent study, the IT and ITeS sectors has faced the highest attrition rate of 23% in comparison to the other industries during first quarter of 2010-11 [22]. Other industries like banking and financial services sector faced an attrition rate of 18%, followed by healthcare (12%) while FMCG, automobiles and manufacturing has faced an attrition rate of 11% [22]. This has been forecasted that ITeS-BPO industry is expected to face a shortage of 0.3 million professionals by 2012 [23]. So, the problem of employee attrition has become a constant worry which should be arrested as early as possible.

Employee attrition is counted as healthy in a limited measure for the influx of new ideas in any type of organization. Healthy employee attrition helps organizations to stay competitive in such a turbulent business environment. Employee attrition in a limited measure is good for the organizations as it brings gains to the organization. However, if employee attrition increases beyond a certain level, these gains are going to be big pains.

Attrition can be defined as a reduction in the number of employees through retirement, resignation or death whereas attrition rate is the rate of shrinkage in size or number [20]. There are two types of employee attrition called as drive and drag attrition. Drive attrition is caused due to the employer whereas drag attrition is caused due to an employee. Drive attrition takes place because of employer’s policies, e.g. sometimes an employer keeps only most productive employees by terminating the other employees at regular intervals while drag attrition is caused due to the insecurities and vulnerabilities linked with the career in a call center. As and when promotions are announced, only a few employees get promoted to the level of team leader and many of the frustrated employees start quitting the jobs [24, 25]. Recruiters explain that high attrition rates also increase the costs incurred on employees significantly [26].

Undoubtedly attrition requires immediate attention of the HR professionals in a developing economy such as India. A number of researchers, practitioners and scholars had tried to find the factors behind attrition which may be clubbed into internal and external factors. The internal factors are linked to the service provider. Service providers face an array of issues which are attributable to the increased attrition levels. Call center employees are known as mouthpieces that follow the instructions given to them by their supervisors when they start login and their work is being tightly controlled and monitored by the latest computer technology [27]. The issue of salary and monetary considerations has been increasing the employee attrition rate [13, 14, 20, and 28]. The expectations of employees have grown exponentially in terms of money because of strong demand and less supply in the market and they start quitting their jobs because they have been offered a higher salary by another company. The nature of the work is quite boring which causes monotony and they start quitting the jobs [29]. Frequently, call center jobs are having limited task variety, the call handlers keep on doing the same job again and again. Sometimes call handlers are expected to say the same sentences repeatedly. This is called scripting [30] which leads to monotony in their working lives.

Long working hours and time pressures (deadlines) are also contributing to the problem of attrition [29]. The limited growth and career development is one of the major reasons for increasing attrition rate [13, 18, and 20]. Furthermore, night shifts (the employees call night shifts as graveyard shifts) are the problem for Indian employees [13] because such shifts disturb the biological cycle of their body causing the problems of physical strain and unfitness [13, 28]. The symptoms of chronic fatigue, gastrointestinal problems, peptic ulcer and even depression are the reasons that shoot up drive attrition [25]. The policies and procedures are not conducive [20, 28]. Moreover deficiencies in the recruitment processes are also attributable to increased level of attrition [29].

The other internal factors such as insufficient leave or holidays, higher education and no personal life are promoting the attrition rates in Indian IT and ITeS call centers [28]. The appraisal and reward systems are not transparent. Many young executives feel de-motivated and under-rewarded [31]. Moreover, the Indian education system does not...
teach the practical aspects of how to do work as it is very bookish [32]; the employees cannot gel with the work pressures and start quitting jobs. In external factors, supply and demand is one of the factors which have been contributing towards attrition [33]. Although, there is an abundant supply of educated people but the availability of an employable pool is less because of the inability of people to speak and write English fluently. The immature and inexperienced agents [13] are not sure what they want to achieve in their career and represent flight risks [29].

2.1 Objectives of the study

The broad objectives of the present research are:

1. To identify the key factors responsible for attrition.
2. To develop employee retention strategies to counter attrition problem in ITeS call centers.

3. Research design and methodology

The study has used descriptive research design. Based on literature review and discussions with call center employees, a questionnaire was developed. The questionnaire used in this study is direct and structured. There are twenty six questions. These questions are related to their job aspects, work patterns, total weekly working hours, reasons for joining and leaving the ITeS call center jobs. Apart from these questions, the questionnaire also comprises of eight sections covering issues related to the nature of job, working environment, training and development, career prospects, relationships with colleagues, appraisals and shift timings. Sixty four statements relating to employee attrition were asked from the respondents. The study uses a five point Likert scale. The respondents were asked to rate these statements on a 1-5 rating scale where 1 = “strongly disagree” and 5 = “strongly agree”.

3.1 Sampling design

The study uses 260 employees covering fourteen ITeS call center employees. All the sample firms serve overseas clients located in North India. The clusters of ITeS call centers of Gurgaon, Noida and Chandigarh-Mohali were taken for the study. The data was collected from between June 2009 and October, 2010 from these organizational locations.

The present study has followed a dual approach. It is comprised of in-depth interviews and questionnaire method. The researcher was able to conduct only forty five in-depth interviews (out of total of 260 employees) with ITeS call center employees (including team leaders, customer care executives and agents). The interview session was mainly conducted with the customer care executives and agents. On an average, most of interviews lasted for about thirty to forty-five minutes. The extensive structured interview session endeavored to get an insight into exact motivation for joining the ITeS call centers organization and also why the people are leaving their ITeS call center jobs. The researcher has sent a total of 500 questionnaires and has got only 260 completed questionnaires in all aspects. These 260 completely filled questionnaires have been taken up for further analysis. The response rate of the survey is 52%. In fact, the data is gathered during nights when the employees were out for breaks.

3.2 Reliability and validation

The questionnaire had a good reliability score and the overall Cronbach Alpha was 0.761. Thus, the instrument was considered reliable for the study. The questionnaire was having a total of eight sections. To evaluate the clarity of the question statements and items, the questionnaire was pilot tested. Validation was done by thirty managerial level employees of the ITeS call centers and twenty academicians. The changes suggested by them were incorporated and the final questionnaire was administered personally in all the three clusters after the pre-testing of the instrument. Statistical Package for the Social Sciences version 19.0 was used for the statistical analyses.

4. Data analysis and discussion

The first section of instrument gathered information about the basic questions related to their current level of management, designation, type of calls handling (inbound/outbound) etc. The question on
total number of weekly working hours (Figure 1) reflected that 54% respondents revealed that they work for 45-40 hours in a week, 32% are working for 50-55 hours a week. Although earlier research suggests that 35-45 hours per week is the optimal working time for executives [34] but the respondents in present study were working for more hours.

![Weekly Working Hours](image)

**Figure 1. Total Weekly Working Hours**

Regrading perception of ITeS call centers (Figure 2) 36% revealed that the ITeS callcenter provides more job opportunities for the Indians and next 32% disclosed that it is a good source of income. Only 13% respondents revealed that the ITeS call center job provides a career growth option. This in a way highlights relatively less growth opportunities prevalent in ITeS call centers.

![Perception of Call Centers](image)

**Figure 2. Perception of ITeS call centers**

4.1 Demographic profile of the total respondents

The last section of the instrument gathered demographic information of the total respondents to ensure the confidentiality of their responses (Table 1). A total of 260 respondents have filled the questionnaires.

<table>
<thead>
<tr>
<th>Main Category</th>
<th>Sub-Categories</th>
<th>Total Responses</th>
<th>Sub-Categories</th>
<th>Total Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>178</td>
<td>Female</td>
<td>82</td>
</tr>
<tr>
<td>Marital Status</td>
<td>Single</td>
<td>41</td>
<td>Married</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>Married</td>
<td>18</td>
<td>Marital</td>
<td>13</td>
</tr>
<tr>
<td>Qualification</td>
<td>Postgraduate</td>
<td>18</td>
<td>Postgraduate</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Graduate</td>
<td>118</td>
<td>Graduate</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Undergraduate</td>
<td>03</td>
<td>Undergraduate</td>
<td>05</td>
</tr>
<tr>
<td></td>
<td>Diploma Holder</td>
<td>33</td>
<td>Diploma Holder</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Any Other</td>
<td>06</td>
<td>Any Other</td>
<td>01</td>
</tr>
<tr>
<td>Age</td>
<td>15-25 years</td>
<td>66</td>
<td>15-25 years</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>25-30 years</td>
<td>86</td>
<td>25-30 years</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>30-45 years</td>
<td>26</td>
<td>30-35 years</td>
<td>13</td>
</tr>
<tr>
<td>Income Group</td>
<td>1-2 Lakhs</td>
<td>35</td>
<td>1-2 Lakhs</td>
<td>21</td>
</tr>
<tr>
<td>(per annum)</td>
<td>2-3 Lakhs</td>
<td>67</td>
<td>2-3 Lakhs</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>3-4 Lakhs</td>
<td>46</td>
<td>3-4 Lakhs</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Above 4 Lakhs</td>
<td>30</td>
<td>Above 4 Lakhs</td>
<td>13</td>
</tr>
<tr>
<td>Job Tenure</td>
<td>0-12</td>
<td>59</td>
<td>0-12</td>
<td>36</td>
</tr>
<tr>
<td>(in months)</td>
<td>13-24</td>
<td>71</td>
<td>13-24</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>25-36</td>
<td>23</td>
<td>25-36</td>
<td>08</td>
</tr>
<tr>
<td></td>
<td>37-48</td>
<td>16</td>
<td>37-48</td>
<td>07</td>
</tr>
<tr>
<td></td>
<td>Above 48</td>
<td>09</td>
<td>Above 48</td>
<td>09</td>
</tr>
</tbody>
</table>
4.2 Factor analysis

Since there were many variables of attrition, factor analysis was done to extract the key factors for attrition. To test the appropriateness of the factor analysis, Kaiser-Meyer-Olkin (KMO) test was calculated. The KMO measure of sampling adequacy is a statistic that provides the proportion of variance in the variables that might be caused by underlying factors. A high value of KMO means that the use of factor analysis may be useful for the data. The KMO value of the present study is 0.704 and is acceptable. The KMO value is acceptable as a middling value [35]. The Bartlett’s test of sphericity is basically a statistical test that shows the presence of correlations among the variables. This test provides the statistical significance that the correlation matrix has significant correlations among at least some of the variables [36]. The correlation matrix is an identity matrix which is having some variables with significant correlations among them. Both these tests have shown significant values and hence the factor analysis is accepted for further analysis.

There is another third measure to quantify the degree of inter correlations among the variables and the appropriateness of the factor analysis is the measure of sampling adequacy (MSA). The value ranges from 0 to 1, reaching 1 means when each variable is perfectly predicted without error by the other variables. This measure can be understood better with the following guidelines: .80 or above, meritorious; .70 or above, middling; .60 or above, mediocre; .50 or above, miserable; and below .50, unacceptable [36]. The MSA value for each variable was above than .50 except for three variables. These three variables are deleted one by one. The variable with lowest MSA value is deleted first and the factor analysis is executed again. After the deletion of three variables (on the basis of conceptual foundation), another variable is found to be with MSA value less than .50. On the deletion of the fourth variable, all the variables are found to have MSA values greater than .50. The communalities of the variables are found to have values greater than .50. Thereafter, the researcher has finally extracted the key employee attrition factors. The study used principal component analysis with Varimax technique to extract factors with Eigen values greater than 1 [37]. A total of eight factors were finally extracted (Table 2). These factors account together for almost 79.91% of total variance. These eight factors along with their Eigen values and Item loadings have been explained in table 2.

Managers attitude: The first factor namely managers attitude having Eigen value of 20.23 covers seven items having factor loadings greater than 0.64. The top rated sub items in this factor included: i) doesn’t maintain good interpersonal relations, ii) Communication problem; and iii) Never helping in handling tough customers. Earlier studies have also reflected about managers attitude as a factor for attrition [13, 15, 26, and 38]. The present study corroborates the findings of earlier studies.

Table 2. Factors for employee attrition in ITeS call centers

<table>
<thead>
<tr>
<th>Factor No.</th>
<th>Factor Name</th>
<th>Total% of Variance</th>
<th>Items</th>
<th>Item Loading</th>
<th>Mean</th>
<th>S.D.</th>
<th>Mean Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Manager’s Attitude</td>
<td>20.23</td>
<td>i. Does not maintain good interpersonal relations</td>
<td>0.856</td>
<td>3.29</td>
<td>1.01</td>
<td>2</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>ii. Communication problem</td>
<td>0.835</td>
<td>3.57</td>
<td>1.05</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>iii. Never help in handling tough customers</td>
<td>0.828</td>
<td>3.23</td>
<td>0.98</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>iv. Boss replacement</td>
<td>0.771</td>
<td>2.70</td>
<td>1.23</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>v. Gets on my nerves</td>
<td>0.732</td>
<td>2.91</td>
<td>1.15</td>
<td>5</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>vi. Treats me as a resource</td>
<td>0.689</td>
<td>2.81</td>
<td>1.01</td>
<td>6</td>
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<td></td>
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<td>vii. Takes the credit for my work</td>
<td>0.641</td>
<td>2.94</td>
<td>0.99</td>
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<tr>
<td>Mean</td>
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<tr>
<td>Mean of Manager’s Attitude 3.06</td>
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<td></td>
<td>3.35</td>
<td>0.94</td>
<td>4</td>
</tr>
<tr>
<td>2.</td>
<td>Work Culture</td>
<td>14.45</td>
<td>i. Ineffective job orientation</td>
<td>0.838</td>
<td>3.35</td>
<td>0.94</td>
<td>4</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>ii. Skills are not used effectively</td>
<td>0.792</td>
<td>3.36</td>
<td>0.99</td>
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<td></td>
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<td>iii. Unfavorable working environment</td>
<td>0.774</td>
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<td>1.02</td>
<td>1</td>
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<td></td>
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<td>iv. Never rewarded for good job</td>
<td>0.708</td>
<td>3.54</td>
<td>0.91</td>
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<td>Factor</td>
<td>Mean of Work Culture 3.46</td>
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<tr>
<td>i. Irritating and abusive customers</td>
<td>0.823</td>
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<td>ii. Tough customers</td>
<td>0.775</td>
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<td>iii. Ineffective customer handling standard procedure</td>
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<td>iv. Recording and continuous monitoring</td>
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<tr>
<td>Mean of Customer Handling Interface 3.58</td>
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<td></td>
</tr>
<tr>
<td>i. Job offers no career growth opportunities</td>
<td>0.735</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>ii. Mismatch between my job and qualification</td>
<td>0.663</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>iii. Bridge my academic career</td>
<td>0.601</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>iv. Career beginner job only</td>
<td>0.587</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Mean of Personal Growth Opportunities 3.18</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>i. Job offers no career growth opportunities</td>
<td>0.735</td>
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<tr>
<td>ii. Mismatch between my job and qualification</td>
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<tr>
<td>iii. Bridge my academic career</td>
<td>0.601</td>
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<td>iv. Career beginner job only</td>
<td>0.587</td>
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<td>Mean of Nature of the Job Profiles 2.85</td>
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<tr>
<td>i. Monotonous job</td>
<td>0.794</td>
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<td>ii. Deskillled</td>
<td>0.748</td>
<td></td>
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<tr>
<td>iii. Stressful job</td>
<td>0.691</td>
<td></td>
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</tr>
<tr>
<td>Mean of Health Hazards and Stress Problems 2.78</td>
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<tr>
<td>i. Take drugs to combat with the tensed job environment</td>
<td>0.716</td>
<td></td>
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<tr>
<td>ii. Colleagues leaving because of health issues</td>
<td>0.709</td>
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<td>iii. At times the employees are prone to psychological problems</td>
<td>0.596</td>
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<tr>
<td>iv. Job is affecting health</td>
<td>0.503</td>
<td></td>
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<tr>
<td>Mean of Performance Management System 2.94</td>
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<tr>
<td>i. Never getting promotions according to my qualification</td>
<td>0.807</td>
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<td>ii. Not satisfied with the performance management system</td>
<td>0.745</td>
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<td>iii. Not satisfied with the other benefits provided to me</td>
<td>0.611</td>
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<td>Mean of Performance Management System 2.94</td>
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<td>i. Would switch if offered with higher package</td>
<td>0.774</td>
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<td>ii. Tough promotions</td>
<td>0.735</td>
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<td>iii. Money is the real motivator</td>
<td>0.476</td>
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<td>iv. Salary hikes are required</td>
<td>0.415</td>
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<td></td>
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<tr>
<td>Mean of Salary Structure and Monetary Incentives 3.73</td>
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<tr>
<td>i. No recognition in the society forces an employee to leave the job</td>
<td>0.659</td>
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<td>ii. Lack of engagement level is in my job</td>
<td>0.639</td>
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<td>Overall Mean all Eight Factors 3.20</td>
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Work culture: It emerged out as the second factor for employee attrition. The items included in this factor had factor loadings more than 0.70. Work culture is an important factor to work in any kind of organization. Ineffective job orientation had the highest loading, while Unfavorable working environment had the highest average. A higher loading score of all items in this factor reflect the criticality of this factor. If an employee is not satisfied with his/her work culture, sooner or later s/he would leave the organization. In personal interviews some respondents revealed that the employee has to meet their targets at any cost and to meet the desired targets no holidays were given to them. On employee remarked that he had to work continuously for two weeks many times even without a break, which ultimately made him shift his job. Further, no gazette holidays were given off which are the days when people plan social parties and outings. Work culture is an important factor for employee attrition. Earlier research revealed that bad work culture reduces job satisfaction and affective commitment over time and in turn, enhances intentions to quit a job [14, 18, 29, 39 and 40].

Customer handling interface: This factor emerged as the third factor that impacts attrition in ITes call centers. Irritating and abusive customers; and customers are tough to handle had higher item loadings and in terms of mean score ineffective implementation of customer handling procedures recorded the highest score. The respondents clearly mentioned that the hard headed customers are contributing towards the problem of attrition in the industry. They revealed that the employees have to be calm and patient irrespective of the bad behavior of the customers. Some respondents mentioned that the customers start abusing them when they get to know that they are talking to an Indian despite our American accents. Some other scholars [41] have also disclosed that the tough customers are also contributing to the problem of employee attrition.

Personal growth opportunities/career prospects
The next important factor for attrition was inadequate career advancement opportunities. The items included in this factor are: job offers no career growth opportunities had the highest item
loading and mismatch between my job and qualification had the highest mean score. The items had factor loadings more than .587. Many participants had left their jobs just for the higher education. 70% respondents clearly told that many of our colleagues are leaving the firm as and when they get jobs related to their educational qualification. Moreover, a number of engineers (from local engineering colleges) were working in the call centers because they had no other option to work. They were hunting the jobs throughout the year. As and when it clicks, they immediate leave. The lack of personal growth opportunities finding is supported by a number of studies also stands an important factor for employee attrition in the industry [11, 13, 18, 25, 28, 29, 41, and 42].

**Nature of the job profiles**

Nature of the job also impacts the attrition rate in the industry. The items included in the factor are boring and monotonous job, de-skilled and stressful job. The items had factor loadings more than .691. In general, ITeS-BPO work is repetitive, mechanical and involves high transaction volumes [13, 43]. The routine ITeS call center job does not offer variety in the job. The jobs are not providing challenging assignments. Younger recruits find it boring and monotonous once they have mastered the process [13, 29, and 44]. This causes the feeling of frustration in them and they start switching the jobs. Moreover, the industry is having more of youngsters which are immature and are having less experience. They enjoy frequent job switching in the initial career establishment stage.

**Health hazards and stress problems**

Health issues are again contributing further to the problem of attrition. It has emerged out one of the factors responsible for attrition in the present study. The items included in this particular factor are an employee has to take drugs to combat with the tensed job environment, colleagues leave because of health problem, at times the employees are prone to psychological problems and the job is affecting the health. The factor loadings of all the items were found to be more than .50. It is an important dimension for employee attrition. The employees of the ITeS call centers suffer from a number of health issues like stress, insomnia, ulcers, etc. [25]. Stress is like a ghost that continues to haunt ITeS call center employees. The employees of ITeS call centers were termed as ‘cyber coolies’ in one of the research studies of outsourcing sector [45]. Many respondents left their respective organizations because of the killing work pressures. Night shifts disturb biological cycle of their body causing the problems of physical strain and fatigue [13, 28]. The stress bearing capacity of women is often comparatively less as compared to men and the job is highly stressful in comparison to the other industry jobs. The health and psychological ailments or illness [13, 29] also contributes for attrition. These include sleeping disorders 83% as compared to industry average of 39.5% and voice loss 8.5% as against 3.9% [46], ear problems-8.5%, digestive disorders-14.9% and eye sight problems 10.6% [47]. Other studies have found to be supportive in context to health issues as one of the contributing factor towards attrition [32, 41, 45, and 47].

**Performance management system**

All the items included in this factor had factor loadings more than .60. The item never getting promotions according to my qualification has been ranked first with higher mean score and has higher item loading as well and is hence very important in this factor. The next item not satisfied with the performance management system was ranked second according to mean score and had higher loading as well. This justifies that respondents were not satisfied with performance incentives as well. Majority of the respondents revealed that although salary review takes place in their organizations but it is simply done for the sake of HR practice. They opined that promotions are rarely based on the performance criteria. The appraisals are simply opaque and in namesake only. They also revealed that an agent would be working in the capacity of an agent for years despite having good experience. Thus, a large number of the respondents were not satisfied with the performance appraisal system because the organizations have politics [14]. Non-transparency, favoritism and nepotism towards some of the employees by their team managers were the common reasons cited for prevailing discrepancy in performance appraisal. This caused frustration and employees
quit the jobs so as to reduce dissonance simmering within them [13, 48].

**Salary structure and monetary incentives**

Another important factor emerged as one of the reasons of employee attrition. The factor included items under it are an employee would switch if he is offered with high package, tough promotions, money being real motivator and salary revise is required. The items had factor loadings in between from 0.40 to 0.80. The issue of salary and incentives has not emerged as the prime factor contributing to the problem of attrition which is prevalent in the literature [13, 25, 28, 29, 41 and 42]. Some of the respondents, especially those having families left the jobs because of salary issues.

**Social recognition and employee engagement**

The employees of the ITeS call centers disclosed that the society never provided them due recognition. Many respondents clearly told that it is always better to say ‘unemployed’ rather than disclosing an employee of the call center industry to the Indian society (including relatives, friends). This finding is also corroborated by earlier literature [17, 18, 42 and 49]. Employee engagement adds further to the problem of employee attrition. The employees were not engaged in the jobs and hence they always look in for the green pastures outside their organizations. Apart from this some of the respondents revealed that twin identity is also one of factors that cause employee attrition.

It is a mistake to assume that all departures occur for the same reasons; in fact one person’s priority may be different from the other person’s priority and moreover tolerance power of an individual may also vary. The present study has also revealed some other factors which contributes to the problem of attrition such as marriage, language barrier, no personal life and lack of social life [25, 28, 45, and 49], lack of employee motivation [41, 49]. Further, the study has also revealed that long distance of commuting [28], hard to understand customer’s accent [13], no flexible work schedules are also contributing to employee attrition.

5. Conclusion

Employee attrition is a serious problem and deserves immediate attention in this competitive world. The findings of this study provide an insight into the consistent problem of employee attrition, as the gravity of this problem may lead to losing your high earned rating and position to your competitors. It is imperative for the management to make relevant changes through continuous HR interventions. The problem of high employee attrition is de-motivating the other employees of the organization. It also increases the recruitment costs for the ITeS call centers by impacting the profits. To tackle the problem of employee attrition, these eight factors need to be focused carefully. These factors have also been supported by some other research studies.

The present study has been undertaken with the objective to identify the key factors responsible for attrition. This has been achieved and based upon factor analysis eight factors responsible for attrition has been identified. In terms of importance it can be said that Manager’s Attitude, work culture, customer handling interface had higher importance. Salary Structure and Monetary Incentives had the lower Eigen values highlighting the less importance given to this factor. These results have been corroborated by [13, 25, 29, and 42].

The second objective of the study has been to develop employee retention strategies to counter attrition problem in ITeS call centers. Based upon factors identified the following strategies would help in reducing attrition. By introducing a better employee job-fit, an open organization culture, career planning, transparent appraisal system and competitive salary would go a long way in retaining the employees in ITeS call centers. The ITeS-BPO employees need to be given more individual and human relations oriented interface by the management. There is also need to inculcate pride for ITeS call center jobs both among employees and within the society. It will certainly be helpful in lowering down the attrition rates. This will ensure that individuals join this industry/organization as a conscious career choice and are there for a longer period of time rather than a stop gap arrangement. Moreover, introduction of fair and timely performance management system would further curb
the problem of employee attrition to a greater extent. Thus the employees of ITeS-BPO firms want more humane and friendly working environment with better career progression rather than just lucrative salary and swanky office places.

6. Limitations

There are a number of limitations to this research study. First of all the time constraint for the data collection period naturally limits the scope of validity and reliability. Secondly, the data was collected from three clusters of North India limits the findings of the research as well. Nevertheless, we still believe our research study can be replicated in the other parts of India and it can also be extended to the other countries also which will be beneficial for them too in the coming future.

7. Future Scope

The findings of the present study can be helpful to different ITeS call centers. These ITeS call centers can make use of these findings in their organizations to arrest employee attrition.

References

1. www.neoIT.com
22. www.myhiringclub.com


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