CER Comparative European Research 2017

Proceedings | Research Track

of the 7th Biannual
CER Comparative European Research
Conference

International Scientific Conference for Ph.D. students of EU countries

March 29-31, 2017 | London

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Published in March, 2017 by Sciemcee Publishing, London.

Proceedings document published in collaboration with SCIEMCEE - Scientific Conference Platform.
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ISBN 978-0-9935191-4-7

SCIEMCEE
PUBLISHING LONDON

Introduction

The conference Proceedings you are holding is a collection of selected peer-reviewed texts presented at the international scientific conference Comparative European Research - CER 2017 (March 29-31).

The biannual international scientific conference is organized under the auspices of the SCIEMCEE scientific platform every March and October and follows up on activities aimed at providing greater support for the scientific activities of Ph.D. students and beginning researchers. The various biannual CER conferences represent a space for the international assessment of the qualitative standard of scientists and the results achieved by the various academic institutes. The CER conference is an ideal place for comparing the standard of scientific work, particularly on a European scale.

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RISK MANAGMEMENT IN HOSPITALS

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Abstract: *Risk management in hospitals is essential to increase patient safety, to save money and to reduce work load for personnel. Managing risk in hospitals is a comprehensive approach – this paper proves this statement with literature research and with expert interviews. As a result, there are various approaches how to start a risk management program in hospitals, however to be successful, it has to be implemented widely and different hierarchical levels should be involved.*

Keywords: *health management, hospital, risk management*

1. Introduction

A successful risk management program helps organizations prioritize strategies for risks that are likely to have the biggest impact on their business (Cole, Chaudhary, & Bang, 2014). A study within the NHS (National Health Service in UK) over eight years analyzing the MSRA rates in hospitals clearly concludes, that risk management leads to reduced infection rates. Another example from this study is, that failure to supply such care cost the NHS £787m in clinical negligence pay-outs during 2009–10 (Fenn, Gray, Rickman, Rivero-Arias, & Vencappa, 2013). The concept of risk management in hospital had its beginning in the 1970s in the USA, following court decisions which established the corporate liability of the hospital for the quality of care and holding medical staff liable for quality of care (Singh & Ghatala, 2012).

This paper helps to understand the importance of risk management. Further this paper summarizes theoretical risk management concepts as well as the results of six expert interviews.

2. Theoretical risk and quality management concepts

In general there are differences in how to approach quality in a healthcare system. A more traditional approach is characterized by being problem oriented, retrospective focus, participation by staff is limited and most of the times isolated and random events. On the other side there is the more innovative approach to quality assurance which is most of the times a dual approach with concomitant focus on problem identification and compliance with standards, full staff participation, planned and systematic, specific topic focused on a particular clinical area and based on well-developed nursing standards.

Another definition for risk management from Kleffner is risk management in healthcare promotes a comprehensive framework for making risk management decisions which maximize value protection and creation by managing risk and uncertainty and their connections to total value (Kleffner, Lee, & Mcgannon, 2003).

The marker Umbrella Model (Figure 1) demonstrates that there are nine universal activities that constitute professional quality assurance practice. These nine activities apply to all professional services in all settings. The model directs quality practice by delineating what broad areas should be addressed and demonstrated the interdependent relationship of each (Marker, Carolyn, 1987). All nine activities should be implemented but not necessarily all at once. Each service should determine which three or four activities are initial priorities: develop the methods, mechanisms, and tools to carry out the activities; and then integrate both the activities and the methods into the quality assurance plan. Operationally, each nursing unit or professional service should create a unit quality assurance manual with all nine activities labelled. After the reporting mechanism has summarized, the data being reviewed for the quarter, along with accomplishments, the manual can be thinned of obsolete data. This thinning process maintains the quality assurance manual in an orderly and current manner.

Figure 1: The marker umbrella model

The Market QA Umbrella Model operationally defines QA as nine essential activities occurring at the hospital, department, division or nursing unit level. The Model advocates a dual approach: (1) data sources for early and consistent problem identification and (2) measuring compliance to existing structure, process, and outcome standards. The umbrella components consist of standards, continuing education, credentialing, performance appraisal, audit, concurrent monitoring, utilization review, risk management, and active problem identification. This model offers nursing and other disciplines a sophisticated

and comprehensive approach to professional quality assurance.
The theoretical concept umbrella model quite comprises with nine components, further it combines quality management with risk management which is discussed controversy.

3. Research and results

For this paper, the author chose to conduct semi-structured expert interviews to explore the definition of patient safety. Expert interview is a method of qualitative empirical research, designed to explore expert knowledge, has been developed considerably since the early 1990s (Bogner, Littig, & Menz, 2009).
In a pragmatic perspective – focusing on the local context of knowledge production, the status of expert could be understood as ascribed by the researcher: a person is attributed as expert by virtue of his role as informant. Who is identified as expert and who not depends on the researcher's judgment (Bogner et al., 2009). In the literature there are basically three approaches to define an expert:

1. Voluntaristic: „Everybody is an expert for his/her life"
2. Constructivist: expert role is ascribed by researchers; experts have special knowledge; experts are made by society (special knowledge and specific functions)
3. Sociology of knowledge: experts have special knowledge which is related to their professions; focus on conscious knowledge (not implicit or tacit knowledge)

The experts in this research fulfill all the following four criteria:

a) To be an expert the interviewee must have substantial knowledge of the processes in hospitals, in particular about risk management systems
b) To be an expert the interviewee must have decision power within his/her role
c) To be considered as an expert, the relevant work experience must be more than 10 years
d) To be considered as an expert patient safety has to be part of the wider working context of the daily business of the interviewee

The semi structured expert interviews are all conducted in face-to-face meetings with duration of 90-120 minutes.

Table 1 List of interviewed experts

No	*Profession*	*Working experience*	*Date*	*Location (area code)*
1	Head physician	31 yrs	19/07/2016	93047
2	Head physician	23 yrs	21/07/2016	93086
3	General manager	35 yrs	27/07/2016	10115
4	Head physician	10 yrs	17/08/2016	64839
5	Head physician & general manager	21 yrs	22/09/2016	14193
6	General Managing Physician	16 yrs	21/11/2016	52074

One of the 14 questions in the interviews is "which risk management tools / methods do you know and which do you use in your hospital. To structure the answers of this open question, table 2 shows systematization with the eight categories of marker umbrella model.

Table 2 Comparison marker model and interview results

Marker Umbrella Model	*Experts*
Standards Development	- labels / color coding
Credentialing	- measure financial impact
Continuing education	- trainings
Perfomance appraisal	- measuring of initiatives
Audit	- internal and external audits
Concurrent monitoring	- 4 eye principle - checklists
Utilization review	- prioritising
Risk management	- risk management team - briefings / bi-directional communication
Active problem identification	- debriefings after error occured - CIRS - error reporting ystem

As the table is showing the result of the expert interviews is as diverse as the umbrella marker model. This is an indicator, that there are no clear definitions of risk management in the hospitals. Every interviewee did start with different tools – no real consensus occurred when evaluating the results.
A majority of hospital executives see patient safety and therefore risk management as their top priority. At the same time, an equal amount view failing to maximize financial sustainability as their biggest threat.

4. Conclusions

Both, literature and experts conclude that risk management in hospital is a complex project and has to be considered comprehensively. For further research it is recommended to analyze deeper the potential initiatives in hospitals and the impact of risk management in hospitals. Besides a common understanding of risk management, the following key success factors resulting from the interviews for implementing risk management:

1. Support of senior management: in most hospitals the structures are still very hierarchical, therefore it is essential that the top management supports the risk management
2. Establish a culture of safety – talk about failures; in addition to talk about failures, systems to report errors is essential for risk management (e.g. CIRS)
3. Clear roles and responsibilities: the role of a full time risk manager is the best option
4. Prioritize and rate risks, establish risk maps (likelihood / impact): not only collecting the risks but also scoring and ranking of risks is essential
5. Derive of actions – after identifying and scoring the risks, the last step to success is derive of actions and procedures

Overall, the roles of healthcare risk and quality professionals are evolving in healthcare organizations. In the past, the two functions often operated separately, and individuals responsible for each function had different

lines of reporting - an organizational structure that further divided risk management and quality. Today, risk management and quality improvement efforts in healthcare organizations are rallying behind patient safety and finding ways to work together more effectively and efficiently to ensure that their organizations deliver safe, high-quality patient care and continue to minimize risks.

References

[1] Bogner, A., Littig, B., & Menz, W. (2009). Interviewing Experts. Production, 281. http://doi.org/10.1057/9780230244276

[2] Cole, S. A., Chaudhary, R., & Bang, D. A. (2014). Sustainable risk management for an evolving healthcare arena. Healthcare Financial Management : Journal of the Healthcare Financial Management Association, 68(6), 110–114.

[3] Fenn, P., Gray, A., Rickman, N., Rivero-Arias, O., & Vencappa, D. (2013). The Impact of Risk Management Standards on Patient Safety: The Determinants of MRSA Infections in Acute NHS Hospitals, 2001-08. Oxford Bulletin of Economics and Statistics, 75(3), 340–361. http://doi.org/10.1111/j.1468-0084.2012.00694.x

[4] Kleffner, A. E., Lee, R. B., & Mcgannon, B. (2003). The effect of corporate governance overnance on the use ofenterprise risk management: EVidence from Canada. Risk Management, 6, 53–73.

[5] Marker, Carolyn, G. (1987). The marker umbrella model for quality assurance: monitoring and evaluating professional practice. Journal of Nursing Quality Assurance, 1, 52–63.

[6] Singh, B., & Ghatala, M. H. (2012). Risk Management in Hospitals. International Journal of Innovation, Management and Technology, 3(4), 5.

CONCEPTION OF FINANCIAL PLAN CREATION WITH APPLICATION OF PROGNOSTIC METHOD IN BUSINESS PRACTICE

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Abstract: *Essentials for effective business is planning from which company´s activities are derived. Planning in company allows effective controlling in each of its fields. Business management realized positive contribution of planning. There isn't developed definite technique to create plans on theoretical level. There are some procedures which are known and their elements or links, which is possible to use in process of business planning. This article contains definitions of planning, financial planning and planning method leading off from prognostic method. It concerns with contribution of stakeholders (owners, management, employees, state) in creation of financial plan and in its fulfilment. It analyses positives and negatives of using one or combination of multiple planning methods. Article´s effort is to show possibilities of usage of different methods and by their means there is reachable higher effectivity of planning process. Authors of this article points on innovative approaches applicable right in plan creations which is possible to adjust according to business preferences. On the basis of previous part was defined aim of article to compile financial plan creation with reaching the lowest deviation from real condition of actual financial item.*

Keywords: *plan, planning, financial plan, prognostic method, stakeholders*

1. Introduction

Presumption of effective trading of companies in market economy is process of realisation of planning and fulfilment of plans. Planning belongs to basic managerial functions from which are derived other ones (organising, staff providing and its progress, staff leading, controlling). Planning is process whose result is constructed plan. Business plans are possible to be structured from different point of views, mainly according to planning level, time horizon and content-material concept of plans. According to content-material concept, companies compile different kinds of plans e.g. marketing plan, production plan and material needs, personal plan, financial plan, investment plan, research and development plan etc. Financial planning preserves image about financial items of accounting reports in future periods. Plan can be created according to different methods including prognostic methods which have different preferences in business practice. Authors try to show possible ways by which plan is created more effectively than in using different one-sided oriented methods.

2. Planning and financial planning

Planning,according to Hittmar [1],can be defined as "anticipation, preparation and preservation of future state and next business development." It deals with future states, but in realization of this process is considerably monitored past state and as well current state. If we take planning into account in sense of general activity it is possible to apply it into all fields of business sphere. In case of company plans financial situation it implements financial planning. Planning is useful to decrease insecurity and increase of foresight level of company´s processes. One of the tasks of financial planning is to identify financial impacts which would be called out by decision accepting or by implementing strategy or tactics. Financial planning according to Majtan et al.[2] is possible to define as "process of assessment of total effects of financial and investment decisions whose result is financial plan." It is part of financial control. As Ruckova [6] said result of financial planning process is financial plan which "introduces activity describing current financial situation of company, estimated height of future costs, defined financial aims and way how to achieve these aims." This one has to be compiled accords with accounting reports of company. During construction of financial plan is necessary that company caters for all elements of internal and external environment. Part of financial planning is budgeting which search for possible sources and planned means to reach given aims. Budget is defined as "financial plan in which all supposed profits and costs in specific time period are compared – week, month, but usually year." [4] Within the frame of budgeting are planned items of costs, profits, incomes and expenses. Planning is derived from past periods (e.g. previous accounting periods), in financial plan proposal are economic results of past periods considered. Companies, in process of creating financial plans choose procedures like for example regressive method, proportional share on takings or other methods used as supportive apparatus (analysis of break-even point, global method, creation of financial models). It is necessary, even in use of possible procedure, not to leave out individual control of financial planning which is possible to realize by means of running check as well as final check.

Created financial plan presents added value for stakeholders. Built-up plan serves for more stakeholders and brings bigger or smaller asset. On the basis of plan stakeholder influences its behavior in its benefit. There exists relation between stakeholder and planning, where

group influences planning process by its needs, skills or sources. One of these groups is owner/shareholder. In terms of this plan it knows to determine level of financial resources which are necessary for running and investments in business – so plan influences its behaviour and at the same time needs are taken into consideration in process of planning. After further analysis is able to determine trading income in future accounting periods. Business management is able to clearly define expected output of subordinates and so create effective motivational environment in team. Mostly, employee should come into contact with plan. By means of plan is clearly defined what is employee expected to do and how his work will be helpful for business. Employee on the basis of plans can adjust his working service to achieve these results. Plan can create motivational base for this stakeholder. Specific stakeholder is state which experiences value mainly in case of public sector. State representatives limit state companies which have to produce on the basis of these regulated plans. Other kind of companies are companies which state supports with subsidy. These businesses draw up plans for state needs to have level of subsidies on suitable level. Financial plan has substantiation for more stakeholders which can their behaviour and output influence by plan requirements.

3. Planning methods coming out from prognostic method

There exists couple of various methods serving to creation of specific form of plans. In case of financial plans there is possibility to use many and all at once. One of the possibilities is using so-called naive models. This kind of planning monitors minimum of specific item in previous periods. Method expresses hypothesis talking about relation between two values of specific monitored variable. These models is possible to use even in small number of observations and so in financial planning there is possibility to apply them in items which emerged before relatively short time period. Mathematically there is possible to express relation this way:

$$\hat{y}_{n+1} = y_n$$

where, $\hat{y}_{n+1}$is level of predicted item in next period and $y_n$is item level in current period

In this case value of prognostic item takes over level of specific item in directly previous period. Assumption for using this method is fact that aroused relation error is only accidental and its mean value is null and dispersal is constant.

In case of previous application way of naive modelthere was only monitored one period. There exists its equivalent which shows increase or decrease in the same degree as it is nowadays. This mathematical relation can be defined this way:

$$\hat{y}_{n+1} = y_n + (y_n - y_{n-1})$$

where, y_{n-1} is level of specific item in directly previous period

Marcek et al. [3] declare that "results of concrete realisation of effects are usually depicted and they have character of concrete system of empiric examinations." In using of this procedure is necessary that business disposes of minimally two empiric examinations. This kind of naive model is used in case of existence of change expectation (increase or decrease) of specific item and it is in similar degree as it was in previous examinations.

The third variation of naive model is perceiving of change level by means of more accurate method than absolute change. This relation is possible to identify like this:

$$\hat{y}_{n+1} = y_n \frac{y_n}{y_{n-1}}$$

In general it stands that this kind of prediction of future state is possible to use in case of expecting of exponentially variable growth. In absolute expression addition changes are growing. If there is decline of variable value, curve isn't as steep as it is in case of growth.

Naive methods belong to one of the essentials ways how to determine future progress of monitored variable. Necessary information base is narrow, but despite it there is important to approach to planned items individually and consider their development.

Average growth coefficient is another possibility of financial plan creation. It is introduced to rate indexes showing future development of time lines. It is method which deliberates longer time lines by means of which there is defined optimal increase or decrease of planned variable. Data of available time lines "make order of values (examinations) about specific quantitative event of socio-economic phenomenon which is chronologically ordered in time" [3] During using of this method it is in force that the more previous data we have the notice value of planned item is bigger. Problem begins when noticeable deviation came up within previous time periods. It can have unfavourable influence on final variable. Mathematical relation of average coefficient of growth is:

$$\bar{k} = \sqrt[n-1]{\frac{y_n}{y_1}}$$

where, $\bar{k}$ is average coefficient of growth, y_1 is value of variable where time line begins and $y_n$is value of variable in last period of time line.

This way of calculating is basically geometric mean n – 1 of coefficients of specific time line. Only first and last value of line is taken into account and it is reason why monotonicity or noticeable fluctuation don´t influence last value of variable. Coefficient expresses how many changes were there at an average between first and last measuring. It gives information about value of item growth by percentage share during making provision for more time periods. By means of average coefficient of growth there is made provision for bigger dynamics of development of planned item as it was in previous case of using naive models.

Another way of prognosticating of future state of planned item by means of linear model. Its relation is mathematically shown here:

$$\hat{y}_t = \hat{b}_0 + \hat{b}_1 x_t$$

where, $\hat{y}_t$is estimation of linear regression model in t-th time examination, $\hat{b}_0$is estimation of constant value of linear regression model, $\hat{b}_1$is estimation fo coefficient value b_1 of linear regression model and $x_t$is independent variable in time t.

This way of prediction of future states of planned items is focused on time lines which are long enough. "Linear models shows generalization of regress analysis on model relation between more interval dependent variables and one or more independent variables." [5] By means of this method are monitored differences of individual time periods and on their basis defined function designates optimal planned value of variable. By this way straight line expressing past periods point straight line into future. "The most often used estimated criterion is minimum of addition of squares of deviations intended as difference between watched values of explained parameter and its calculated values." [3] Method is realised by means of method of the smallest squares which is based on two elemental conditions:

- Addition of deviations of real and balanced values must be equal to null
- Addition of square power (squares) of deviations of real and balanced values must be minimal." [7]

Linear model isn´t appropriate to implement in inducting of a new item, whereas development in this case isn´t linear.

4. Application summary of prognostic methods

Part of each managerial function is making decisions. In case of planning making decisions consists of defining of used method of future state prediction. Not every time is necessary to decide for one of possible ways.

Businesses often decide for naive models. Their advantage is needed short time line for gaining of relevant predicted variable. In case of that business created new item of plan, which didn´t register before, using of this way is suitable. Using of other one from mentioned methods wouldn't bring such effect as it is in this way of detecting future development of monitored item. Disadvantage is that if we had enough examinations we would only use small part of data. These data have their value which can be increased by their processing. There can arise deviation from real state which will get multiple item value. During application of naive models is true that it is necessary to have personal involvement to individual items. Decision about the same level of all planned items (the first from described ways) as it was in directly previous periods is risky and we can say that improbable. One of the reasons is always changing market environment and behaviour of customers. Another advantage is simplicity of using of naive models. Question is whether this advantage can´t show as negative on noticed value of such arranged plan. As the individual name of methods shows their using is idealistic and naive.

Average growth coefficient makes provision of longer time period so more time data. Its notice value is bigger as it is seen in naive models. Longer time line gives information about dynamism of influencing factors which affect planned variable. Advantage is wider view of examination of influence of external agents of business environment. Significantly bigger is difficulty of data processing needed in this kind of prediction. Elaborateness of method responds to results in which are item deviations from real state relatively low. Another disadvantage is that method, like previous ones, doesn't bargain for aims defined by company. These are important to be integrated into plans by means of individual approach of responsible employees who adjust the items. Plan made this way will have higher value for more stakeholders. Employees will be significantly influenced positive way whereas fulfilment of individual items will be considerably easier, because plan is accessible if we take into account level of deviation.

Linear model method is achievable creating of a plan which has high notice value, too. Problem begins when planned items don't have linear trend. You can see from the name that it is one of the conditions of method application. Disadvantage is hard calculation. It is almost necessary to have software to calculate linear model. Its use is advantage right in items with sufficient amount of data from previous time periods. In this case is made provision for dynamics of influencing environment factors, too. Plenty of previous time periods isn't necessary condition for use of a model. There exists continual proportion between data amount and level of value of created plan for stakeholders of company. Like in case of average coefficient growth even in this way of prognosticating these groups feel value of a plan, but only when method is applied correctly.

5. Use of combination of prognostic method

Each of mentioned prognostic methods has its advantages and disadvantages of use. Their display will be earlier or later seen on quality of plans and ultimately on quality of output of individual stakeholders, too. In process of planning there is necessary to accept more decisions. One of the most important decisions is choosing of a method according to which plans will be created. This decision is important factor which influence final plan. It isn't necessary to decide only for one of the methods. Individual approach to separate planning items can be achieved maximal effect in which advantages of the method will be used and partly or absolutely eliminated their negative displays. For this approach there is necessity of intern involvement of plan creator who knows individual business processes.

In case of activities realisation connected with creation of article there was generated financial plan of company by this described way. For reaching of high notice value there were data from more time periods analysed by means of all methods of prognosticating described in this article. Nevertheless that items were planned by means of various methods, not every time it was possible to presume that specific item will in future periods gain level which concrete method identified. After further analysis it was necessary to consider another possibilities where by averaging of two or more ways start up more probable

values of planned variables. Their anticipated deviations were estimated by main economist of a company who has known functioning of production processes as well as defined aims of a company. On this basis was created graphic formulation of prognostic methods and implemented for business financial plans.

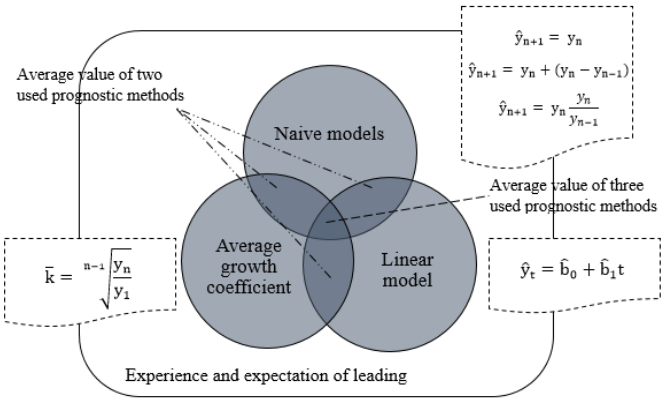

Figure 1: Financial planning of businesses with use of various prognostic methods

Figure documents individual possibilities of prognostic methods use. If we only use one method it isn't always effective so intersections shows arithmetic means of two or three ways of financial plan creating. Use of experience and leading expectations can´t absent because this influence lower deviation level of individual planned items.

During testing of applicability of this way of financial plan creation there was chosen procedure which is so called back in time. This procedure consist of analyse directly previous period by means of described methods. There was created complex plan comparable with last period. After comparison there were detected small deviations which were often caused by unpredictable situations. Despite of this finding, deviation level was acceptable. In contrast to other ways of plan creation this one gives possibilities to his creator from which is capable to choose the most probable in dependence on experience and on the basis personal interval presumption of item level. This positive expose of methods use caused integration of personal experience and knowing of defined business aims.

Time intensity as well as elaborateness itself of way of prediction of planned items is considerably higher than in case of use of only one method. However, none of prognostic methods doesn't make provision for other internal and external factors of environment as in the case of use of described methods and their combinations. In spite of this fact choosing of this way of planning gives considerably higher added value to stakeholders. This value will mostly comprise of more precise plans and on their basis is possible to adjust working outputs. With this matter of fact is connected clear specification of workload and level of expected outputs. This value will be visible at the end of future period when process of comparison and summarization of results reveals minimal deviations from real state of planned state.

6. Conclusion

Significance of company planning is mostly in revealing of future states which can be positive or negative. From good-quality planning process is derived good-quality of created plans, too. Companies have more possibilities how to approach to their creation. There exist several prognostic methods and on their basis there is possible to investigate and after that estimate individual items.

Plan should get into the contact with specific stakeholders of business and that in its creation but in its fulfilment by realisation of business outputs, too. These subjects should make provision for individual items and adjust its working activities in dependence on level of items which they can influence. Sooner or later change will be visible and it is possible to presume that it will bring value to specific stakeholder or other.

In process of planning there comes to making decisions about number and type of planning methods. The easiest way is choice of only one planning method. This way can be beneficial in some cases which consists of calculation simplicity and short time period requirement. This type of plan creation doesn't make provision for other factors which influence business running. They provide information about possible shift of items from purely statistic angle in consideration of all previous time periods. Article gives possible approach which takes into account various influencing variables of plan items. It is reachable by choice possibility which is offered to plan creator. Possibly there is possible to integrate more specialists from different fields and so reach harmony of production and other departments which knows their defined aims as well as other business elements.

There is possibility to achieve minimal deviations by method of use of more prognostic methods and their consecutive combination. Aim of article was elaboration of conception of financial plan creation with reaching the lowest deviations from real state of specific financial item. By means of authors depicted approach this aim in business practice is achievable significantly easier and more effective way. Procedure choice is on the basis of companies 'choice with regard on authors´ recommendations.Likewise other conceptions it is possible, sometimes necessary, to adjust depicted conception according to business needs. It isn't possible to create unified procedure applicable for all business subjects. Likewise it is in case of planning conception. Depicted conception gives possibilities which can increase value for various business stakeholders.

References

[1] HITTMAR, S., 2006, *Manazment – teoreticke a prakticke otazky riadeniaspolocensko-ekonomickych systemov.* Zilina – EDIS, Slovakia, 2006, p. 177.

[2] MAJTAN. S. and kol., 2009, *Podnikovehospodarstvo.* Bratislava: Sprint dva, Slovakia, 2009, p. 318.

[3] MARCEK, D. – PANCIKOVA, L. – MARCEK, M., 2008, *Ekonometria a soft computing.* Zilina – EDIS, Slovakia, 2008, p. 269.

[4] NEUBAUEROVA, E. – BELICKOVA, K., 2005, *Nastrojeekonomikyverejnehosektora.* Bratislava: MERKURY, s. r. o., Slovakia, 2005, p. 182.
[5] RIMARCIK, M., 2007, *Statistika pre prax.* author published, 2007, p. 199.
[6] RUCKOVA, P., 2011, *Financnianalyza.* Praha: GRADA Publishing, Czech Republic, 2011, p. 144.
[7] STEDRON, B. – POTUCEK, M. – KNAPEK, J. – MAZOUCH, P. and kol., 2012, *Prognosticke metody a jejich aplikace.* Praha: C.H. Beck, Czech Republic, 2012, p. 198.

OPTIMIZATION OF PROCESSES ON THE FAMILY ANIMAL FARM BY INCLUDING MAINTENANCE INTO ROUTINE PROCESSES

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Abstract: *This paper deals with solving problems that some farmers in livestock production domain in Slovakia meet daily. Nowadays also for small size farming technical devices are necessary because they fasten the work and/or they can manipulate with heavy elements. If the farmer wants to benefit from the use of different machines, these machines has to be in a good condition besides other relative facts. The aim of this paper is to point specially on the case when farmer neglects the maintenance works on the machinery and he only solves critical situations when the machine is not able to fill the work to which it was dedicated such as the failure. It is presenting reasons and solutions why and how include the machinery maintenance in necessary processes realized through the whole year.*

Keywords: *farmer, machine maintenance, failure, processes optimization, small scale sheep farming*

1. Introduction

There exist different approaches of farmers to small scale sheep farming. Because the characteristics of different approaches, their comparison and searching for their optimal combination is not the aim of this article, we only can encourage and direct curious readers to consult convenient literature sources.

Between facts which are important for us and support our orientation on processes running at the farm belong:

- Sheep breeding is in Slovakia considered as a typical sign of our culture, it belongs into so-called cultural heritage. This is the reason why it should be in the interest of all of us to preserve this kind of farm management [9] by financial or knowledge based aid even it is not a part of Representative list cultural heritage of Slovakia [10].
- Animal mass production generates 18% of greenhouse gas but in case of small size farming this percentage decreases [7] and is friendlier to nature.
- Sheep-punching helps to maintain and conserve different biotopes situated at foothills and/or mountain regions.

These information declare our justified interest in this sector as operations manager.

The life of a farmer is hard, it has a big influence on his lifestyle and so it is reasonable to find ways how to make him this task easier.

We will describe the case of one farmer which is not unique in Slovakia that is why it can serve as an illustrative example. He has 150 sheep which need to be shepherd, 120 of them need to be milked (1-3 times a day depending on time which passed from being yeaning), transform the milk into dairy products, prepare the food for winter period (hay) for all them and some extra for new lambs, and clean up the barn (manure disposal). These are only activities that a farmer makes himself. Also, there are activities which are ensured by external suppliers such as the medical care and sheep shearing. Obviously the farmer had to make a decision make or buy.

The figure 1 presents activities executed by farmer himself through the whole year.

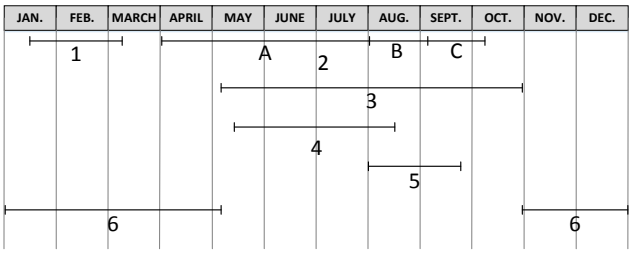

Figure 1: Simple presentation of farmer´s activities executed through the whole year, where activities were replaced by numbers because of readability.
(1)Yeaning (natural/manual help)
(2) Milking process (manual) and milk transportation (manual/mechanical)
A 3 times a day; B 2 times a day; C once a day
(3) Transport of water to summer stage (mechanical)
(4) Preparation of hay (mechanical)
(5) Manure disposal (mechanical)
(6)Feeding during winter (manual/mechanical)

As it is visible on the figure 1, mechanization ensures activities related to preparation of food reserve for winter, manipulation with bales of hay from the place of stocking to the place of consumption, regular transport of water tank to the summer stage of sheep that means close to the milking stage, transport of milk from milking stage to transformation station, and to cleaning the barn and manure disposal.

Among devices that farmer needs for his work during the year belong:

- *tractor* – the core device, it is multifunctional, it can be exploited for different activities at farm. Usually it is not used separately but as a carrier element and

actuator for additive equipment. It is the most exploited during the summer for hay preparation and barn cleaning. The failure of tractor has as a consequence interruption of almost all mechanized activities. It is also the reason why is the farmer owning more than one tractor.

- *tractor attachments* such as:
  - different transporters – for hay transport, for manure disposal,
  - water tank,
  - attachments to prepare and treat the hay – the disk mowers, the hay tedder to spread the hay, the rake to collect hay, the hay baler, and round bale wrapper,
  - skid-steer loader (bobcat) – is used to manipulate with hay bales and for cleaning the barn soil from the manure,
- *car* – ideally with higher chassis for transport sheep´s summer stage for milking and for transport of milk to be treated,
- milking machine – the use of this machine has been shown to farmer as non-economical investment because of high operational costs for mentioned number of sheep that is why he is milking manually even it means doubling time expenditure (1 manual milking takes in average 1 and ¾ hour).

All machinery is not under any shelter, so it suffers from weather conditions through the whole year.

The above mentioned machines are not new even not maintained (it means that they are no under maintenance works). All correcting operations are made only after the failure occurs. That causes the waste of time which is extremely precious in summer time because of (1) big quantity of activities to be done and (2) because of dependence on weather.

The farmer is not doing maintenance works because he do not know to do it. To do maintenance works would mean for him or to learn it but he has no time to do it because of other work he has to do or to delegate the maintenance to another person and pay him for this service. But here we brush up against a great obstacle for insertion of maintenance among other regular activities.

Actually, breakdowns of machines are solved operatively with the help of one neighbor who is an expert enthusiast in the domain of agricultural machines, mainly tractors. He is able to repair machines relatively quickly and he is not asking for financial refundment for offered service.

For this reason we would like to propose to the farmer the plan for maintenance management and to insert this activity among other activities necessarily conducted in the farm. And point also to a fact that it is more advantageous from the economic point of view. And here we hit another problem: the farmer has no exact recording of performances so he is not able to objectively judge and evaluate how expensive is neglecting the maintenance. He is doing it as a makeshift.

2. Farm machine maintenance

Machines and devices which are in permanent use and so they fill the aim to which they were intended do sometimes suffer from failures. Expected as well as no expected [1]. As the age of machine is higher the probability of no expected failures occurrence increases. So because machines and devices of our farmer are older, more important the maintenance is [6] (see figure 2). The maintenance increases the reliability of machine which by the opposite decreases the probability of failure occurrence. Mainly failures by deterioration.

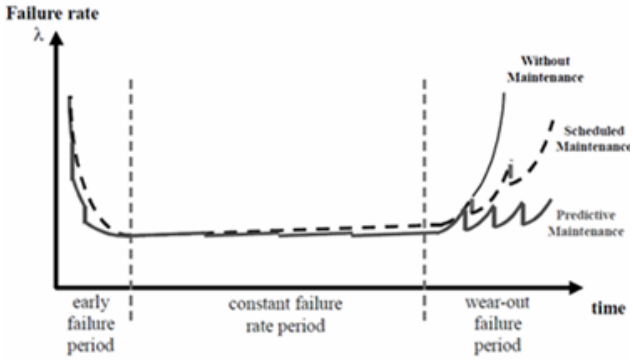

Figure 2: Model presenting the running of the machine with the potential of failure occurrence through the time (source [8]).

Despite large researches and declared advantages of doing maintenance, many organizations are not doing it. They only make reparations after the machine´s breakdown [5]. This approach significantly influence the fluency of running operations and decreases thereby their productivity rate. And that is in spite of Bateman [2] who emphasized that besides the reactive maintenance, there is also maintenance preventive a predictive.

The reactive maintenance is an already mentioned case, when intervention into machine is made only after the defect occurs. It is not possible to predict it so event the corrective intervention cannot be planned.

Opposite to that there exists a maintenance preventive which is realized regularly always in predetermined moments. It is executed in spite of the fact that the machine is running. But this corrective intervention can prevent no expected failures in the less convenient moments. So the probability of failure occurrence decreases. The possibility to plan the maintenance permits to plan the shutdown to the moment the most acceptable according to production interruption. This is the greatest advantage of the preventive maintenance.

Predictive maintenance together with diagnostic maintenance belong to the group of control-based maintenance [3].

Predictive maintenance is also the kind of maintenance which anticipates the occurrence of loss-causing event which certainly contain production interruption. But it is realized due to defined level of probability indicating the occurrence of a particular error on machine. That means that is not realized regularly, but enough in advance. The advantage resides on the elimination of number of machine running interruptions as lowest as possible. The technique chosen to detect the probability of machine failure has to

take into account a time. It is a waiting time between problem identification till its correction during which machine cannot break down. In comparison to preventive maintenance, predictive is less frequent but more expensive.
Another kind of control-based maintenance is a diagnostic maintenance. It is based on detection of real state of machine´s material components [3]. This kind of maintenance is typical for motor vehicles being serviced in car services between which belong tractors for example. Diagnostic components are necessary for this kind of maintenance and are too expensive for a small farmer.
In the scientific literature the subject of maintenance is often joined to scheduling [1] [4]. This is obvious from characteristics of different maintenance types. But the planning of activities typical for processes in the farm is subject to "caprices of the nature". That concerns mainly activities which are more demanding on mechanization or which are even dependent on it (mowing, bales transportation, manipulation with bales, manure disposal…).

3. Recommendations for a small farmer

From the above mentioned results that for our small farmer with the midsized sheep herd is the most suitable the preventive maintenance. It can be very well planned for the period when machines are not in use or are used only occasionally. Because if the machine break down in the middle of the "hay season" this failure can have existential consequences. May be the farmer would resign to farming, but it is not desirable from the point of view of higher interests presented in the introduction. The most critical is the season of hay preparation for the herd … the failure of machine(s) can result in radical decisions.
If the farmer includes the maintenance of his machinery in the winter period when he uses only a fragment of his machinery and only rarely, it will be more probable, that the hay will be prepared and stored before the rain turns it into a damage.
Modified figure with included preventive maintenance should look like on the figure 3.
The first step towards implementation of preventive maintenance is to make a study make or buy to be able make a right decision. Decision making process make or buy is based on economic data, i.e. to evaluate self-maintenance costs because than it is easy to compare to an offer of any external serviceman.
As we know, the mentioned neighbor expert enthusiast would like to continue to take care of farmer´s machinery in refundment conditions as they are set actually (in kind) but he also prefers the preventive maintenance to failure corrections. He said and proposed it to a farmer.

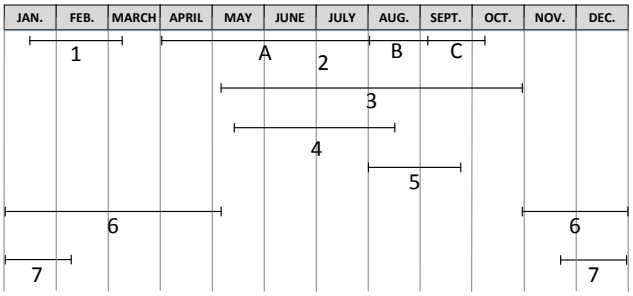

Figure 3: Simple presentation of farmer´s activities executed through the whole year with included maintenance, where activities were replaced by the same numbers as on fig.2 because of readability. (7) Predictive maintenance

Because farmer did not make any steps towards including maintenance to regular processes in the farm. There may be two reasons to this attitude: (1) the farmer do not believe in any changes after including preventive maintenance to routine processes, he cannot see a deeper implication, or (2) he is afraid of increased expenses (build a shelter for machines, pay serviceman/stronger commit towards neighbor, more spare parts required). For these two reason we recommend to farmer to accept the guidance from people who understand problems touching his farming. Example can be found in neighborhood where another farmer has a shepherd and is doing his job with a complete review of his expenses and incomes. So for this farmer, it is easier to make decision make or buy, because he is able to make comparisons.
We are convinced, that our farmer should start to optimize his processes and to start maintaining its machinery is the easiest way for reaching desired optimization.

4. Conclusion

Our allegation that also a small farmer should do the preventive maintenance is reinforced also by the fact that bigger farmers are maintaining their machinery during winter period for years. The failure of the machine in the middle of the harvest would cause them decreases of their incomes so it may cause losses from interrupted production. For example car plant Volkswagen reckoned the loss of 1 hour lasting shutdown of the production line on 1 million Euros. To calculate losses in case of our farmer is not easy, because he can finish his hay bales production in case of favorable weather. Losses of our farmer are highly influenced by the risk of adverse weather combined with the risk of machine failure which is increasing with the age of the machine and with its no-maintenance.
In the future, it would be useful to deal with the problem of small farmers deeper. The scope of whole farmer´s production process optimization remains open. It would be useful to deal with issues like data collection, economic evaluation of farming (including all processes), planning different activities, etc. However it is not possible neither desirable to plan in the long term but it should be operational management (besides preventive maintenance which should be set for winter time). When it is harvest

period or hay preparation period, farmers do not care if it is Friday or holiday. To be in full alert for and during season, the every farmer needs to have his machinery in a state that he can rely on it. He can rely on it in case when the maintenance was made and so was decreased the probability of failure occurrence.

With regard to protecting our cultural heritage, farmers are not asked to do everything manually. But it is neither possible to do everything like our ancestors did. Our farmer does not want to mechanize all operations on the farm, but on the other side he does not want to return back in future and do hay preparation manually. He needs machines to keep the standard of production, but he also needs to realize, that machine maintenance will be in his favor.

References

[1] Aghezzaf, E.-H., Khatab, A., & Tam, P. L. (2016). *Reliability Engineering & System Safety*, Vol. 145, pp. 190-198, 2016.

[2] Bateman, J. F., *Industrial management*, Vol. 37, No. 1, pp. 19-21, 1995

[3] Jardine, A. K., Lin, D., & Banjevic, D. *Mechanical Systems and Signal Processing*, Vol. 20, No. 7, pp. 1483-1510, 2006

[4] Su, L.H. & Wang, H.-M., *Computers and industrial engineering*, Vol. 103, pp. 242-249, January 2017

[5] Swanson, L., *International Journal of Production Economics*, Vol. 70, No. 3, pp. 237-244, 2001.

[6] Yang, L., Ma, X., Peng, R., Zai, Q., & Zhao, Y., *Reliability Engineering & System Safety*, Vol. 160, pp. 201-211, 2017.

[7] Intergovernmental Panel on Climate Change – Working group III., March 2001 http://www.ipcc.ch/ipccreports/tar/wg3/index.php?idp=0

[8]https://tmilinovic.wordpress.com/2013/08/26/predictive-maintenance-by-using-r-statistical-language-for-predictive-analytics/

[9] http://www.ludovakultura.sk/index.php?id=4298

[10] http://www.unesco.sk/reprezentativny-zoznam-nehmotneho-kulturneho-dedicstva-Slovenska

Session: Economy, Financing, Public Administration

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BARRIERS TO DEVELOPMENT OF SMALL AND MEDIUM ENTERPRISES SECTOR IN POLAND

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Abstract: *Small and medium-sized enterprises are the basis of Poland's economy, but many barriers prevent them from developing. Therefore their identification and possible attempt to reduce these barriers are of great importance for entrepreneurs. Thus, the general aim of these considerations is to analyze barriers to the development of the SME sector. Both in the literature of the subject and in business practice there are a number of barriers, both on the business environment side and inside. Analysis of the discussed matter allows to indicate many barriers limiting the development of enterprises operating in the Polish economy. Therefore, it is worthwhile to trace the condensed characteristics of the most relevant ones. Unfortunately, it is difficult to clearly indicate the significance of individual barriers, especially since some of them are of different importance for particular groups of entities.*

Keywords: *development barriers, SME sector, Polish economy*

1. Introduction

The sector of small and medium-sized enterprises, the SME sector is a mix of both private and public sector, which consists of small, medium and micro enterprises. The term "medium and small enterprises" is used in the international business arena. It is used not only by European Union countries, but also by the World Bank, the United Nations and the World Trade Organization.

In Poland, the sector of small and medium-sized enterprises was discovered in the 1990s. "The government, in taking concrete steps to delineate the path of development and to support those weaker market participants, implemented the following programs: in 1995, *the Small and Medium Sized Enterprises in the economy* Program, in 1999 *Directions of government actions towards small and medium enterprises up to 2002 and in 2002. First of all entrepreneurship"* [1]. After the transformation period, Polish entrepreneurs gained access to various branches of the economy, which led to the development of private entrepreneurship sector. Thanks to the abolition of legal restrictions that were characteristic of communism, citizens could create and build their own initiatives. As it was a period of dynamic growth of the businesses and the economy market was open and receptive to new ideas, a large number of small and medium-sized businesses emerged at that time. It was precisely thanks to the establishment of the SME sector that the unemployment in Poland was limited, which allowed the development of individual regions influencing the activation of the entire economy [1]. At present, the development of small and medium enterprises is practically the only chance to increase employment as well as to effectively compete for the Polish economy on the international arena. However, there is a number of barriers to the development and proper functioning of these entities. Therefore, this article is intended to discuss the most important of them.

2. Barriers to the development of SME

Small and medium-sized companies, despite the fact that they are extremely important for the Polish economy, they constantly need to confront obstacles and dangers that are an impediment to their development. As a consequence, it also blocks the development of the entire economy.

Literature qualifies these risks in two ways. These are internal and external barriers. External dangers include:

- market threats, it means that they are most often the result of low purchasing power of society. This is a consequence of a reduction in market demand that results in a reduction in the turnover of small businesses. "Significant threats to business development are the aggressive effects of competition, above all the growing number of domestic competitors, and the risks of greater liberalization of trade with the EU" [2]. The financial problems of small businesses are also related to the expansion of medium and large companies. In addition, there is a danger of a low number of orders, as well as finding other outlets and finding distributors distributing the products of these companies;
- limitations of human resources, which are associated with showing reluctance of certain groups of employees to work in small and medium-sized enterprises. Such barriers are usually danger for small, private companies. The problem is also the low activity of employees in the change of place of residence in order to take a job in another city/country [3]. Threat to the development of the SME sector is also the lack of qualified production staff. HR risks include also the lack of appropriately educated executives, but also the reluctance of employers to sign contracts for an indefinite period, to bind employees to the company. The result is that employees move to other economic entities [2];
- Financial barriers - the fundamental financial threat are the problems that arise from the lack of access to the commercial sector. This is due both to the high

cost of capital and the need for large loan guarantees, which is connected to the complex, tedious and lengthy process of processing loan applications. The SME sector is also exposed to problems arising in the provision of banking services, where they have to deal with:

- high fees and bank commissions,
- low quality of banking services,
- insufficient competencies of bank employees [4].

The biggest barrier to the development of small enterprises is the lack of financial resources for development and the difficulty in raising capital from external sources [5], mainly in the form of bank loans [6]. Factors that limit develompent include rising production costs, wherein sources of this growth are outside the enterprises. These are the rising prices of raw materials and materials, labor costs, excise taxes, etc., which lowers the profits of entrepreneurs by narrowing down the scale of possible investments [7];

- social barriers, these risks are mainly due to the low social prestige of the entrepreneurs. Lack of respect for small entrepreneurs does not affect their image and respect well, causing that fewer and fewer people want to start their own businesses. In addition, a small entrepreneur is often seen as a combiner because he does not show ethics in his pursuit of business, only being set for maximum profit [4];
- Threats resulting from inappropriate economic policy - inadequate economic policy pose a threat to the SME sector, as a result of very general regulations, lack of financial support for small and medium-sized businesses, which consequently slows their development. Social insurance is also the problem. It is due to complicated procedures for transferring data to social insurance institution, divergent interpretations of the rules, as well as errors in the software. The tax system is also a threat, primarily paying too much taxes [8];
- Threats due to low availability of infrastructure and its quality - the lack of adequate road conditions or the low number of motorways affect barriers to transport and communication. Entities based in rural areas are often confronted with the lack of appropriate policy for wastewater treatment or water management. Other problems may also be problems with electrification of rural areas, which do not fully meet the standards and also hinder the development of small and medium enterprises;
- legal barriers, resulting from the lack of information policy on the development of the SME sector, and the overly complex provisions of the Law on Economic Law that concern the opening and running of the business. The barrier is also the instability of economic law and innumerable regulations, amendments to laws or different interpretations of regulations, which result, among others, from being a member of the European Union [8].

External threats also include a small amount of information on the development opportunities of the SME sector, primarily relating to programs targeting small and medium-sized enterprises and the introduction of new legal solutions for this sector. The barrier is also the lack of education in the range of running, setting up and functioning of small and medium-sized enterprises, for example (too little or no training in running own business) [9].

The second category of threats to the development of small and medium-sized enterprises are internal barriers, i.e., threats resulting from poor management quality, size of activity or mistakes made during production. An extremely important group of threats to running a business are barriers related to the management of an economic entity. These include, in particular, errors resulting from:

- lack of appropriate qualifications and abilities to manage the business by owners and managers,
- lack of skills and qualifications in sales, marketing, etc.,
- lack of qualifications in financial management,
- lack of qualifications in terms of access to information sources and opportunities that appear at the market,
- lack of development strategy,
- poor location of the company,
- dependence on one target group [8].

The dangers resulting from the erroneous management of an enterprise make it lose its image in the economic arena. Management should be properly educated paying special attention to the leadership of the team. The company should primarily has a readily available location and a product, or service tailored to the needs of the customer. Among organizational structures there should not be any communication problems. It can cause malfunction and low level of work. It should also be noted that management errors can be caused by lack of knowledge of modern management techniques, not receiving information sent from the environment, or lack of willingness of the owner to get acquainted with the current trends in running a business.

Another threat to small and medium-sized enterprises is the threat of barriers to production. Lack of investment in new technologies, continuous working on worn-out machines, may result in poor quality of services or goods. It also happens that an enterprise with outdated machinery is not able to accept order that require new technology from the company. The SME sector is also struggling with the lack of opportunities, mainly financial, in keeping up with technical progress [2].

Internal barriers to the development of small and medium-sized enterprises also include risks related to the size of the business. The most common problem faced by the SME sector is the inadequate location of the premises, which is a misplaced seat due to the excessive price of renting or buying premises and an attractive location. Businesses tend to choose cheaper locations located in the wrong place with difficult access. "Other barriers to the development of SME sector companies are the costs of repairing the premises and adapting them to the specific nature and size of their activities. The problem may also be the lack of parking spaces near the company headquarters, or the distance from the main communication routes." [2].

The table below summarizes the major barriers and threats to the development of small and medium-sized enterprises:

Table 1 Risks and barriers for SMEs

Risks and barriers to the development of small and medium-sized enterprises	
Internal barriers	*External barriers*
Incorrect management	HR barriers
Threats resulting from the size of the business	Market threats
Production barriers	Financial barriers
	Social barriers
	Legal barriers
	Threats resulting from the wrong economic policy
	Barriers arising from lack of or insufficient quality of infrastructure
	Barriers resulting from a small amount of information

Source: own elaboration based on: [2]

3. Conclusions

The barriers within Polish companies and their surroundings indicate the necessity of pursuing a well-targeted economic policy, especially industrial and pro-innovation, which is business friendly.

Comparing some of the problems faced by small and medium-sized enterprises, one can see a resemblance to the problems faced by large companies. However, taking into account the specific nature of the business and the budget of the SME sector, these difficulties are incomparably more problematic for small and medium-sized enterprises. To support the development of small and medium-sized enterprises, the state should demonstrate greater support for this sector, both in financial and in education matter, for future entrepreneurs.

References

[1] Wielgus G., *Rozwój sektora małych i średnich przedsiębiorstw w Polsce*, GUS, Cracow 2006, p. 128.

[2] Matejun M., *Wewnętrzne bariery rozwoju firm sektora MSP*, [w:] S. Lachiewicz (ed.), *Zarządzanie rozwojem organizacji*, Volume II, Wydawnictwo Politechniki Łódzkiej, Łódź 2007, pp. 123; 124; 125.

[3] Kwiatkowska W., *Aktywność zawodowa ludności w Polsce. Determinanty, tendencje i struktura*, [w:] E. Dworak, T. Grabia, W. Kasperkiewicz, W. Kwiatkowska, *Gospodarka oparta na wiedzy, innowacyjność i rynek pracy*, Wydawnictwo Uniwersytetu Łódzkiego, Łódź 2014, pp. 111-138.

[4] Piasecki B., *Przedsiębiorczość i mała firma, teoria i praktyka*, UŁ, Łódź 2000, pp. 186; 190.

[5] Woźniak M., *Instrumenty wspierające dostęp małych i średnich przedsiębiorstw do kapitału obcego w Polsce na tle innych krajów Unii Europejskiej*, [w:] A. P. Balcerzak, E. Rogalska (ed.), *Stymulowanie innowacyjności i konkurencyjności przedsiębiorstwa w otoczeniu globalnej gospodarki wiedzy*, Wydawnictwo Naukowe Uniwersytetu Mikołaja Kopernika, Toruń 2010, pp. 255-267.

[6] Lipińska-Tyburczy S., *Dostępność kredytu bankowego dla przedsiębiorstw sektora MSP*, [w:] A. P. Balcerzak, E. Rogalska (ed.), *Stymulowanie innowacyjności i konkurencyjności przedsiębiorstwa w otoczeniu globalnej gospodarki wiedzy*, Wydawnictwo Naukowe Uniwersytetu Mikołaja Kopernika, Toruń 2010, pp. 239-253.

[7] Kosiedowski W., *Przedsiębiorczość i innowacyjność jako czynniki rozwoju regionalnego i lokalnego*, Włocławek 2002, pp. 226-228.

[8] Lachiewicz S., Matejun M., *Specyfika zarządzania małymi i średnimi przedsiębiorstwami,* Difin, Warsaw 2012, p. 28.

[9] Mikuła B., Pietruszka-Okryl A., Potocki A., (ed.), *Podstawy zarządzania przedsiębiorstwami w gospodarce opartej na wiedzy*, Difin, Warsaw 2007, pp. 113-138.

APPLICATION OF COMPARATIVE LAW IN LEGAL INTERPRETATION – THE DERIVATIVE CONCEPT OF LEGAL INTERPRETATION

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Abstract: *The article deals with a special kind of comparative studies, namely comparative law. It does not, however, aim to present considerations, which is the domain of comparative law. On the contrary, the content of the article - apart from a brief introduction to the theory of comparative law – focuses on its application in the practice of law, and more specifically in the process of legal interpretation, under the Polish derivative concept of legal interpretation developed by M. Zielinski. Importantly, in addition to presenting the views expressed in the literature, the article shares the author's own perspective and refers to the views expressed in case law (Polish courts).*

Keywords: *comparative law, Polish law, legal interpretation, derivative concept of legal interpretation*

1. Introduction

Comparative law (from Latin *comparo* – to compare) has no universal recognition in the science of law and legal practice. Unfortunately, it is often underestimated, being accused of having little practical application. This, in turn, leads to the belief that comparative law is a sort of scientific curiosity, sometimes complementing university law studies.

This paper aims to challenge this perception of comparative law as it appears that comparative studies can only broaden the knowledge of lawyers and stimulate research discussions, but also – as this article will attempt to demonstrate – constitutes a valuable source of argumentation in justifying legal decisions in the process of legal interpretation, namely the functional interpretation at the perceptual stage of interpretation.

2. The concept of "comparative law"

The definition of "comparative law" is rarely found in the Polish legal literature.

One of the most well-known definitions of that term was introduced by W. Gromski, according to whom comparative law is the branch of jurisprudence dealing with comparative studies of different legal systems [1].

As the very name suggests, the function of comparative law is - generally speaking - to compare different legal systems. Nevertheless, it should be emphasized that according to W. Gromski "these studies [comparative law] aim to determine both similarities and differences in the origin, structure and operation of various legal systems, legal branches, legal institutions and legal norms" [1].

It should be noted that modern comparative law exceeds beyond the comparison of the legal systems of specific states, and it also deals with international legal standards [2].

Furthermore, comparative studies are also concerned with comparing specific legal cultures, as evidenced by the book by Z. Brodecki, M. Konopacka and A. Brodecka-Chamera, published in 2010 under the title of "Komparatystyka kultur prawnych ["Comparative studies of legal cultures"].

This above outline of the definition and the subject of comparative law leads to the conclusion that it does not deal solely with the current state of affairs, but also seeks causes and examines the development of different legal issues. It follows that it is closely linked with the history of law, engaged in the development of legal systems and legal institutions.

There is, however an important difference between comparative law and legal history, expressed in the fact that the latter deals with the vertical comparison of legal systems (comparison of law in terms of time: in the past and in the present, evolution of law over time).

Comparative law, meanwhile examines the very origin and development of a given law (institution, regulation, etc.) in various jurisdictions. More specifically, comparative law focuses on the course of this development of law in different systems, comparing and examining the interactions existing between different legal systems (e.g. the development process of a reception statue on the basis another legal system).

It is worth noting that, despite this above-mentioned divergence, some literature still promotes the view that the development of a given law in one system can be predicted based on the development of that same law in another system. Therefore, comparative law and the history of law should cooperate and complement each other [4] since, together, they form a coherent whole that allows to determine and compare certain legal issues both in terms of their development in time as well as in different legal systems.

3. The derivative concept of legal interpretation

In Poland, the legal theory distinguishes several concepts of legal interpretation, including – one of the most recent – the derivative concept.

This concept first began to assume its shape in 1960 thanks to Z. Ziembliśnki, who then made a distinction between the legal rule and the legal norm. This distinction went on to become one of the fundamental elements of the derivative concept of legal interpretation. The concept was

further developed by the student of Z. Ziembiński, M. Zielinski. Currently, it is being developed by the Poznan-Szczecin school of the theory and philosophy of law [3].
At the same time, it should be stressed that the derivative concept of legal interpretation is not based on the principle that all things linguistically clear are not subject to interpretation (*clara non sunt interpretanda*), as it adopts the rule that every legal provision, even if seemingly unambiguous, should be subject to linguistic and extralinguistic interpretation (*omnia sunt interpretanda*).
The derivative concept of legal interpretation also forms part of the curriculum of university law studies, both at the Adam Mickiewicz University in Poznan and the University of Szczecin, where doctoral legal studies include a separate subject of "legal interpretation" concluded with an examination. Interestingly, lectures on this subject are given by M. Zielinski.

4. The place of comparative law in the process of legal interpretation

Application of comparative arguments in legal interpretation is no *novum* since references to foreign legal systems are common both in the legal literature and in case law.
An example of referencing the solutions adopted by foreign law by the representatives of the legal doctrine can be the textbook by A. Bierć entitled "*Zarys prawa prywatnego. Część ogólna*" [„*The outline of private law. Introduction*"] in which references to legal institutions in different legal systems are used as an argument to justify a given outcome of legal interpretation [5].
On the other hand, an example of referencing foreign legal solutions by case law may be the Supreme Court resolution of 24 April 2014 (Ref. No. III CZP 17/14), in support of which comparative interpretation is applied in reference to foreign legal systems, namely Austrian and French [6].
Referring the above to the possible application of comparative law legal interpretation based on the derivative concept, it should be explained that, in principle, the derivative concept of interpretation is limited both to the language of a state, as well as to the knowledge and values prevailing in a given society.
It is important that in determining the meaning of specific norm-shaping expressions, or phrases (language expressions that came about as a result of the reconstruction of the legislation), provided there is no legal definition contained in the legal text, it is appropriate to refer to the consistent meaning of that expression approved by the doctrine and case law [9]. At this point it should be said that even though meaningful should be the significance ascribed to a given expression by the representatives of the native doctrine, it would not be a mistake to confront the ascription of the meaning of a particular expression of the national doctrine with the meaning adopted the doctrine of a foreign state, under the condition, however, that any such treatment is exercised carefully, in principle with respect to basic and consistent expressions (e.g. claim, property, possession, limitation, etc.).
Another field where comparative law may be applied in legal interpretation based on the derivative concept seems to be the process of accounting for the assumption of a rational legislator, who should follow a certain system of values (axiological assumption) as there are some universally acceptable values protected under different legal systems - sometimes with some nuances. As a rule, however, they are identical within a certain cultural environment since they derive from a common element of morality [10].
These observations suggest that the derivative concept of legal interpretation - in accordance with its theoretical assumptions - can encompass comparative law in the process of legal interpretation.

6. Conclusions

The considerations presented in this article lead to the conclusion that comparative law should not be seen merely as a method of research on foreign legal systems. Importantly, the concept of comparative studies in the Polish legal literature - though still rarely discussed - seems to arouse more and more academic interest. At the same time it is worth noting that the advantages of the application of comparative law in legal interpretation is acknowledged by both representatives of the doctrine and as well as by case law.
Comparative law can be a valuable tool enriching the process of the interpretation of national law, namely that based on the derivative concept of legal interpretation.
First, comparative law can provide the interpreter argumentation reinforcing the meaning of a given expression or institution (reference to the meaning in a different legal system).
Second, through comparative legal studies, the interpreter can determine whether the national legislature and the legislator in another state are guided by the same values and conduct extralinguistic interpretation based on the thus established values shared by different legal systems, as primary social values.

References

[1] Banaszak B., *Porównawcze prawo konstytucyjne współczesnych państw demokratycznych* [*Comparative constitutional law of modern democratic states*], Warszawa, Wolters Kluwer Polska, 2012, p. 23.
[2] Brodecki Z., Konopacka, M., Brodecka-Chamera, A., *Komparatystyka kultur prawnych* [*Comparative studies of legal cultures*] Warszawa, Wolters Kluwer Polska, 2010, p. 18.
[3] Zieliński, M., *Wykładnia prawa. Zasady, reguły, wskazówki* [*Legal interpretation. Principles, rules, guidelines*], Warszawa, Wolters Kluwer Polska, 2012, pp. 67-96.
[4] Richter, K., *Perspektiven einer gemeinsamen Methodik in Rechtsvergleichung und Rechtsgeschichte* [*The perspectives of a common methodology in comparative law and legal history*], http://www.klaus-richter.eu/fileadmin/user_upload /klausrichter/standard/pdf/Veroeffentlichungen/sonstige/Rvgl-NIE.pdf

[5] http://wpiaus.pl/index.php?option=com_phocadownload&view=category&download=3229:plan-studiow-iii-stopnia-na-kierunku-prawo&id=313:ssd-ssd-plan-studiow&Itemid=2109.
[6] http://wpiaus.pl/index.php?option=com_phocadownload&view=category&download=4964:ii-rok-dzienne-studia-doktoranckie-semestr-zimowy-2016-2017&id=312:ssd-rozklady-zajec&Itemid=2110.
[7] Bierć, A., *Zarys prawa prywatnego. Część ogólna* [*The outline of private law. Introduction*], Warszawa, Wolters Kluwer Polska, 2012, pp. 167-168.
[8] Uchwała Sądu Najwyższego z dnia 24 kwietnia 2014 r., sygn. akt III CZP 17/14, http://www.sn.pl/Sites /orzecznictwo/Orzeczenia2/III%20CZP%2017-14.pdf.
[9] Zieliński M., *Wykładnia prawa. Zasady, reguły, wskazówki* [*Legal interpretation. Principles, rules, guidelines*], Warszawa, Wolters Kluwer Polska, 2012, pp. 267-284.
[10] Zieliński M., *Wykładnia prawa. Zasady, reguły, wskazówki* [*Legal interpretation. Principles, rules, guidelines*], Warszawa, Wolters Kluwer Polska, 2012, pp. 304-305.

APPLICATION OF CHARTER OF FUNDAMENTAL RIGHTS OF THE EU BY MEMBER STATES

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Abstract: *This article is focused on problem of application of the Charter by Member States. Provision of Art. 51 (1) of the Charter states, that the Charter is binding for Member States only when they are implementing Union law. The Charter, and not only Explanations of the Charter, do not explain what does it mean "implementing of Union law". The main question is, whether the Charter is binding for Member State in situation, when there is only indirect connection with Union law. Another important question is, which provisions of the Charter have direct effect. Should provisions of the Charter, which contain principles, take priority over the Constitution?*

Keywords: *Charter, European union, principles, implementing*

1. Introduction

The Charter of Fundamental Rights came into force and became a legally binding document by adopting the Lisbon Treaty. It became a part of the primary law of the European Union. However, the fundamental rights have already been a part of Union´ s law as a part of general principles of law. The adoption of legally binding catalogue of fundamental rights in the EU is a visible step in protection of fundamental rights because of several reasons.

One of the reasons is positivity, which is connected with each catalogue of rights, and which limits judge's law-making and limits "finding" of fundamental rights by system of "case by case". In other words, the Charter represents the fulfilment of the requirement of legal certainty for individuals, which includes also a requirement on recognisability of law and predictability of law.

The Charter has the status of primary law in the law of the Union. The primary law in the legal system of the EU represents legal norms with highest legal force. In fact thereof, there is a very clear intention of the legislature of the Union to grant the protection of fundamental rights in a position which refuses to accept lower normative legal acts in breach of fundamental rights.

EU legislature, in this case, is not represented only by institutions of the Union, (the authors of secondary law), but also by the Member States in situations when they are implementing Union law. In accordance with Art. 51. Sec. 1 of the Charter, the Charter is binding on Member States only in the event that the situation falls within „implementing Union law ". To find out when the Charter is binding for Member States is therefore necessary to clarify what the "implementing Union law" means. In the next part of the article we want to focus on the question of when the situation falls under "Union law", and to answer the question when the Charter is obligatory for Member States, and which of its provisions have direct effect.

2. Union´s enforcement of laws

Article 51 (1) states that: *"The provisions of this Charter are addressed to the institutions and bodies of the Union with due regard for the principle of subsidiarity and to the Member States only when they are implementing Union law. They shall therefore respect the rights, observe the principles and promote the application thereof in accordance with their respective powers."*

The Explanations relating to the Charter states that: *"it follows unambiguously from the case-law of the Court of Justice that the requirement to respect fundamental rights defined in the context of the Union is only binding on the Member States when they act in the scope of Union law…"*

It follows that articles of the Charter are not eligible for a separate application. In order to be applicable (useful) it is necessary to apply at least one rule of Union law. [1]

However, post-Lisbon case law of the Court of Justice obliges Member States to respect fundamental rights not only in case of implementing Union´s law, but more widely.

In case *Franson* the Court established that the fundamental rights guaranteed in the legal order of the European Union are applicable in all situations governed by Union law, but not outside such situations. In this respect, the Court has already observed that it has no power to examine the compatibility with the Charter of national legislation lying outside the scope of European Union law. On the other hand, if such legislation falls within the scope of Union´s law, the Court, when requested to give a preliminary ruling, must provide all the guidance as to interpretation necessary in order for the national court to determine whether that legislation is compatible with the fundamental rights, the observance of which the Court ensures.[1]

The wording "implementing Union law" used in the text of Art. 51 (1) of the Charter is by its significance identical to the wording used in the Explanations by words: "when they act in the scope of Union law". Neither the wording used in Explanations further explains in which situations Member State implements Union law. [2]

At this point it should be mentioned that from the point of view of national law, a certain coherence with Union law can be found in almost every case. Even in situations where the national legal norm is not directly implemented from legally binding act of the Union, it is possible in

almost every case to find an indirect connection, respectively, the impact of Union law on the content of the national legislation.

Problems of interpretation therefore arise whether in such situation to fall under the "implementing of Union law" is an indirect connection with Union law sufficient, or a direct connection shall exist there.

In response to that question we incline to the view that the rule of Union law must be not only interpreted in the case, but also applied in reality. [3]

It follows from the requirements contained in Art. 51 (1), which uses the wording "implementing" of Union law and not only on its "interpretation".

The applicability of EU law must be specific and objectively certainly linked to the case and have crucial relevance to a decision in the matter. [4]

It follows also in case law of the Court of Justice, which in relation to this matter establishes: *"However, it should be borne in mind that the concept of 'implementing Union law', as referred to in Article 51 of the Charter, requires a certain degree of connection above and beyond the matters covered being closely related or one of those matters having an indirect impact on the other."*[5]

In conclusion we can say that, situation falls within the "implementing of Union law" only if a connection with the Union law achieve a certain degree that exceeds a simple similarity of areas. The mere similarity of the areas of law and an indirect impact of one area to another is insufficient for the applicability of the Charter.

3. The distinction between rights and principles

In addition to assessing whether the situation falls within the scope of EU law, for the application of the Charter at national level is also necessary to solve the question of which provisions of the Charter have a direct effect.

For the national application of the charter is important to assess, whether a particular article of the Charter, which should be applied by a national public authority, bases individual´s direct claim for positive action of Member States.

The essence of the direct effect is the right of the individual to invoke before the national public authorities the protection of the rights that individual has under Union law. A basic prerequisite to direct effect of union law is intelligibility, clarity, definiteness and unconditional character of legal norm.

As it is clear from Art. 51 (1) of the Charter, institutions and bodies of the Union and Member states shall therefore respect the rights and observe the principles.

From this article implies the distinction between rights and principles. Principles as opposed to fundamental rights do not constitute a direct right of individuals to positive action by public authorities. Only articles of the Charter, which state rights, may have the direct effect but not the principles. How important is the distinction between rights and principles and how to distinguish rights from principles?

Art. 52 (5) of the Charter states that: *„The provisions of this Charter which contain principles may be implemented by legislative and executive acts taken by institutions, bodies, offices and agencies of the Union, and by acts of Member States when they are implementing Union law, in the exercise of their respective powers. They shall be judicially cognisable only in the interpretation of such acts and in the ruling on their legality."*

Provisions of the Art. 52 (5) indicate that the principle may be invoked only in the interpretation of legislative and executive acts of the institutions of the Union and the implementing acts of Member States.

The Explanations of that Article state that: *„Principles may be implemented through legislative or executive acts (adopted by the Union in accordance with its powers, and by the Member States only when they implement Union law) accordingly, they become significant for the Courts only when such acts are interpreted or reviewed."*

However, we don't know from the Explanations whether the principle should be applied also in the interpretation of those acts, which were not directly involved in implementation of those principles.

It should be mentioned, that the text of the Charter is not uniform in distinguishing between rights and principles. For example, Art. 41 (1) and (2) states right to good administrations:

"1. Every person has the right to have his or her affairs handled impartially, fairly and within a reasonable time by the institutions, bodies, offices and agencies of the Union.

2. This right includes:

a) the right of every person to be heard, before any individual measure which would affect him or her adversely is taken

b) the right of every person to have access to his or her file, while respecting the legitimate interests of confidentiality and of professional and business secrecy

c) the obligation of the administration to give reasons for its decisions."

This Article, as well as Articles 43, 44 and 46 can be used as an example of those provisions of the Charter, which contain rights. Also wording of this Articles use the terminology "every person has the right". [6]

On the other hand provision of Article 24 (1) also uses term "rights". This article states that:

"1. Children shall have the right to such protection and care as is necessary for their well-being. They may express their views freely. Such views shall be taken into consideration on matters which concern them in accordance with their age and maturity."

The Explanations of this article do not explain whether it states the right or the principle. In our opinion, the provision of Art. 24 (1) states a principle. The reason for this conclusion is that from the provision of Art. 24 (1) we cannot deduce an individual's entitlement to positive action of the state. For a direct effect of this provision is necessary to accept an implementation of the act.

The same conclusion is possible also in relation to other Articles of the Charter, for example Articles 25 and 26.

Character of the provision of Art. 26 was also established by the Court of Justice in case Glatzel, in which the Court states that: *"herefore, although Article 26 of the Charter requires the European Union to respect and recognise the right of persons with disabilities to benefit from*

integration measures, the principle enshrined by that article does not require the EU legislature to adopt any specific measure. In order for that article to be fully effective, it must be given more specific expression in European Union or national law. Accordingly, that article cannot by itself confer on individuals a subjective right which they may invoke as such."[7]

The same conclusion is clear also from decision in case Association de médiation sociale in relation to Art. 27. In points 45, 46 and 47 the Court establishes: *"It is therefore clear from the wording of Article 27 of the Charter that, for this article to be fully effective, it must be given more specific expression in European Union or national law. It is not possible to infer from the wording of Article 27 of the Charter or from the explanatory notes to that article that Article 3(1) of Directive 2002/14, as a directly applicable rule of law, lays down and addresses to the Member States a prohibition on excluding from the calculation of the staff numbers in an undertaking a specific category of employees initially included in the group of persons to be taken into account in that calculation. In this connection, the facts of the case may be distinguished from those which gave rise to Kücükdeveci in so far as the principle of non-discrimination on grounds of age at issue in that case, laid down in Article 21(1) of the Charter, is sufficient in itself to confer on individuals an individual right which they may invoke as such."*[8]

The distinction between rights and principles in the Charter is closely related to the reasons for which the Member States did not adopt the "Constitution for Europe". Different view of the Member States on issue of fundamental rights, especially of social rights, led to a compromise solution, which result in the definition of rights and principles. It is necessary to mention that currently some of the social rights in the Charter have character of principles.

4. Conclusion

In this paper, we have attempted to define the conditions for the application of the EU Charter of Fundamental Rights by Member States.

In order for the national application of the Charter by national court in a particular situation Charter it is necessary to focus on the question if situation falls within he "implementing of EU law." In the light of the Court's case-law, the situation falls within enforcement of Union law if the Member State applies at least one legal rule of Union law.

However, the connection with Union law shall achieve a degree which exceeds just simple similarity. Indirectly connection with union law is not sufficient for the application of the Charter by Member States.

For the national application of the Charter is also important to recognise, in which provision of the Charter the Charter states the rights and in which the Charter states the principles.

This distinction between the rights and the principles can be recognized by examination of certain provision of the Charter. If the provision states entitlement of individuals to positive action of the state it is the provision, which states the rights. The provision of the Charter should state a certain right, which can be enforceable and it should have the normative character.

In cases where the Charter provides only principle, it does not have direct effect. "Universal precedence of the Charter over the protection guaranteed by the Constitution of the Member States is incompatible with a requirement of common sense in those situations, in which the Constitution sets out specific rights and the Charter sets the principles only."

Certain provisions of the Charter lay down the principles, which lead to the creation of new human rights respectively, to the expansion of existing fundamental rights. We can recognise even a provision in which national law may provide broader protection. [9]

References

[1] MAZÁK, J. et al. Charter of fundamental rights of the European Union in proceeding before courts in Slovak republic. 2016. Košice, p. 33

[2] C-617/10 judgement in case Akerberg Franson, 26. 2. 2013, EU:C:2013:105.

[3] MAZÁK, J. et al.: Charter of fundamental rights of the European Union in proceeding before courts in Slovak republic. 2016. Košice, p. 32.

[4] MAZÁK, J. et al.: Charter of fundamental rights of the European Union in proceeding before courts in Slovak republic. 2016. Košice, p. 32.

[5] C-206/13 judgement in case Siragusa, 6. 3. 2014, EU:C:2014:126. Point 24.

[6] DRGONEC, J.: Constitutional and union law in protection of fundamental rights (Shine and shadows of Charter of fundamental rights of the EU). Justičná revue, 69, 2017, no. 1, p. 1-17.

[7] C-356/12 judgement in case Glatzel, 22. 5. 2014, EU:C:2014:350.

[8] C-176/12 judgement in case Association de médiation sociale, 15. 1. 2014, EU:C:2014:2.

[9] DRGONEC, J.: Constitutional and union law in protection of fundamental rights (Shine and shadows of Charter of fundamental rights of the EU). Justičná revue, 69, 2017, no. 1, p. 1-17.

INSPECTIONS – DO UNDERTAKINGS HAVE THE ACCESS TO THE COURT OF JUSTICE OF THE EUROPEAN UNION?

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Abstract: *This paper deals with the access to judicial review in relation to the inspections conducted by the European Commission based on the Regulation 1/2003. The inspections, as one of the strongest powers in the hands of the Commission, are introduced only briefly, as the main point of the paper is to deal with the question whether the undertakings have the access to the Court of Justice of the European Union. The analysis is divided into two parts. The first part deals with the inspection decision, which is a document based on which the European Commission starts the inspection. The second one is related to the conduct of the inspection, i.e. the Commission's acts during the inspection. Whereas the former analysis confirms relatively easy access to the court, the latter uncovers that it is generally difficult to have a legal standing. Nevertheless, there are several ways how the court may be reached. Yet, if the impossibility of the judicial review was established, this might lead to the incompatibility of the inspections with the right to fair trial and even the right to privacy.*

Keywords: *Regulation 1/2003, inspections, judicial review, legal standing*

1. Introduction

The inspections are usually considered to be highly controversial, particularly due to the absence of the *full ex ante* judicial control. Nevertheless, the Court of Justice of the European Union (hereinafter "the CJEU") insists on the compatibility with the protection of privacy and the protection of the fair trial, as guaranteed in the Charter of the fundamental rights of the EU, as well as in the European convention on human rights and fundamental freedoms [1]. One of the reasons why is the existence of *the ex post* judicial review, which may compensate the absence of the *ex ante* review. The idea is that the European Commission does not have to ask the court to issue a judicial warrant before the inspection takes place, if there is a possibility that the concerned undertaking (in which premises the inspection takes place) can challenge the inspection decision after the inspection. Hence, the only thing that differs is the timing of the judicial review.

This paper analyses the access to the CJEU. The analysis is divided into two parts, whereas the first part deals with the inspection decision and the second part deals with the acts of the Commission during the inspection. The outcome of these analyses is of great importance for the compatibility of the inspections with the right to fair trial as well as the right to privacy. If the judicial review was not possible, the fundamental rights of the undertakings would be infringed [2].

The paper is divided into two parts, the first one introducing the inspections and the second one dealing with the access to the court separately for the inspection decisions and separately for the Commission's acts during the inspections.

2. Inspections in the field of competition law

Looking at the procedural Regulation 1/2003 [3], one cannot overlook the importance of the provisions on powers of investigation, which enable the Commission to detect and to proceed an infringement of the Articles 101 or 102 of the Treaty on the Functioning of the EU (TFEU) (Recital 23 of [3]). The power to conduct inspections is justifiably considered to be the most draconian mean to provide information (p. 960 in [4]). Article 20 is concerned with the inspections in the "*premises, land and means of transport of undertakings and associations of undertakings*" (Article 20 (2) (a) of [3]) thus in the so called business premises. This type of inspections can be based either on a written authorisation or on a decision of the European Commission, whereas in the latter case the undertaking is obliged to submit itself to the inspection (Article 20 (3) and (4) of [3]). There is also a possibility to conduct an inspection in non-business premises. Article 21 defines to non-business premises as "*any other premises, land and means of transport, including the homes of directors, managers and other members of staff of the undertakings and associations of undertakings*" (Article 21 (1) (a) of [3]).

According to Article 20 (2) and 21 (4) of [3], the persons conducting the inspections are entitled to enter the premises, to examine the records related to the business, take copies and extracts of them. Moreover, there are two additional powers when the inspection is conducted in the business premises, namely the power to seal premises, books and records and the power to ask questions (Article 20 (2) (d) and (e) of [3]).

3. Judicial review of the inspection

Judicial review is of crucial importance regarding any administrative procedure. It is even more true regarding the inspections decisions, since there is no, or at least not full, a priori judicial review of them (Article 20 (8) and Article 21 (3) of [3]). Moreover, the inspections threaten the fundamental rights of the undertakings as suggested above. Without a proper judicial review the right to a fair

trial may be infringed [5] and, subsequently, the right to privacy too [6].

3.1 Judicial review of the inspection decision

The judicial review is safeguarded by the CJEU which the undertaking under inspection must be informed about (Article 20 (4) of [3]). In the view of the Article 263 TFEU, the inspection decision is addressed to the undertaking and the inspection decision is the act of the European Commission other than recommendation and opinions. Hence, the undertaking has a legal standing and it may institute the proceeding within two months after the notification of the inspection decision. However, the expiration of the two months period means that the decision is definite for the undertaking (para 409 in [7]). Apart from the formal requirements, the undertaking shall prove one of the grounds for annulment of the decision based in the Article 263 (2) TFEU, namely: "*lack of competence, infringement of an essential procedural requirement, infringement of the Treaties or of any rule of law relating to their application, or misuse of powers*."

It is important to note that the CJEU, especially in the *Deutsche Bahn* case, pointed out that the *ex ante* judicial control was compensated by bringing an action for annulment with a simultaneous application for suspensory effect (para 98 in [1]). However, this statement is questionable. Due to the Article 278 TFEU, the action will not have suspensory effect, unless the CJEU is of the opinion that the circumstances require so. However, it can be hardly feasible that the undertaking will be able to draw up the application, to deliver it to the CJEU and to obtain the decision within the hours and therefore to prevent the Commission from conducting the inspection. Besides, the undertaking cannot oppose the inspection by its own without the risk of being sanctioned [8]. It is also possible for the undertaking to obtain an interim measure based on the Article 279 TFEU, however, the rules on procedure are the same as for the suspensor effect of the action [9]. The feasibility of obtaining the interim measure is quite low, especially due to the burden of proof which is difficult to bear, as proved by the case law of the CJEU [10]. Hence, the only likely judicial review of the inspection decision is by the action lodged after the inspection. It is essential to note that this action is accessible for the undertaking.

3.2 Judicial review of the acts of the Commission during the inspection

The inspection decision which enables the Commission to conduct the inspection shall be differentiated from the acts the Commission (via its employees and other designated persons, hereinafter "inspectors") conducts during the inspection. The inspection decision may be valid, however, certain acts of the inspectors may trespass the limits. For instance, an inspector may search documents obviously unrelated to the scope of the inspection decision, thus acting *ultra vires*. May these acts of the inspectors be brought before the CJEU? The answer is not a clear cut.

The acts cannot be challenged together with the inspection decision. In the *Nexans* case [11], the applicant asked for annulment of 1) the inspection decision itself; 2) the decision taken during the inspection to copy the entire content of certain computer files; 3) decision to interview an employee of the applicant during the inspection. The second and third decision was held to be intermediate measures which were only implementing the inspection decision. The applications for their annulment was held inadmissible as they were not challengeable acts (paras 115-134 in [11]). However, it is claimed by some scholars that the *Akzo Nobel* case [12] suggested that even measures taken during the inspection are open to legal standing, as they form "*tacit decisions*" [13]. Nevertheless, this has not been supported by the case law [11].

None the less, there are certain ways how to reach the court. The first possibility requires the undertaking not to comply with the inspection decision. Consequently, a decision imposing a fine for refusal to produce the requested documents or to provide requested answers will be issued. This decision is a separate decision and it is admissible to the CJEU (para 126 in [11]). Naturally, it bears a great risk for the undertaking to be charged by the fine eventually. The second and less risky possibility is to challenge the acts together with the final decision on the infringement of competition law (paras 413, 414 in [7]). Thus, it is the action on the final decision which can provide a vehicle to challenge the acts of the inspectors. The undertaking may dispute the pieces of evidence found during the inspection. The third possibility is related to the situation when, after the first inspection, another inspection takes place. If the second inspection decision is based, at least partially, on the evidence found during the first inspection, the challenge of the second inspection decision may, effectively, brings before the court the acts of the inspectors during the first inspection by which they found the evidence [1]. The fourth way how to bring the acts of the inspectors before the CJEU is connected with the legal professional privilege [13]. If the inspectors find a document which is allegedly covered by the legal professional privilege, the dispute over the nature of the document may, eventually, be challenged before the court.

Fifth, there is a possibility the EU would be held liable for the non-contractual damage caused to the undertaking by the inspectors (Article 340 (2) TFEU). The CJEU pointed out this possibility in the *Deusche Bahn* case (para 99 in [1]. The fact leading to the non-contractual liability of the EU might seem to consist in the acts of the inspectors, if they acted beyond the competences, e.g. they searched the documents apparently outside of the scope of the inspection decision. However, this way is not an easy one to take, since several conditions must be met [14]. The formal requirements are rather straightforward, as the legal standing is given to anyone who claims to be injured by the act or omission of the EU [15], if the person lodges the action within five years from the occurrence of the event giving rise to the liability (Article 46 of the Statute of the Court of Justice of the European Union, Protocol No.3 to the TFEU).

The substantive conditions are more demanding. First condition consists in the rule of law infringed which had to be of such nature as to confer the rights on individuals. For instance, the undertaking may claim that the right of

defence or the right to privacy was infringed. Second, the breach had to be sufficiently serious. As Chalmers highlighted (p. 462 in [4]), even decent failure to observe rights of defence is likely to incur liability. Hence, if the right of defence is considered to be infringed, this infringement will be sufficiently serious. Third, the direct causal link between the breach and the damages has to be established. As to the damages themselves, there is panoply of recoverable pecuniary as well as non-pecuniary losses (p. 463 in [4]). However, the mere infringement of the fundamental rights is not enough, since there is a need for the actual damage to be proven. This may cause a problem [16]. If the damage shall be actual, certain and quantifiable, one may ask what damages are at stake in the presented example [17]. One theoretical candidate for the sufficient damage could be a trade secrecy leak. However, if no document leaks out, especially due to the fact that the Commission would dully protect all the documents, no damage of this kind occurs. Second candidate could be a new investigation launched based on a piece of evidence illegally obtained. Nevertheless, there is a possibility that the Commission will not expressly rely on this piece of evidence and thus the causal link may be difficult to prove [18]. Third, and more likely candidate is related to the situation when a document covered by legal professional privilege was seized. This would give further rights to the undertaking [18].

The action on damages might not seem very fruitful in this context. None the less, an importance of this possibility as a vehicle to reach the CJEU should not be underestimated. If the actual damage occurs via the acts of the inspectors during the inspection, the CJEU will review the acts and reimburse the undertaking. However, the weaknesses of the action for damages lie in two issues, the first one being the lack of actual damage or the lack of evidence to prove the causal link. The second one is the fact that the undertakings yearn for returning of the documents unlawfully taken and not for a compensation of the damage done [16]. The CJEU rejected its competence to order to return the document unlawfully taken or to destroy the copies unlawfully done in the *Nexans* case (para 136 in [11]). None the less, the Commission may not use these documents for justification of the final decision on infringement, which deprives the documents of their evidential nature.

4. Conclusion

The access to the CJEU is rather straightforward as far as the inspection decision is concerned. The undertakings have to meet the general requirements laid down in the Article 263 TFEU which is usually not problematical. Yet, once it comes to the review of the inspection *per se*, i.e. the inspectors' acts during the inspection, the access to the CJEU is more intricate. There are five ways how to bring the acts of the inspectors before the CJEU. It is possible to challenge the decision on fines when the undertaking opposes to submit itself to the inspection. The final decision on infringement and the further inspection decision based on the evidence found during the inspection in question both serve as a vehicle for bringing the acts before the Court. Furthermore, there is also the possibility to claim the damages based on the Article 340 (2) TFEU, even though it is not easy to satisfy the conditions therein. If, as it might happen, the seized document is supposed to be covered by legal professional privilege, there is a legal standing too. Finally, there is a theoretical possibility to claim that the acts are "*tacit decisions*, however, the option does not seem to be fruitful.

Eventually, it is important to highlight that if the judicial review was considered insufficient, there would be problems with the compatibility of the inspections with the fundamental rights, as the access to a court is intrinsic to the right to fair trial and, subsequently, also to the right to privacy.

Acknowledgements

This paper was supported from a Grant project of "Agentúra na podporu výskumu a vývoja" APVV -0158 - 12 "Efektívnosť právnej úpravy ochrany hospodárskej súťaže v kontexte jej aplikácie v praxi."

References

[1] Joined cases T-289/11, T-290/11 and T-521/11. *Deutsche Bahn AG and Others v European Commission* [2013] (GC 6 September 2013)

[2] M. Patakyová: *Right to Privacy and European Competition Law*. IN: Forum Iuris Europaeum 2016, no. 2. In press.

[3] Regulation 1/2003 of 16 December 2002 on the implementation of the rules on competition laid down in Articles 81 and 82 EC [2003] OJ L 1/1

[4] D. Chalmers, G. Davies, G. Monti European Union Law (3rd edn, reprinted, Cambridge University Press, 2015)

[5] See Article 6 (1) of the European convention on human rights and fundamental freedoms or Article 47 of the Charter of the fundamental rights of the EU

[6] *Delta Pekárny A.S. v. République Tchèque*, App No 97/11 (EctHR 2nd October 2014)

[7] C-305/94 *Limburgse Vinyl Maatschappij NV, Elf Atochem SA, BASF AG, Shell International Chemical Company Ltd, DSM NV, DSM Kunststoffen BV, Wacker-Chemie GmbH, Hoechst AG, Société artésienne de vinyle, Montedison SpA, Imperial Chemical Industries plc, Hüls AG and Enichem SpA v Commission* [1999] ECR II-00391

[8] S. Kerse and N. Khan, *EC Antitrust Procedure*, London, Sweey & Maxwell, 2005, p. 179

[9] Rules of Procedure of the General Court [2015] OJ L 105, Articles 156-161

[10] N. Zingales, *The Hearing Officer in EU Competition Law Proceedings: Ensuring Full Respect for the Right to Be Heard?*", The Competition Law Review, Vol. 7, No. 1, pp. 129-156, 2010, p. 135

[11] T-135/09 *Nexans France SAS and Nexans France v European Commission* [2012] (GC 14 November 2012)

[12] Joined cases T-125/03 and T-253/03 *Akzo Nobel Chemicals Ltd and Akcros Chemicals Ltd v Commission of the European Communities* [2007] ECR II-03523, para 52

[13] D. Théophile and I. Simic, *Legal Challenges to Dawn Raid Inspections under the Principles of EU, French and*

ECHR Law, Journal of Competition Law & Practice, Vol. 3, No. 6, pp. 511-520, 2012, 518
[14] C-352/98 P *Laboratoires pharmaceutiques Bergaderm SA and Jean-Jacques Goupil v Commission* [2000] ECR I-05291, para 42
[15] Case 118/83 CMC *Cooperativa muratori e cementisti and others v Commission* [1985] ECR 2325, para 31
[16] A. Steen, *Dawn Raids and Human Rights: Where are We Now?*, Kluwer Competition Law Block, 25 January 2016 < http://kluwercompetitionlawblog.com/2016/01/25/dawn-raids-and-human-rights-where-are-we-now/> accessed 5 February 2016
[17] K. Gutman, *The evolution of the action for damages against the European Union and its place in the system of judicial protection*, Common Law Market Review, Vol. 48, No.3, pp. 695-750, 2011, pp. 735-7
[18] A. Steen, Nexans, *Deutsche Bahn, and the ECJ's Refusal to Follow ECHR Case Law on Dawn Raids*, Journal of European Competition Law & Practice, Vol. 7, No. 2, pp.180-193, 2016, p. 191

EXPROPRIATION AND ENVIRONMENTAL PROTECTION

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Abstract: *Expropriation is an institute of contemporary legislation whose applicability, or implementation, is discussed. Expropriation is a fundamental public interference in the property rights of other entities, but is not characterized as priority. Expropriation follows the achievement of a certain aim, otherwise it would not be possible and at the very least or rationally justifiable. It is permitted in the public interest under the rule of law, and for compensation. The public interest is an indefinite legal term that is proven in expropriation proceedings. The basic legislation is contained in Act No. 184/2006 Coll., on abolition or limitation of ownership rights related to land or buildings (hereinafter the "Expropriation Act"), as amended, but relating laws are what are key in terms of the environment. The paper discusses selected aspects of currently valid legislation on expropriation, the prepared amendment relating to recodification of private law, and attention mainly focuses on current case law (the decision of the Supreme Administrative Court of 07 April 2016, case no. 9 As 89/2015-28, dealing with the question of expanding the subject of expropriation to land that the expropriator does not need to achieve the purpose of expropriation.). This is viewed through the criterion of the expropriation purpose – environmental protection in the broadest sense.*

Keywords: *purpose of expropriation, forced limitation of ownership right, public interest, under the rule of law, for compensation*

1. Introduction

Expropriation is an institute of contemporary legislation whose applicability, or implementation, is discussed. It generally concerns the forced transfer of ownership right or other right similar in nature, as well as its forced limitation. The valid and effective legal definition of Sec 2(a) of Act No. 184/2006 Coll., on expropriation, as amended, describes expropriation as abolition or limitation of ownership right or a right corresponding to easement to land or to a building for achieving the purpose of expropriation determined by a special law.

Expropriation is a fundamental public interference in the property rights of other entities, but is not characterized as priority. That is an agreement when expropriation is only an exception from the principle of the inviolability of the mentioned rights.

Expropriation follows the achievement of a certain aim, otherwise it would not be possible and at the very least logically or rationally justifiable. Due to the intensity of interference of this institution in the mentioned rights of other entities, it is necessary that the reasons for which expropriation is to occur are highly relevant. According to the purposeful focus of expropriation, it is possible to determine this institute – upon taking into account the criterion of environmental protection – expropriation with environmental purposes vs. the other purposes.

This paper discusses selected aspects of currently valid legislation on expropriation, the prepared amendment relating to recodification of private law, and attention mainly focuses on one recent example of case law. This is viewed through the criterion of the expropriation purpose – environmental protection in the broadest sense.

2. Legislation and its amendment[1]

Everybody has the right to own property, whereas this right has the same content and protection in the case of all owners. Constitutional starting points of expropriation legislation, as well as interference in ownership right, are anchored in Article No. 11(4) of the Charter of Fundamental Rights and Basic Freedoms. *"Expropriation or forced limitation of ownership right is permitted in the public interest under the rule of law, and for compensation."* Expropriation legislation is principally contained in Act No. 184/2006 Coll., on abolition or limitation of ownership right to land or a building (hereinafter the "Expropriation Act"), as amended, but further augmented by other legal regulations. It is necessary to mention Act No. 183/2006 Coll., on town planning and the building code (the Building Act), as amended, for the environmental purpose of expropriation it further concerns e.g. Act No. 254/2001 Coll., on waters and on amendment to certain acts (hereinafter the "Water Act"), Act No. 20/1987 Coll., on state landmark conservation, and Act No. 114/1992 Coll., on nature and landscape protection, all as amended.

Also characterized by secondary environmental impacts is the legislation contained in Act No. 458/2000 Coll., on business conditions and public administration in the energy sectors and on amendment to other acts (the "Energy Act), or in Act No. 13/1997 Coll., on roads, all as amended, and in a series of other legal regulations (primarily however, expropriation does not occur due to environmental protection). Specific regulation on expropriation is contained in Act No. 416/2009 Coll., on acceleration of construction of transport, water and energy infrastructure, as amended.

The Expropriation Act has undergone three amendments since the moment of its adoption and effectiveness on 01 January 2007 until now. It is currently in the legislative amendment process, the aim of which is to react to changes established by Act No. 89/2012 Coll., Civil Code

(effective as of 01 January 2014), and which fundamentally concern expropriation legislation. Also in the light of this amendment, reflection of the mentioned legislation will be discussed [2].

Under Sec 1 of the Expropriation Act, this defines the subject of the actual regulation as regulation of conditions of expropriation or forced limitation of ownership right, which is possible in the public interest, under the rule of law and for compensation, as well as conditions for providing compensation for abolition or limitation of ownership right or right corresponding to easement to land or to a building, and finally conditions of cancellation of abolition or limitation of ownership right or right corresponding to easement to land or to a building and return of these rights to their original bearers. The amendment reflecting recodification is already evident in this initial provision of the Expropriation Act. This is to newly regulate not only conditions of abolition and limitation of ownership right or right corresponding to easement (new in terms of terminology easement to land or to a building), but also conditions of abolition or limitation of the right to build. Legislators find it essential to anchor into the expropriation regulation the possibility of expropriating the right to build as it was introduced as a new institute in the Civil Code, and which cannot be denied with regard to the essence and sense of application in the area of expropriation. This is indicated by the legal term *"right of expropriation"*. Also regulated by this act is the transfer of the right of expropriation or assumption of a right limiting right of expropriation – all for achieving the purpose of expropriation as regulated by a special law. Amendment to Sec 2 brings new definitions. Upon examining individual changes, it concerns changes more in terms of terminology than materiality. The legislative term expropriation changes to abolition or limitation of the right of expropriation for achieving the purpose of expropriation determined by a special law. The provisions of Sec 2 further define the expropriated party, the expropriating party and expropriation proceedings.

The primary prerequisite for expropriation is public interest, *"expropriation is only possible when in the public interest"*. Public interest is a vague legal term. Public interest in expropriation is proven in expropriation proceedings.

Environmental protection is generally defined in Sec 9 of Act No. 17/1992 Coll., on the environment, as amended. It includes activities by which contamination or damage to the environment is prevented, or which limit and remove such contamination or damage. This concerns an expression of a conservative approach, which leads in principle to preserving or restoring the condition of the environment. It is necessary to approach environmental protection also as towards creation of the environment, thus the option of everybody to reshape the environment in accordance with the principles of sustainable development. A typical example of creating the environment is building diverse cultural monuments, public areas, civic centers, transport infrastructure, etc. Environmental protection, whether in the sense of preservation, restoration or creation of the environment, is designated by the professional public as a public interest, or public interest in environmental protection is qualified.

Growing along with the public interest as a vague legal term is the importance of criteria or methods by which its content will be fulfilled. Standards working with the term public interest require the relevant legal interpretation. What forms the content should develop from a specific situation or understanding, and consequent interpretation of a specific case. Then remains application for a case existing in real time. The term public interest (or method of its specification) was indirectly defined at the level of environmental protection by a series of judicial decisions (compare the verdict of the Supreme Administrative Court (hereinafter *"SAC"*) of 29 March 2007, case no. 1As 16/2006-54).

"Expropriation is only possible under the rule of law." If the law does not contain the possibility of expropriation, it is not possible to accede to this. This is true even if a clear overwhelming public interest in the given matter appears to the expropriating party, which in his opinion would justify expropriation. By this essential prerequisite of expropriation, legitimate expectation is assured, and legal certainty is anchored the same for the potential expropriated party. The law must determine that *"it is possible to expropriate"*.

Another essential condition of expropriation is its permissibility for the purpose of expropriation determined by a special law and only if the public interest for achieving this aim exceeds the preservation of the existing rights of the expropriated party. If rights needed for implementation of the purpose of expropriation can be obtained by agreement or another manner, expropriation is not permissible.

Expropriation is not the primary solution, and should come in to play only later if reaching an agreement is not possible (compare the Expropriation Act). The amendment expects changes within terms during which the expropriating party attempts to reach an agreement. Instead of the existing 90 days, a shortening to 60 days has been drafted. The expropriating party must first attempt to conclude an agreement on obtaining the necessary rights to land or to a building. If he is not capable of doing this within the term of 90, or possibly 60 days, which starts from the day following the day when the expropriated party receives the proposal for concluding an agreement, it is possible to consider expropriation. Under Sec 4(2), (3) of the Expropriation Act, besides requirements or appendices, the agreement must establish the right of the expropriated party to the return of transferred rights if implementation of the purpose of transfer is not commenced within 3 years of conclusion of an agreement. The effort to reach agreement is not necessary under conditions of Sec 4(5), typically if the expropriated party is not known or if he is limited in his freedom of contract. For co-ownership, termination of co-ownership takes precedence over expropriation. The provisions of Sec 3(2) of the Expropriation Act stipulate harmony with the aims and tasks of town planning (if performance of a change follows thereby in use or in spatial arrangement of the

territory, including placement of buildings and their changes).

In relation to the Expropriation Act, one must point out Sec 170 of the Building Act. Also coming into consideration from the environmental standpoint is the very regulation under letters b) and d). It is possible to abolish or limit rights to land and buildings necessary for implementing constructions or other public measures pursuant to this law, if they are defined in the issued land-use planning documents and if it concerns a public measure, specifically diminishing the threat of regional flooding and other natural catastrophes, increasing the retention capabilities of the territory, establishing elements of the Territorial System of Ecological Stability and protection of archaeological heritage, or if it concerns redevelopment (revitalization) of a territory.

Special laws determine the purposes of expropriation. An example can be these component acts categorized into areas of environmental protection legislation, anchoring the possibility of expropriation.

Under Sec 11 of the Water Act, regulating questions relating to the transfer of rights from expropriation, *"If the permitted use of water is unavoidably required in the public interest and the authorized person fails to use his permission fully or partially, the water authority may oblige such authorized person to allow his water management structure or equipment to be used for the permitted water use by another natural person or legal entity selected by the water authority for the necessary period or a period during which a decision regarding the dispossession of or limitation of proprietary rights to the water management structure is made, for reasonable compensation."*, or further under Sec 55a, under which the rights to land and buildings necessary for implementing publicly works for flood protection can be abolished or limited in the procedure as per the Expropriation Act.

Under Sec 15 of the Act on State Landmark Conservation, which regulates measures for securing care of cultural monuments, *"If the owner of an immovable cultural landmark that is not owned by the state permanently neglects its duties, thus threatening the preservation of the landmark, or if it uses the landmark in a manner contrary to its cultural and political significance, landmark value or technical condition, and if no agreement is reached with the owner on the sale of the landmark to the state, the cultural landmark may, in the interest of society and as an exceptional measure, be expropriated upon proposal of the municipal office of a municipality with extended powers by virtue of a decision of the expropriation authority."* The same applies under Sec 17 of the mentioned act, according to which protection zones are created around immovable cultural landmarks if their protection or protection of their environment so requires. If it is necessary for creating a protective zone to gain some land or buildings, or perform their removal, and agreement is not reached with the owner, it is possible to expropriate this land and buildings.

Under Sec 60 of the Protection of Nature and Country Act, it is possible to expropriate real estate or a right to it for the purpose of protecting nature and country in cases determined by special regulation. Nevertheless, this regulation is very broad, and is not an actual definition of the purpose of expropriation, and refers to the Building Act principally the same as stated above. Environmental expropriation, which truly follows by its purpose of environmental protection, has not yet come into practice.

The Expropriation Act also regulates the rights of third parties, and the utterly fundamental question of compensation upon expropriation. Expropriation is only possible for compensation. Compensation involves not only the standard price for land or a building (this is judged according to the true state and the purpose of use to the date of filing the motion on expropriation), or the price of easement or right to a building, but also relating costs (especially moving costs or costs affiliated with change in place of business). Appraisal is performed according to the regulation on appraisals effective at the time of deciding on expropriation. No matter what the amount or method, compensation must always be provided to the expropriated party. Often appearing more advantageous however is the compensation procedure under Sec 11 of the Expropriation Act, where instead of paying the standard price for land or a building, other land or a building is provided, if the expropriating party and expropriated party agree to such an arrangement. Meanwhile, the right is not effected to settlement of any price difference in the appropriated land or building and the compensatory land or building. Compensation is regulated in the law not only in relation to the expropriated party, but also in regard to the entitled party from relating rights. This typically means from easement tied to land or a building, or from the right to build, specifically compensation in the amount of its price. Similarly, compensation is paid for further relating costs. Payment is generally made at once in cash (compare Sec 13 of the Expropriation Act), in full amount. This is otherwise the case if there are to be paid yet unpaid receivables of a mortgagee, of a sublien creditor, of the entitled party from the security transfer of the right, of the entitled party from easement or right to build. The expropriation authority decides on compensation for the expropriated party and determines what part of this compensation the expropriating party provides to listed persons based on a filed agreement on division of compensation with officially certified signatures of the contracting parties, otherwise it imposes upon the expropriating party the obligation of rendering compensation into the custody of the court in whose circuit the land or building is situated.

The provisions of Sec 5 an. of the Expropriation Act contain regulation of expropriation proceedings. They regulate the question of participants in expropriation proceedings, who are generally the expropriating party and the expropriated party (there may be others). The expropriation authority is the municipal office of a municipality with extended powers, Prague City Hall, and city hall of a territorially divided statutory city. It is possible to further mention the option of canceling expropriation and having a hearing before the court on expropriation. It is generally known that the statement on expropriation is examined in the framework of

administrative justice, but so is the statement on compensation in the framework of justice according to part V of Act No. 99/1963 Coll., Code of Civil Procedure.

3. Current case law

A contemporary question of expropriation is the expansion of the subject of expropriation to land, which the expropriating party does not need to achieve the purpose of expropriation. Expropriation is founded on the principle of its adequacy to the nature and seriousness of the given problem. The principle of expropriation lies in the necessity of this solution as judged in the decision of the Supreme Administrative Court of 7.4.2016, case no. 9 As 89/2015-28. Meanwhile, Sec 4(3) of the Expropriation Act breaks with this principle. From current case law, it is possible to point out the very verdict of the Supreme Administrative Court, by which the possibility was examined for expanding expropriation to an immovable thing, which itself is not important for expropriation, but access to this immovable thing would not be sufficiently resolved after the other property was expropriated.

The subject of interest was the decision of the Municipal Authority of Třinec (expropriation office), of 19.6.2013, ref. MěÚT/64780/2012/SŘaÚP/Pie. The municipal authority decided to abolish the ownership right to the defined grounds of person A. Based on a request of person A, expropriation was expanded to further land ("disputed land"), which was not decisive for the purpose of expropriation. This expansion was challenged and reached all the way to the Supreme Administrative Court - because the inclusion of the disputed land into expropriation is an unacceptable expansion of the subject of expropriation. This is utterly unneeded for constructing the public work, in consequence of whose building the motion for expropriation was filed, and the expropriating party will not use it in any way.

According to the expropriation authority, expansion occurred because by expropriation of the other plots, access to the disputed land by vehicle or on foot would be rendered impossible. The regional court decided that there are no fundamental objections that no construction activity will be developed on the disputed land in relation to construction of a public road, and that the land is unneeded by the expropriating party. It is necessary to consider devaluation of the residual land in terms of constitutional guarantees of ownership. If land improvements are intended in the given territory, but have not yet been commenced, and no decision has come regarding fundamental changes in the framework of land improvements, they cannot be taken into account. When assessing whether conditions are met of the inability to use the disputed land or the possibility of using it with unreasonable difficulties, future resolution by means of land improvements cannot be taken into account. It was utterly correctly pointed out that only a legal and enforceable decision on specific land improvements could be relevant for the expropriation authority, and not an indefinite promise.

The Supreme Administrative Court stated that the provisions of Sec 4(3) of the Expropriation Act provide for a deviation from the generally standardized ban of expropriation only in a scope necessary for achieving the purpose of expropriation, so the expropriation authority cannot approach it only at the motion of the expropriated party, and it is not possible to perform such expansion from the will of the expropriating party. "Above-framework" expropriation is not essential to achieve the expropriation purpose. When expanding expropriation, the opposing argumentation is inappropriate that it will not be using the disputed land at all for construction of a public work, because this criterion is not important for fulfilling the hypothesis of the given standard. The regional court correctly deduced that expropriation above the framework of essentially necessary scope must be perceived as a part of the right to compensation for expropriation. If by expropriation, another movable thing or right corresponding to easement in ownership of the expropriated party is fundamentally devalued, it is necessary to request the possibility of expanding expropriation. Moreover, after expropriation, the owner of the immovable thing did not even need to be capable of duly performing its obligations arising from ownership if it had no access to it. What is key is whether devaluation is of such intensity that it is not possible to use the immovable thing or right corresponding to easement without the expropriated land, building or their part, or easement in general, or only with unreasonable difficulties. In this matter, at the time of deciding by the administrative bodies on expropriation, no other access way of the person participating in proceedings on the disputed land existed than right through land whose expropriation the expropriating party had requested. The Supreme Administrative Court stated regarding the intended land improvements that even if the will of the State Land Office was proven to provide for an access way to the disputed land to the benefit of the owner of such land in the framework of future proceedings on land improvements, it is not possible to guarantee it. It is utterly essential for it to concern a definite and legally enforceable title, which ensures the expropriated party access to his land at the time immediately following expropriation. By this, there is no hypothetical possibility of providing such access in the framework of land improvements in proceedings that have not even yet been commenced.

4. Conclusion

This paper deals with legislation on expropriation and its amendment resolved in the legislative process, towards a selected current judicial decision.

Expropriation is in a way a controversial institute, because strong interference occurs in the expropriated rights of other persons. Regulation of expropriation hides a series of interesting questions – from the actual regulation of expropriation itself, to its essence, essential conditions and procedural regulation of expropriation proceedings. With regard to the existing case law, one may add that expropriation for "purely" environmental purposes is generally not performed. Environmental protection is secondary to other primary purposes of expropriation. The question is whether regulating environmental protection

offers another, for example less drastic means of implementation. Or another question is whether (not from the legal aspect) it has not assumed such relevance just yet. One example would be expropriation for the purposes of a future Territorial System of Ecological Stability.

A condition for expropriation proceedings is that they can be performed in a scope necessary to achieve the purpose of expropriation. This is proven in the proceedings. One may be of the opinion that while preserving constitutionality as well as the principle of proportionality and adequacy in relation to expropriated entities, it is more than appropriate that - already thus limited entities of expropriation rights - have the possibility of deciding and expressing the will that the expropriation would be expanded to further land, building or its part, and motioning for such expansion. The condition of when he must prove that remaining rights cannot be exercised at all or only with unreasonable difficulties brings balance to the relationship between the expropriated party and the expropriating party, so that no unreasonable demands would be placed even on this, when he will not need these remaining rights and will not exercise them for the purpose of expropriation.

References

[1] Conclusions from a seminar held on 05 May 2016 in the framework of the subject D4SVZ12 Current Questions of Legal Science and Practice II - Spring 2016, Mgr. Jakub Hanák, Ph.D. Faculty of Law, Masaryk University.

[2] Bill amending Act No. 184/2006 Coll., on abolition or limitation of ownership right to land or to a building (the Expropriation Act), as amended by subsequent regulations no. 253/16 [online]. [cit 10.3.2017]. Available from: https://apps.odok.cz/veklep-detail?pid=KORNA47DYJME

[3] Court decision and legal regulations cited in the text.

SHARE PRICE OF THE COMPANIES LISTED ON THE WIG-UKRAINE AND THEIR FAIR VALUE

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Abstract: *This paper examines share price of the companies listed on the WIG-UKRAINE and their fair value between 2012-2017. Data from 2012 to 2017 were collected from the Stooq.pl (Polish portal of shares). Two hypotheses are tested: (1) value of the shares based on the market price; (2) value of the shares as the fair value of shares. The WIG-UKRAINE sector was analysed and characterised, also the companies participating in it were described. Nevertheless, the market value of shares does not reflect the fair value of the shares which is currently assigned to different companies in the sector. The research analysed the key financial ratios, the actual value of shares; also the fair value of the WIG-UKRAINE sector companies listed on the Warsaw Stock Exchange was calculated.*

Keywords: *WIG-UKRAINE, fair value of shares, company, market value of shares*

1. Introduction

Share valuation is one of the most complex processes on financial markets since the value of shares does not depend only on demand and supply on the market, but also on many factors that determine its price, starting from business valuation by using different methods in the given time to the presentation of mechanisms changing the value of shares in a manner either increasing or decreasing its value. For this reason, it is so important to value shares and determine its fair value in a manner that is objective and independent of speculative values that distort share prices and hence of the value of a WSE-listed company, which research conducted on the WIG-Ukraine index applies to. The value of companies listed on this index should be analyzed in terms of estimating their fair value, since presently their value should arouse significant controversies, especially at good operation of companies.

2. Fair value of listed companies

Share price of the companies listed on the Stock Exchange should reflect also their fair value. The fair value can be defined in several ways. In view of the foregoing, the fair value is a value used repeatedly in accounting, and thus in Article 28 (6) of the Accounting Act of 29.09.1994 as "the amount for which a given asset component could be exchanged, and the liability could be paid on market transaction terms between interested and well-informed, unrelated parties [2].

In view of whether the price of shares that are quoted on the stock exchange corresponds to their fair value, should be found in the value alone, since, after all, the values may be diverse, like the value of a similar company, producing similar goods and operating in the same industry, will also be diverse for various reasons.

The subject of trade covers minority shares, and the main market participants are retail investors or minority institutional investors, thus the price of shares should reflect the fair value characterizing the liquid minority interest.

The value presented in this way seems righteous, which is confirmed by the premium paid by the investors who announce calls for subscription for shares and plan in this way the purchase of the controlling interest. Then the premium reflects the difference between the level of liquid minority interest and the level of controlling interest. Sometimes the level takes into account benefits resulting from synergy. An investor purchasing the controlling interest in this way receives premiums that appear after taking over control of a company, in the form of funds, business management and making a number of strategic decisions.

The fair value of the share price should be determined in accordance with the idea of capital market, namely the market participants should have equal access to data, information and all messages concerning a given company [10, 11]. However, the investors are divided into three groups:

a) People with access to the most closely guarded information that affects the price and the business value, namely those can the company's management board or shareholders,
b) Institutional investors with blocks of shares with simultaneous access to the company's management board,
c) Individual investors who have access to public information.

There is one premise more to determine the fair value of share price. The investors are fond of investing in shares, namely they buy them as in the past they managed to earn on them and they feel that presently the share price is ideal and reflects their fair value and will enable them to obtain fair dividend in the future [1, 3].

Such a purchase or sale of shares can largely overestimate or underestimate the share value of a quoted company. Here the WIG-UKRAINE industry may serve as an example, namely shares in WIG-UKRAINE companies at the beginning of the new millennium, when shares in these companies were being purchased without any analysis in technical terms, but looking at their name and value, which

was increasing overnight. In view of the foregoing, this led to excessively high business value above its fair value.
The share price should thus reflect the fair value of a company listed on the Warsaw Stock Exchange. For the value of these companies be fair, the market must make available to all investors information regarding companies listed on the Warsaw Stock Exchange. The shareholders should be treated equally; therefore we cannot distinguish majority shareholders as those who should have information unavailable for minority shareholders. First of all, shares should be liquid securities, therefore they should be in free float and have real-time transferability, namely at any moment and at any time during the office hours of the Warsaw Stock Exchange on a business day [5].

3. WIG-UKRAINE AND SHARES IN THE COMPANIES LISTED ON IT

The WIG-UKRAINE index, presented in Figure 1, shows that from 2012 to 03.2017, the WIG-UKRAINE sector companies in Poland showed a lateral trend in their values.

Figure 1: WIG-UKRAINE in the period from 01.2012 to 03.2017 [12].

However, from the first quarter of 2015, a significant upward trend as well as the achievement of the highest levels, up to the level of 631.08 points in the index. The values reported on 27.03.2017 reflect the upward trend and confirm it. However, the market values do not reflect the fair value of the WIG-UKRAINE sector companies.

Value of the WIG-Ukraine index:
WIG-Ukraine(t) = [M(t) / (M(0) * K(t)] * 1000.00
M (t) – index portfolio capitalization at session t
M (0) – index portfolio capitalization on a base day
K (t) – index adjustment factor at session t

4. Analysis and valuation of the WIG-UKRAINE companies quoted on the Warsaw Stock Exchange (WSE) in Poland

In the WIG-UKRAINE sector, it is possible to record one company, the value of which approached to its next to the maximum price on 27.03.2017, and this is KERNEL. The remaining companies did not have its maximum or even fair value, though they can show the net profit and good financial condition, and it is ASTARTA and OVOSTAR. Some companies were overvalued by even 90%. These companies are COALENERG, KSGAGRO and MILKILAND. However, the flagship companies, such as ASTARTA and KERNEL, stay ahead (Table 1-2).

Table 1 The WIG-UKRAINE sector's companies quoted on the Warsaw Stock Exchange in Poland as of 27.03.2017 (own development based on the data of the Warsaw Stock Exchange)

Name	*Average rating*	*rating*
AGROTON	2.0/5.0	No data
ASTARTA	4.0/5.0	AAA
COALENERG	3.5/5.0	D
IMCOMPANY	4.0/5.0	AAA
KERNEL	3.5/5.0	AAA
KSGAGRO	3.5/5.0	D
MILKILAND	5.0/5.0	D
OVOSTAR	4.0/5.0	AAA

Table 2 The WIG-UKRAINE sector's companies quoted on the Warsaw Stock Exchange in Poland as of 27.03.2017 (own development based on the data of the Warsaw Stock Exchange)

Name	*Current price PLN*	*Maximum price PLN from the beginning of the stock exchange quotation*
AGROTON	5.87	41.39
ASTARTA	66.50	95.00
COALENERG	1.11	26.40
IMCOMPANY	9.39	16.70
KERNEL	72.08	79.82
KSGAGRO	2.83	27.80
MILKILAND	2.39	39.97
OVOSTAR	93.00	115.00

Table 3-4 presents the key ratios that show the financial condition of the WIG-UKRAINE sector's companies. Within the eight examined companies, the generated profit per share was reported in 3 companies. It shows that the WIG-UKRAINE companies prosper properly on the financial market and are able to record higher or lower profits. However, the profit was not reported in one companies, and he was AGROTON.
The price to the operating earnings shows the losses of the company at the negative, and this state of affairs was reported in two stock exchange quoted company, and they were AGROTON and MILKILAND. KERNEL, OVOSTAR, KOALENERG and ASTARTA generated a positive ratio, and the other companies, KSGAGRO, and IMCOMPANY generated a positive one-digit ratio but it is a satisfactory result [4, 6].
In contrast, analysing P/BV and P/P, it should be noted that both the price to the book value and the price to profit demonstrate that two companies operate exemplary on the market and have a value of about 1.0, and these are: ASTARTA and OVOSTAR [4, 5, 7].
Other companies do not significantly differ from the average values, and these are COALENERG, IMCOMPANY, KERNEL, KSGAGRO, MILKILAND.

Table 3 Technical evaluation of the WIG-UKRAINE sector's companies quoted on the Warsaw Stock Exchange in Poland as of 27.03.2017 (own development based on the financial data of the of the Warsaw Stock Exchange)

Name	*P/OE (price/ operating earnings)*	*P/BV (price/ book value)*
AGROTON	No data	No data
ASTARTA	3.11	1.33
COALENERG	4.91	-0.25
IMCOMPANY	1.43	1.11
KERNEL	5.09	1.29
KSGAGRO	0.78	-2.19
MILKILAND	-0.80	0.83
OVOSTAR	6.53	1.74

Table 4 Technical evaluation of the WIG-UKRAINE sector's companies quoted on the Warsaw Stock Exchange in Poland as of 31.12.2016 (own development based on the financial data of the Warsaw Stock Exchange)

Name	*P/P (price/ profit)*	*Profit per share*
AGROTON	No data	0.000
ASTARTA	1.18	(EUR) 0.001
COALENERG	0.58	-0.082
IMCOMPANY	0.64	-0.061
KERNEL	0.73	1.182
KSGAGRO	0.45	-0.015
MILKILAND	0.11	-0.311
OVOSTAR	1.88	0.690

Table 5-6 presents the studies concerning, among others, the net profit, depreciation, EBITDA and assets of the telecommunication sector's companies [8, 9].
According to the obtained values, it is clear that only COALENERG, IMCOMPANY, KSGAGRO, MILKILAND showed a loss, which was confirmed by the previous ratios included in Table 2.

Table 5 Technical evaluation of the WIG-UKRAINE sector's companies quoted on the Warsaw Stock Exchange in Poland as of 31.12.2016 (own development based on the financial data of the Warsaw Stock Exchange)

Name	*Net profit (net loss) in thousands EUR*	*Depreciation in thousands EUR*
AGROTON	0.00	0.00
ASTARTA	3397	7163
COALENERG	-3709	760
IMCOMPANY	-1917	2829
KERNEL	95364	13751
KSGAGRO	-222	392
MILKILAND	-9727	2570
OVOSTAR	3105	640

Other companies have shown a substantial profit which was generated in 2016.

Table 6 Technical evaluation of the WIG-UKRAINE sector's companies quoted on the Warsaw Stock Exchange in Poland as of 31.12.2016 (own development based on the financial data of the companies quoted on the Warsaw Stock Exchange in Poland)

Name	*EBITDA in thousands EUR*	*Assets in thousands EUR*
AGROTON	0.00	(USD) 80311
ASTARTA	19818	529237
COALENERG	1772	75329
IMCOMPANY	6162	203683
KERNEL	129833	1920833
KSGAGRO	3337	60874
MILKILAND	1475	180187
OVOSTAR	3623	107177

According to the book value per share, it is possible to deduce that some companies are overvalued, and these are IMCOMPANY, KERNEL and OVOSTAR , and in the case of the ASTARTA, MILKILAND company, undervalued (Table 7).

Table 7 The WIG-UKRAINE sector's companies quoted on the Warsaw Stock Exchange in Poland as of 31.12.2016 (own development based on the data of the Warsaw Stock Exchange)

Name	*Book value per share in EUR*
AGROTON	(USD) 2.302
ASTARTA	0.118
COALENERG	-1.059
IMCOMPANY	2.257
KERNEL	13.491
KSGAGRO	-0.678
MILKILAND	0.623
OVOSTAR	17.936

However, it is important not to follow this opinion because the values are only the book values, and the calculation of them is purely mathematical and financial.
In the case of using the economic attitude and interpretation, it would occur that the companies do not have the fair value [2, 11].
The profitability of the equity as well as the profitability of assets is shown only by ASTARTA, IMCOMPANY and MILKILAND however, AGROTON, KOALENERG, KERNEL KSGAGRO and OVOSTAR do not have it.
Therefore, according to the presented study, it is possible to observe that the flagship WIG-UKRAINE concerns have the profitability and they are not threatened by any disturbance of the financial liquidity (Table 8).
The current price of shares of the companies listed on the WIG-Ukraine should reflect their business value and their fair value, but it is not like that.

Table 8 The WIG-UKRAINE sector's companies quoted on the Warsaw Stock Exchange in Poland as of 31.12.2016 (own development based on the data of the Warsaw Stock Exchange)

Name	*ROE*	*ROA*
AGROTON	No data	No data
ASTARTA	0.22	0.13
COALENERG	No data	No data
IMCOMPANY	50.69	11.23
KERNEL	-5.40	-3.25
KSGAGRO	No data	No data
MILKILAND	7.69	5.66
OVOSTAR	No data	No data

Currently, the value of companies significantly deviates from the maximum value achieved a few years ago. The only one exception is IMCOMPANY, which achieved the maximum value in its history. Other companies have the value less than 50%, and even 90% of the maximum one (Table 9).

Table 9 The WIG-UKRAINE sector's companies quoted on the Warsaw Stock Exchange in Poland as of 27.03.2017 (own development based on the data of the Warsaw Stock Exchange)

Name	*Current value*	*Maximum value*
AGROTON	5.87	41.39
ASTARTA	66.50	95.00
COALENERG	1.11	26.40
IMCOMPANY	9.39	16.70
KERNEL	72.08	79.82
KSGAGRO	2.83	27.80
MILKILAND	2.39	39.97
OVOSTAR	93.00	115.00

However, the fair value which should be reflected by the share prices of the examined companies significantly differs from the calculated value, which was presented in Table 10. In some cases, it is even 10% of the current value. The fair value is considerable higher than the current value of the examined companies, and only similar in one company, IMCOMPANY.

Table 10 The WIG-UKRAINE sector's companies quoted on the Warsaw Stock Exchange in Poland as of 27.03.2017 (own development based on the data of the Warsaw Stock Exchange)

Name	*Fair value*	*Deviation from the fair value in PLN*
AGROTON	15.00	9.13
ASTARTA	75.00	8.50
COALENERG	8.00	6.89
IMCOMPANY	15.00	5.61
KERNEL	79.00	6.92
KSGAGRO	9.00	6.17
MILKILAND	12.00	9.61
OVOSTAR	110.00	17.00

5. Conclusion

The share price of the companies listed on the WIG-Ukraine is largely undervalued by the present financial situation worldwide and even by speculative actions of particular capital groups that "wander around" the world and subsist thanks to speculative actions using only surplus on share purchase and sale and then relocate capital to another place. Such investors are not interested in the business value and in the company's situation, its share price, but only in profit.

We can see clearly that the share price of the companies listed on the WIG-Ukraine differs significantly from the fair value that has been calculated and presented in the paper. In view of the foregoing, we should particularly emphasize that this value should be achieved in the future periods, the proof of which is even growing total value of price to earnings (P/OE) on the WIG-Ukraine index, where its minimal level has been already achieved. The fair value of the WIG-Ukraine companies should be achieved in the period of a few years, namely until 2018, given improved situation on world financial markets. It should be noted that there is no measured at fair value of shares and it is not easy to measure the stock shares showing their fair value.

References

[1] Borowski K., „Wyznaczanie punktów zwrotnych indeksu Wig przy pomocy wybranych metod analizy czasowej". *Bossa.pl*, pp. 1-5.

[2] Jajuga K., Jajuga T. „Inwestycje". Wydawnictwo Naukowe PWN, Warszawa 1996, pp. 34-57.

[3] Jędrzejczak M., „Estymacja wartości godziwej. Podejście symulacyjne", Powszechne Wydawnictwo Ekonomiczne, Warszawa 2011, pp. 133-138.

[4] Parvi R., "Valuation of shares and their fair value of the companies listed on the WIG-CHEMIA quoted on the Warsaw Stock Exchange in Poland within 2006-2016", ESD – Economic and Social Development 15th International Scientific Conference on Economic and Social Development – Human Resources Development, Varazdin 9-10 June 2016, ISSN 1849-7535, pp. 121-135.

[5] Parvi R., "Investment funds and their financial effectiveness", Goce Delchev University Macedonia & THOMSON Ltd. Slovakia, *EDIS* - Publishing Institution of the University of Zilina, *2014*, pp. 262-267.

[6] Parvi R., "Share price of companies listed on WIG20 and their fair value". EDIS - Publishing Institution of the University of Zilina EIIC – 3 rd Electronic International Interdisciplinary Conference 2014, pp. 169-177.

[7] Parvi R., "Valuation of shares and their fair value of the companies listed on the WIG30 quoted on the Warsaw Stock Exchange in Poland within 2005-2015", Czech Technical University in Prague. Czech Institute of Academic Education z.s. 2015. pp. 177-184.

[8] Pastusiak R., "Przedsiębiorstwo na rynku kapitałowym". Wydawnictwo CeDeWu, Warszawa 2010, pp. 34-46.

[9] Pierce R., "Stocks, Options & Spreads, Infinity Publishing" 2004, pp. 110-115.

[10] Thompson B., "Stock Market Superstar", Insomniac Press 2008, pp. 52-54.

[11] Veale S., "Stocks, Bonds, Options, Futures", Prentice Hall Press 2001, pp. 88-125.

[12] Stooq.pl, "WIG-UKRAIN", stooq.pl/q/?s=wig_ukrain, accessed: March 27th, 2017.

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ANALYSIS OF SOLAR RADIATION AND PV PANEL EFFICIENCY AT PRAGUE - SUCHDOL

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Abstract: *This article presents an analysis of the efficiency of photovoltaic cells with a view of the critical process parameters. There is analyzed influence of temperature on conversion solar radiation to electric energy in period of 2005 and 2015 based on data gathered by the meteostation that is located at Prague – Suchdol. The collected weather data are analyzed with regard to their impact on solar radiation and conversion efficiency into electricity. The author focuses on the selected time period of the hottest days in the period.*

Keywords: *Solar radiation, PV, conversion efficiency, temperature*

1. Introduction

The total solar energy of all wavelengths received per unit time by unit area of surface oriented normally to the sun's rays at the top of the earth's atmosphere is called the solar constant. Value of the solar constant is 1373 Wm^{-2} [1]. This value is a maximum of solar radiation falling on the PV cell that can be convert to electric energy.

Existing PV panels have very low efficiencies of conversion solar radiation to electric energy with only about 12 - 29%. Gallium Arsenide solar cells have a high efficiency of 29%, while Silicon solar cells have an efficiency of about 12-14%. [2].

Presented an article is focused at analysis of possible conversion of solar radiation to electric energy at specific location – Prague – Suchdol. All data are gathered by meteostation for the period of 2007 and 2015.

The article is not engaged in measuring the specific technical implementation of PV cells, but it only analysis the factors that affect the efficiency of PV cells in terms of weather data during these years. Direction and angle settings have an affect the optimal utilization of the PV cell. Since the solar radiation was measured by pyranometer, the article does not consider the direction of the sunlight. It only affects the length of the solar radiation incident on the panel.

1.1 The site description

Location Prague Suchdol is classified according to the Köppen-Geiger climate classification [3] as Dfb category Cold, Without dry season, Warm Summer) with these characteristics:

- Average temperature of the hottest month: $T_{hot} > 10$ °C
- Average temperature of the coldest month: $T_{cold} \leq 0$ °C
- Number of months where the temperature is above 10: Tmon10≥4 (temperature value of +10 °C has to occur for at least four months)
- Warm summer not $T_{max} \geq +22$ °C and at least 4 $T_{mon} \geq +10$ °C

The dominant climate type by Europe land area is cold D (44.4%) [3]. Köppen-Geiger climate classification shall determine the fundamental limits on the use of solar energy in ensuring electricity consumption.

1.2 Meteostation – specification

The Meteostation is placed at the campus of the Czech University of Agriculture Prague – Suchdol.

Elevation at the site is approximately 280 m, longitude 14° 22′, latitude 50° 08′. Annual average air temperature around 9 °C, average annual precipitation total near 500 mm, appropriate time zone CET (GMT + 1hour). [4]

The Meteostation have been gathered data:

- Air temperature
- Air humidity
- Air pressure
- Global solar radiation
- Wind speed
- Wind direction
- Avg daily temp.
- Avg daily air humidity
- Temperature extremes
- Air pressure
- Wind maximum
- Precipitation
- Daily totals of precipitation

All data are sampled in 10 Min, 15 Min and 60 Min sample period at disposal in a raw stage only. The row data can be read by PC200W system only. The cloud factor has not been measured at the meteostation.

The temperature is a ground temperature (5 cm above surface). Temperatures are represented by one sample per one hour (15 Min), air pressure (not reduced) is represented by one sample per one hour (15 Min), and global solar radiation is represented by 10 Min (daily) totals per m^2. Wind speed is represented by one hour (15 Min) averages, direction by the same (10 m above ground) [4].

The Table 1 sums up the technical details of meteostation.

Table 1 Technical specification [4]

Unit	*Sensor*
Datalogger	CR10X-2M Measurement and Control Module, CS, USA
Sensors	PT100/3 1/3 DIN PT100 temperature sensor, CS, UK
	HMP45C air temperature and relative humidity probe, VAISALA, Finland
	RPT410F pressure sensor, CS, UK
	SR03 rain-gauge, FIEDLER, CZ
	A100R/W200P wind speed and direction sensor, EM, UK
	CM11 pyranometer, K&Z, NL
Telecommunications	NL100 Network Link Interface, CS, USA
	DWL-900AP+wireless access point

1.3 Energy Conversion Efficiency

A solar cell's energy conversion efficiency (η), is the percentage of power converted (from absorbed light to electrical energy) and collected, when a solar cell is connected to an electrical circuit. This term is calculated using the ratio of the Maximum Power Point (MPP), P_{max}, divided by the solar radiation (E ,in Wm^{-2}) incident to solar cell and the surface area of the solar cell (S_c ,in m^2) [5]:

$$\eta = \frac{P_{max}}{E \times S_c}$$

Ideally, E should be equal to global insolation Q [Wm^{-2}]:

$$Q = D\cos(z) + S$$

where D is direct insolation, z is solar zenith angle and S is diffuse radiation [6]. The field of view of the measurement, a pyranometer, is 2πsr, which includes the entire upward hemisphere.

Optimal adaptation occurs only at one particular operating point MPP and noted in our case P_{max}:

$$P_{max} \vdots \frac{dp}{dv} = 0$$

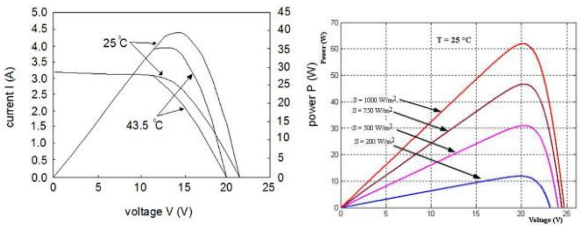
Several factors affect solar cell efficiency. The factors that affecting efficiency of solar cells are cell temperature (air temperature), fill factor, using the MPP with solar cell and energy conversion efficiency for solar cell [2].

We can state that the maximum possible area formed by the intersection of horizontal line (voltage) extended to the I-V curve and vertical line extended to the I-V curve. The MPP is always present at the point of intersection of these extended lines from voltage axis (voltage at maximum power, V_{mp}) and current axis (current at maximum power, I_{mp}). This MPP represents the maximum output Power [7]:

$$P_{max} = V_{mp} \times I_{mp}$$

extracted from the solar PV system to the electrical load.

If the temperature of PV panel surface raises app. twice, the MPP decreases by about 15% and 37 % (depended on the PV cell technology). It decreases P_{max} between 40% and 85% against normal operating condition – see Figure 1 a).



a) ***b)***

Figure 1: Critical factors affecting MPP a) Temperature effects for I-V and P-V characteristics of solar cell module [7]*, b) Influence of the Solar Radiation for Constant Temperature* [2]

2. Local condition analysis

Analyzed data represent the period between January 1 2007 and December 31 2015. Sunshine profile of each year is shown in Table 2. Important for the purposes of the analysis is such hours when the condition $Solar\ radiation > 0$ is valid. Average values for the whole period are showed in Table 2.

Table 2 Average values of the period 2007 and 2015

Quantity	***Unit***	***Value***	***Comment***
AirTC	°C	9,547	Actual value of Air Temperature (at timestamp)
RH	%	72,201	Relative Humidity
Temperature	°C	8,426	Temperature – minimum value
BAR	hPa	981,175	Air pressure
Wind speed	ms^{-1}	2,135	
Wind direction	°	211,723	
Rain	mm	0,062	
Solar radiance 24h	kJ	459,672	Average value over 24 hours
Adjusted Solar radiance	kJ	818,858	The average value during sunshine for 24 hours

The temperature distribution over the entire period is shown n Figure 2. The critical values are in the range above 25°C, which represents a total of 6.3%.

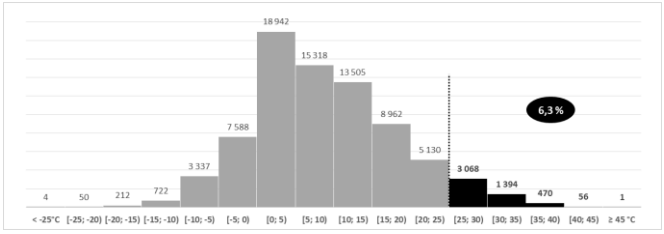


Figure 2: Histogram of Air Temperature (2007 – 2015)

2.1 Daily profile of critical temperature

The critical value of air temperature is over 25°C. Photovoltaic panels can supply electric power on average 56.7 % of hours per year (in total 4 969 Hours) when sunshine incident to PV panel. At the same days, the rain has at the level of 0.

Table 4 Number of hours reaching a temperature limit

Year	*> 25℃*	*> 30℃*	*> 35℃*	*> 40℃*
2007	578	229	48	3
2008	509	184	44	0
2009	531	150	24	0
2010	456	218	70	4
2011	571	178	28	1
2012	656	234	46	8
2013	561	241	92	14
2014	471	173	35	0
2015	656	314	140	27
TOTAL	**4 989**	**1 921**	**527**	**57**

Table 5 Total Solar radiation

Year	*Total per Year*	*Number of Hours over >25°C*	*Ratio*
2007	4 037 674	1 264 580	0,31
2008	3 882 601	1 135 021	0,29
2009	3 852 757	1 153 247	0,30
2010	3 808 032	993 904	0,26
2011	4 115 637	1 235 772	0,30
2012	4 102 064	1 318 792	0,32
2013	3 781 243	1 196 214	0,32
2014	3 877 883	1 001 878	0,26
2015	4 036 138	1 267 211	0,31

On average, 60% of Solar radiation was reached on days with a temperature above 25 ° C. The ratio of total annual Solar radiation during hours with air temperature higher than 25 ° C represents 30% of solar energy for the period 2005-2015. Just in these hours, the efficiency of PV panels has been decreasing. Dependence of Solar radiation on the air temperature is shown in the Figure 2.
Outcomes of the dependent variables analysis are showed on the Figure 3 to Figure 7. Important conclusion is that Solar radiation and Temperature is dependent variable.
Estimation of Solar radiation is: $E = 53{,}89 \times T + 520{,}28$
Coefficient of determination is $R^2 = 0{,}095$

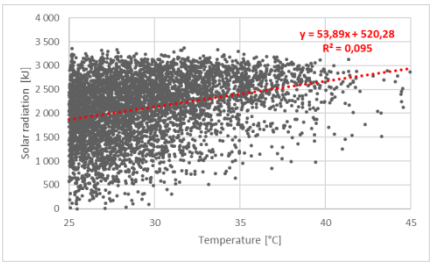


Figure 3: Dependencies Solar radiation on temperature

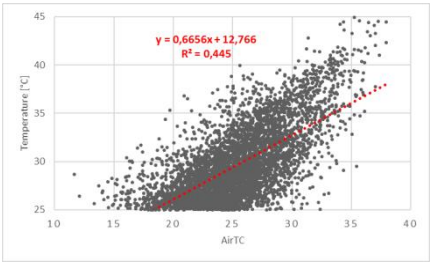


Figure 4: Dependency Air pressure and temperature

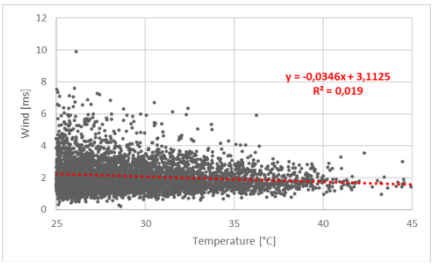


Figure 5: Dependency of temperature and Wind speed

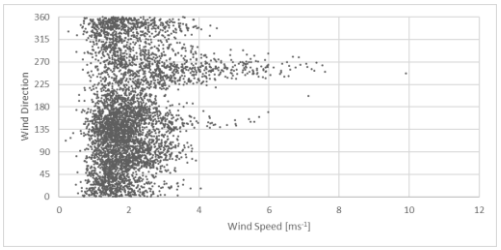


Figure 6: Dependency of Wind Speed and Wind Direction

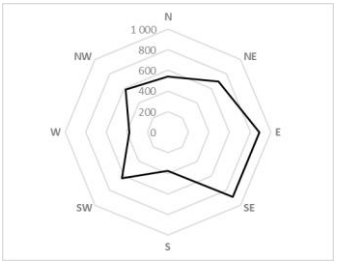


Figure 7: Wind direction rose

2.2 Daily profile for the hottest days

From the perspective of the critical factors of efficiency of energy conversion η are important the hours in which is achieved temperature higher than 30 °C. The day number 197 and 198 are the days when temperature is stable on the hottest level. In these days had been occurrences hours with temperature over 25°C in the year 2007, 2009.2010, 2011, 2013, 2014 and 2015.

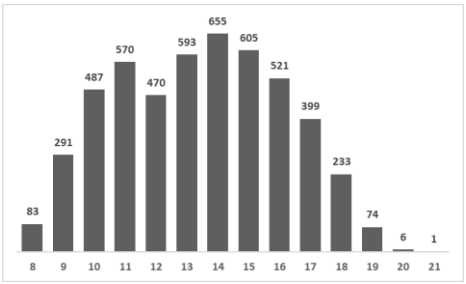


Figure 8: Daily profile – histogram

Table 7 Daily average profile of Air Temperature

Hour	195	196	197	198	199	200	Avg
1	14,41	13,23	12,67	13,25	14,93	12,85	13,56
2	14,04	12,29	11,79	12,96	14,17	12,26	12,92
3	13,59	12,18	11,54	12,55	13,71	12,34	12,65
4	13,04	12,10	11,61	12,41	13,26	12,22	12,44
5	13,15	12,47	11,87	12,56	13,04	12,16	12,54
6	14,69	13,92	13,65	14,54	14,60	13,23	14,10
7	17,29	16,44	17,05	18,05	17,23	16,24	17,05
8	21,09	18,85	22,44	22,82	19,54	20,47	20,87
9	23,70	20,95	26,27	26,66	23,40	24,35	24,22
10	25,76	22,44	27,16	28,24	25,38	28,15	26,19
11	25,83	23,37	28,50	30,00	25,17	26,92	26,63
12	25,50	23,66	27,05	28,68	22,64	26,17	25,62
13	24,01	24,41	28,22	28,90	23,21	25,88	25,77
14	26,55	25,81	30,50	28,07	23,84	25,01	26,63
15	26,94	25,77	31,18	27,50	24,30	26,04	26,96
16	25,45	24,89	30,19	27,21	24,84	26,77	26,56
17	24,13	24,60	28,68	24,36	24,88	24,14	25,13
18	22,43	22,98	26,22	24,41	22,85	23,39	23,71
19	19,14	20,65	22,97	21,72	20,10	21,06	20,94
20	16,13	16,75	17,79	18,64	16,28	17,61	17,20
21	14,86	14,29	15,34	16,92	14,27	15,31	15,17
22	14,56	13,71	14,15	15,84	14,29	14,34	14,48
23	14,05	13,19	13,50	15,27	14,44	14,15	14,10
24	13,95	12,96	13,61	14,32	13,83	13,72	13,73
Avg	19,35	18,41	20,58	20,66	18,92	19,37	19,55

Table 8 Daily average profile of Solar Radiation

Hour	195	196	197	198	199	200	Avg
1	-	-	-	-	0	-	0
2	-	-	-	-	0	-	0
3	-	-	-	-	0	-	0
4	0	0	0	0	0	-	0
5	49	52	53	54	30	32	45
6	367	225	314	286	226	244	277
7	708	489	732	688	527	534	613
8	1 240	846	1 153	1 144	889	1 090	1 061
9	1 600	1 129	1 673	1 687	1 355	1 577	1 504
10	2 030	1 540	2 019	1 900	1 671	2 220	1 896
11	2 294	1 605	2 379	2 342	1 677	2 331	2 105
12	2 167	1 796	2 399	2 457	1 584	2 280	2 114
13	1 815	1 922	2 112	2 334	1 432	2 034	1 941
14	2 237	1 884	2 211	1 892	1 425	1 615	1 877
15	1 764	1 636	2 232	1 619	1 630	1 754	1 773
16	1 345	1 262	1 792	1 313	1 542	1 791	1 508
17	1 235	1 117	1 441	833	1 204	1 032	1 144
18	692	761	934	683	823	733	771
19	409	399	461	354	374	371	395
20	86	103	91	65	73	69	81
21	1	1	0	1	1	1	1
22	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-
Avg	835	699	917	819	686	821	796

3. Conclusions

Finally, characteristic of the solar cell changes with the Solar radiation E (Wm^{-2}) and temperature T (ºC), that is $P = f(V, E, T)$. Temperature is a critical parameter affecting the efficiency of PV cells.

Average hourly temperatures become the highest values in mid-July. In these days is the highest Solar radiation. Unfortunately, in these days occurs to lower level of the conversion Solar radiation to electrical energy. Cooling PV panels using the wind is not effective in Prague - Suchdol. The reason is the lack of wind speed and prevailing wind direction. To increase efficiency, it is necessary to provide additional cooling of the PV panels. The days and times when it is exceeded the critical temperature of 25 °C for that location can be estimated based on historical data.

As shown in Figure 9, we can identify changes in response to changes in the monitored values. It should be applied for evaluation possible electric energy gathered from PV panels at Praha – Suchdol.

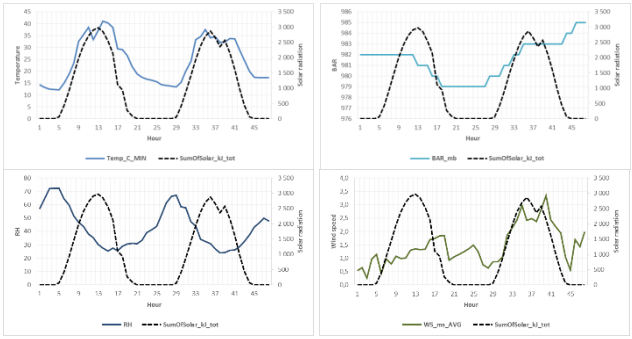


Figure 9: Daily profile – 16-7-2007 and 17.7.2007

References

[1] D. K. McDANIELS, The sun, our future energy source, New York: John Wiley & Sons, 1979.

[2] P. Srivastava, P. Gupta and A. Singh, "Critical Factors Affecting Efficiency of Maximum Power Point Tracking in Solar Cells," vol. 7, no. 1, 2015.

[3] M. C. Peel, B. L. Finlayson and T. A. McMahon, "Updated Word map of the Köppen-Geiger climate classification," *Hydrology and Earth System Sciences*, no. 11, pp. 1633 - 1644, 2007.

[4] "Meteostation of the Czech University of Agriculture Prague," CZU Prague, 2016. [Online]. Available: http://meteostanice.agrobiologie.cz/. [Accessed 2 2017].

[5] F. Dincer and M. Meral, "Critical Factors that Affecting Efficiency of Solar Cells," *Smart Grid and Renewable Energy*, vol. 1, no. 1, pp. 47-50, 2010.

[6] R. L. Hulstrom, Ed., Solar Resources, London, England: The MIT Press, 2003.

[7] Y. Suita and S. Tadakuma, "Driving Performances of Solar Energz Powered vehicle with MPTC," 2006.

[8] W. Ali , P. Cofie, J. Fuller, S. Lokesh and E. Kolawole, "Performance and Efficiency Simulation Study of a Smart-Grid Connected Photovoltaic System," *Energy and Power Engineering*, vol. 9, no. 2, pp. 71-85, 2017.

[9] D. L. King, "Photovoltaic module and array performance characterization methods for all system operating conditions," in *AIP Conference Proceeding*, Lakewood, Colorado (USA), 1997.

HYDRAULIC HEXAPOD AS A LABORATORY PLATFORM WITH 6 DEGREES OF FREEDOM: KINEMATIC SOLUTION AND MOTION CONTROL

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Abstract: *The article describes the hexapod with six linear hydraulic motors and six degrees of freedom. The hexapod consists of rigid base plate, movable platform and six linear hydraulic motors, which are joined to base plate and movable platform by ball joints. In the first part of the article is resolved hexapod kinematics using matrix methods of investigation of spatial multibody systems. Hexapod is used for laboratory vibration excitation equivalent to vibration measured with accelerometers in real part operation. The second part of the article describes the synthesis of control signal from the values measured by accelerometers. The computation routines of the synthesis is programmed in Maple interface.*

Keywords: *hexapod, motion control, transformation matrix, 6 DOF*

1. Introduction

The object of study is a laboratory hydraulic hexapod used for dynamic testing of mechanical components [1] [2] and subassemblies, e.g. car seats (fig.1, fig.2). Dimensions of hexapod described herein are known from drawing documentation. Essence of the experiments performed on the the hexapod is mounting investigated object to the movable platform and excite the desired movement or vibration by hydraulic motors of the hexapod. Each experiment should best possible to simulate real operation conditions of components. Therefore the desired movement is measured in real operation by accelerometers.

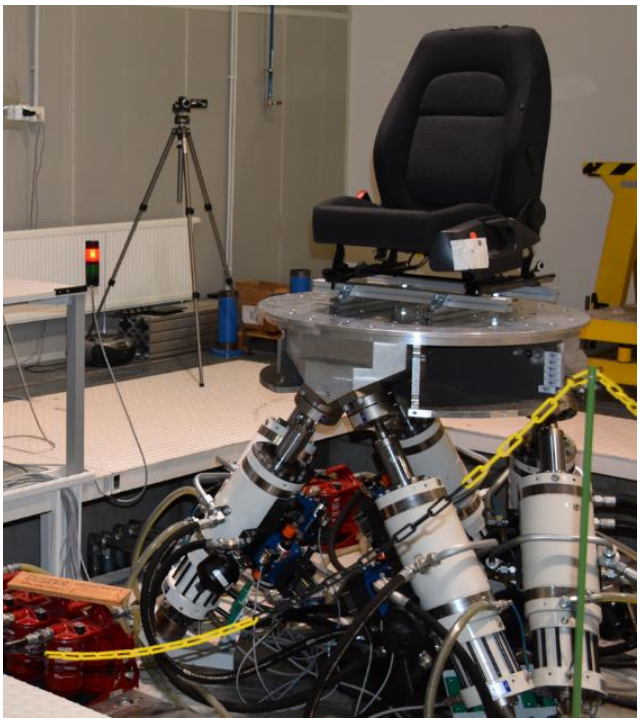

Figure 1: The hexapod with a car seat

So the aim of the work is accelerometers' signals conversion to control signals for hydraulic motors of hexapod. Because it is a processing of large amounts of measured data, it requires the conversion to be simple and fast.

Figure 2: Schematic CAD model of the hexapod

2. Description of the hexapod

Hexapod consists of a base plate, the movable platform and six hydraulic linear motors, which are joined to the base plate and platform by ball joints. The movable platform has six degrees of freedom towards the base plate [3]. There are two coordinate systems on hexapod: Fixed $a: A x_a\ y_a\ z_a$ (rigid fixed with the base plate) and movable $b: B x_b\ y_b\ z_b$ (rigid fixed with the movable platform). At default position of the platform both of the coordinate systems coincide and are at the middle point of platform's upper surface (fig.3).

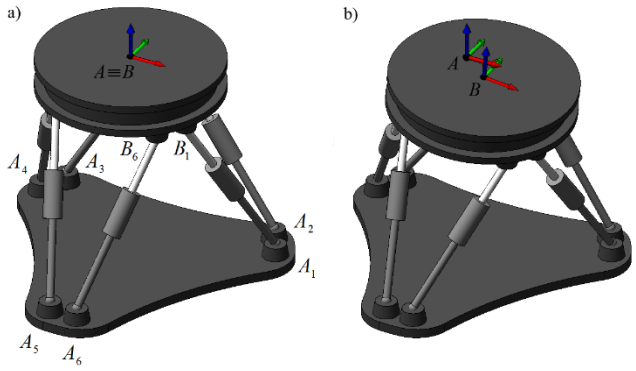

Figure 3: a) hexapod at default position, b) hexapod at general position

3. Coordinate systems transformation

Hydraulic motors are numbered 1 to 6, ball joints on the base plate A_1 to A_6, ball joints on the movable platform B_1 to B_6 (on fig.3 are identified only joints B_1 and B_6). Augmented radius vectors of arbitrary point Q in coordinate systems a and b during motion $b:a$ are constrained by transformation equation

$$\mathbf{r}_{aQ} = \mathbf{T}_{ab}\,\mathbf{r}_{bQ}\,, \tag{1}$$

where $\mathbf{r}_{aQ}$ is the augmented position vector of point Q in coordinate system a, $\mathbf{r}_{bQ}$ is the augmented position vector of point Q in coordinate system b and $\mathbf{T}_{ab}$ is transformation matrix of motion $b:a$.

Augmented radius vectors of joints $A_i,\ i=1..6$ in coordinate system a and joints $B_i,\ i=1..6$ in coordinate system b are known from dimensions of hexapod and they are

$$\mathbf{r}_{aAi} = \begin{bmatrix}\mathbf{u}_{aAi}\\ 1\end{bmatrix},\quad \mathbf{r}_{bBi} = \begin{bmatrix}\mathbf{u}_{bBi}\\ 1\end{bmatrix} \qquad \mathbf{u}_{aAi} = \left[x_{aAi}, y_{aAi}, z_{aAi}\right]^T,\quad \mathbf{u}_{bBi} = \left[x_{bBi}, y_{bBi}, z_{bBi}\right]^T \tag{2}$$

Transformation matrix during general motion $b:a$ is

$$\mathbf{T}_{ab} = \begin{bmatrix}\mathbf{S}_{ab} & \mathbf{u}_{ab}\\ \mathbf{O} & 1\end{bmatrix},\quad \mathbf{S}_{ab} = \begin{bmatrix}a_{11} & a_{12} & a_{13}\\ a_{21} & a_{22} & a_{23}\\ a_{31} & a_{32} & a_{33}\end{bmatrix},\quad \mathbf{u}_{ab} = \begin{bmatrix}a_1\\ a_2\\ a_3\end{bmatrix},\quad \mathbf{O} = [0,0,0] \tag{3}$$

where $\mathbf{S}_{ab}$ is directional cosines matrix and $\mathbf{u}_{ab}$ radius vector of point B in coordinate system a.

3. Kinematic solution

Each hydraulic motor has a default length L_0. Piston stroke of i-th hydraulic motor from default position is z_i. Current length of i-th hydraulic motor (distance of joints A_i and B_i) is $L_0 + z_i,\ i=1..6$.

There are six conditions for current lengths of hydraulic motors in arbitrary position [3] of the movable platform

$$\left|\mathbf{u}_{aBi} - \mathbf{u}_{aAi}\right| = L_0 + z_i,\ i=1..6\,. \tag{4}$$

Using scalar product for determination of vector length, it is possible to convert (5) to equation

$$\left(\mathbf{u}_{aBi} - \mathbf{u}_{aAi}\right)\left(\mathbf{u}_{aBi} - \mathbf{u}_{aAi}\right) = \left(L_0 + z_i\right)^2,\ i=1..6 \tag{5}$$

It applies for the augmented radius vectors B_i in coordinate system a the transformation equation (1)

$$\mathbf{r}_{aBi} = \mathbf{T}_{ab}\,\mathbf{r}_{bBi} = \begin{bmatrix}\mathbf{u}_{aBi}\\ 1\end{bmatrix} = \begin{bmatrix}\mathbf{S}_{ab} & \mathbf{u}_{ab}\\ \mathbf{O} & 1\end{bmatrix}\begin{bmatrix}\mathbf{u}_{bBi}\\ 1\end{bmatrix}. \tag{6}$$

The physical meaning of variable $\left(L_0 + z_i\right)$ (current length of i-th hydraulic motor) enforces a condition $L_0 + z_i > 0$. Because the left hand side of (5) is a sum of second powers, it is $\left(\mathbf{u}_{aBi} - \mathbf{u}_{aAi}\right)\cdot\left(\mathbf{u}_{aBi} - \mathbf{u}_{aAi}\right) > 0$. Piston stroke of i-th hydraulic motor therefore is

$$z_i = \sqrt{\left(\mathbf{u}_{aBi} - \mathbf{u}_{aAi}\right)\left(\mathbf{u}_{aBi} - \mathbf{u}_{aAi}\right)} - L_0 \tag{7}$$

If the transformation matrix components are known, solving of hydraulic motors' piston strokes is easy.

4. Solving of transformation matrix components

The task is based so that it is necessary to compute the components of the transformation matrix from the measured signals of accelerometers (known radius vectors of n points, where n is the number of triaxial accelerometers used). Because accelerometers' signals are composed of the acceleration values in three mutually perpendicular directions, it is necessary first to convert these values to the position values.

Let there is a coordinate system in the space of studied body so that after mounting the body to hexapod movable platform the coordinate system coincides with coordinate system b. Let there are n triaxial accelerometers on studied body so that accelerometers' axes are parallel with axes of coordinate system b and they don't lie on straight line. Augmented radius vector of j-th accelerometer in the coordinate system b is known and it is

$$\mathbf{r}_{bMj} = \begin{bmatrix}\mathbf{u}_{bMj}\\ 1\end{bmatrix},\quad \mathbf{u}_{bMj} = \left[x_{bMj}, y_{bMj}, z_{bMj}\right]^T,\quad j=1..n\,. \tag{8}$$

Coordinate systems a and b are chosen so that they coincide in default position of movable platform. Let components of the converted signal of j-th accelerometer are x_j, y_j, z_j. Augmented radius vectors of accelerometers in coordinate system a are

$$\mathbf{r}_{aMj} = \begin{bmatrix}\mathbf{u}_{aMj}\\ 1\end{bmatrix} \qquad \mathbf{u}_{aMj} = \left[x_{bMj} + x_j, y_{bMj} + y_j, z_{bMj} + z_j\right]^T,\quad j=1..n \tag{9}$$

For radius vectors of accelerometers also applies the transformation equation (1), therefore

$$\mathbf{r}_{aMj} = \mathbf{T}_{ab}\,\mathbf{r}_{bMj}, \quad j = 1..n\,. \tag{10}$$

4.1 Solving transformation matrix components using three accelerometers

Position of body in 3D space is definitely determined by the coordinates of its three points which do not lie in a straight line. Of these nine coordinates are independent only six because the assumption of a rigid body implies three conditions of constant mutual distances of these points.

When using three accelerometers it is $n = 3$. We have nine available signal components $x_j, y_j, z_j, j = 1..n$. Of these are independent six components only, e.g. $x_1, y_1, z_1, y_2, z_2, z_3$. Using (10) we get a system of six linear equations for twelve unknown transformation matrix components $a_{ij}, a_i, i, j = 1..3$ for each recorded time point.

Directional cosines matrix $\mathbf{S}_{ab}$ contains in columns coordinates of unit directional vectors of coordinate system's b axes in coordinate system a. Let we denote these vectors $\mathbf{b}_x$, $\mathbf{b}_y$, $\mathbf{b}_z$, where

$$\mathbf{b}_x = \left[a_{11}, a_{21}, a_{31}\right]^T, \mathbf{b}_y = \left[a_{12}, a_{22}, a_{32}\right]^T, \mathbf{b}_z = \left[a_{13}, a_{23}, a_{33}\right]^T. \tag{11}$$

Any two of these vectors have to be perpendicular and length of each of them is 1, which can be expressed using scalar products

$$\begin{aligned} &\mathbf{b}_x\mathbf{b}_y = 0, \quad \mathbf{b}_y\mathbf{b}_z = 0, \quad \mathbf{b}_z\mathbf{b}_x = 0 \\ &\mathbf{b}_x\mathbf{b}_x = 1, \quad \mathbf{b}_y\mathbf{b}_y = 1, \quad \mathbf{b}_z\mathbf{b}_z = 1 \end{aligned}. \tag{12}$$

For calculation of transformation matrix components it is necessary to solve system of twelve equations for twelve unknowns. The equation system consists of six linear equations obtained from (10) and six non-linear equations (12).

Solution of this equation system is necessary to be done for each time point of measured accelerometers' signals. Because it is a system of non-linear equations, it is possible to solve it using appropriate iterative method. However, this task is at the high number of measured values time consuming and demanding on computer capacity.

4.2 Solving transformation matrix components using four accelerometers

When using four accelerometers it is $n = 4$. We have twelve available signal components $x_j, y_j, z_j, j = 1..n$. Six of them are independent again. If we assume that studied body is ideally rigid and accelerometers are ideally fixed to the body, components of these signals comply with six conditions for constant distances between accelerometers. These six conditions are equivalent with equations (12), because they represent the fact that the studied body is rigid and thus the movable coordinate system remains orthonormal.

If we substitute the measured values to equation (10) and if we use all twelve components of accelerometer signals, we obtain a system of twelve linear equations for twelve unknown components of transformation matrix (3).

We will write this system in a matrix form

$$\mathbf{M}_S\,\mathbf{x} = \mathbf{p}\,, \tag{13}$$

where $\mathbf{M}_S$ is matrix of equation system (square, 12th order), $\mathbf{x}$ vector of unknowns and $\mathbf{p}$ vector of right hand sides. The matrix $\mathbf{M}_S$ contains components of vectors $\mathbf{u}_{bMj}$, vector $\mathbf{x}$ twelve unknown transformation matrix components and vector $\mathbf{p}$ components of vectors $\mathbf{u}_{aMj}$.

The system (13) has just one solution if and only if the determinant of the matrix of equation system $D_S = |\mathbf{M}_S| \neq 0$. If this condition is accomplished, then the equation system is easy to solve, e.g. using Gauss elimination or matrix inverse, because the matrix $\mathbf{M}_S$ contains many zero components.

It applies the theorem $D_S \neq 0$ if and only if the accelerometers 1 to 4 don't lie in a plane. This theorem we will prove. Let there are three vectors with start point in location of accelerometer 1 and end points in locations of accelerometers 2, 3, 4. Components of these vectors we put into columns of matrix $\mathbf{M}_V$, so that

$$\mathbf{M}_V = \left[\mathbf{u}_{bM2} - \mathbf{u}_{bM1}, \mathbf{u}_{bM3} - \mathbf{u}_{bM1}, \mathbf{u}_{bM4} - \mathbf{u}_{bM1}\right]. \tag{14}$$

Determinant of matrix $\mathbf{M}_V$ we denote $D_V = |\mathbf{M}_V|$. By direct calculation of determinants D_S and D_V it is possible to verify the equality

$$D_S = D_V^3\,. \tag{15}$$

The condition $D_S \neq 0$ is true if and only if the determinant $D_V \neq 0$, which results from the equality (15). A determinant is nonzero if and only if all its columns are linearly independent, which occurs only if the accelerometers 1 to 4 don't lie on a plane. This condition is necessary and sufficient. The proof is finished.

5. Conclusions

It was explored kinematics of hydraulic hexapod with six degrees of freedom. It was also proposed the method of conversion of transformation matrix components to strokes of hexapod hydraulic motors. For simulation of motion, measured in real operation using accelerometers, it is necessary to convert measured data to transformation matrix components at each time. There are two methods deduced: When using three accelerometers and when using four accelerometers. It was mathematically deduced, when using four accelerometers the conversion is significantly faster and easier.

Acknowledgements

The research was made possible by VÚTS, a.s., research project NPU - L012, 99253/5 and Technical university of Liberec, Faculty of Mechanical Engineering, Department of the Design of Machine Elements and Mechanism.

References

[1] Petřík, J., Martonka, R., *Measuring platform for seat testing.* Proceedings of 52th International Conference of Machine Design Departments, pages 184 – 187, ISBN 978-80-248-2450-5. VŠ TU Ostrava, 2011.

[2] Fliegel, V., Martonka, R., *Electro-dynamic measuring equipment.* Proceedings of the Conference MMa MS, pages 101-103, ISBN 978-80-553-0731-2. Technická univerzita v Košiciach, 2011.

[3] Fliegel, V., Martonka, R., *Hexapod-the Platform with 6DOF*. Proceedings of 54th International Conference of Machine Design Departments, pages 111 – 116, ISBN 978-80-7372-986-8. Technická univerzita v Liberci, 2013.

ASSESSMENT OF THE IMPACT ON THE ENVIRONMENT OF THE PHOTOVOLTAIC POWER PLANTS

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Abstract: *One of the main cause of environmental degradation is excessive consumption of energy from conventional sources. Because of the need to reduce greenhouse gas emissions and the progressive depletion of fossil fuels now a days, modern societies began greater usage of alternative energy sources that includes the Sun's energy. Each energy affects the quality of the environment, but not all of them to the same extent. Therefore, the essence of the present research was assessment of the impact on the environment of the photovoltaic power plants. This paper addresses three issue areas. The first area is the analysis of the current state of knowledge about the life cycle of photovoltaic power plants. The second area consisted of analysis of ecological analyzed the renewable energy source based on the method of LCA (Life Cycle Assessment). The last – third area issues accounted for presentation and discussion of the test results are specified levels of hazard impacts on the environment of the different stages of the life cycle of photovoltaic power plant. Based on the results of research there were proposed guidelines for pro-environmental management of post-consumer plastics, materials and components of photovoltaic power plants.*

Keywords: *photovoltaic power plants, Life Cycle Assessment (LCA), renewable energy sources, mechanical engineering*

1. Introduction

The life cycle assessment (LCA) of each photovoltaic installation takes place in five basic phases. It involves following sequential stages: formulation of needs and construction, production, exploitation and post-use management. The last stage of the life cycle assessment is at the same time the reason for starting another. The analysis and assessment of the life cycle of photovoltaic components creates guidelines and recommendations for the creation of more environmentally friendly technical objects by creating new needs that are being produced at the next stages of the life cycle. [2, 5, 9].

Formulation of the need must take place in the sphere of production, exploitation or the post- use management of the previous life cycle of the installation or even before designing a new solution. The needs definition should not predefine the ways of satisfying it. If you can't meet your needs based on an already existing solution, take action to create a new installation. The second stage is construction, there is a process of synthesis of the plant, which has specific properties that allow to meet the requirements resulting from the solutions adopted in the solution evaluation phase. The construction of photovoltaic systems involves the selection of energy conversion systems, materials and information, the development of the concept of operation, the appropriate use of the properties of matter and physical phenomena, the development of mechanisms, the creation of favorable relationships, and the desired coupling between their elements. The third phase, that is production, consists in the production of a photovoltaic system with predetermined properties, i.e. the potential of the project. At this stage there are activities in the scope of organization of production processes, process engineering design and material realization of all elements of the installation. The fourth stage of the life cycle assessment is the exploitation phase. During the operation, the technical entity performs the tasks it was designed for and then manufactured. Operation includes power, operation, use and management. Up until a certain moment the post-consumer managment hadn`t been distinguished as a separate phase of the photovoltaic installation life cycle. However, with time, the attention was paid not only to the highest quality of the end products and the effectiveness of processes, but also to the fact that the products and the process itself were less harmfull. The problem of post-consumer management is more often being taken into account at all earlier stages of the life cycle assessment [1, 3, 4, 6, 9, 10, 11].

The main objective of the development was adopted to assess the impact on the environment photovoltaic power plants.

2. Material and methods

The study was based on the analysis of the LCA life cycle of a photovoltaic farm with a capacity of 1 MW (location: Northern Poland), using the method Eco-indicator 99 and software SimaPro 7.1. The level of negative impacts, both throughout the life cycle assessment and in different stages of material (production, operation, management postconsumer) was identified. The total impact and negative impact on human health, environmental quality and resource depletion were assessed. The level of the negative impacts of the various phases and the entire life cycle assessment of photovoltaic installation including the possible development of post-consumer plastics materials and components in the form of recycling were evaluated numerically.

The LCA rating method, in accordance with ISO 14000, consisted of four successive basic elements: the definition of the objective and scope, the analysis of a set of inputs and outputs (LCI), impact assessment (LCIA) and interpretation. The entire evaluation was an iterative

process, distinguishing multiple feedback loops. Each and every analytical phase was followed by the operational interpretation of the obtained data [7, 13].
Used when assessing the impact of the method Eco-indicator 99 belongs to the group methods for modeling the environmental impact of environmental endpoint mechanism. The process of characterization is done for the eleven categories of impact, coming within three larger groups referred to as impact areas or categories of damages. There are the following areas of impact: human health, ecosystem quality, and resources. The results of the impact-area indicators are further analyzed through normalization, grouping, and weighing into the final Ecolabel. The final result of the analysis was to obtain environmental factors expressed in environmental points (Pt), constituting aggregated units enabling comparisons of eco-balance sheets.
A thousand environmental points is equal to the impact on one's environment, the average European within a year [7, 8, 12]. Conducted the analysis may include a bottom-up, and it served mainly the description of the existing reality (retrospective analysis), but also modeling a more pro-environmental solutions (prospective analysis). The level of advancement classifies it in detailed analysis. The geographic scope of the analysis is the area of Europe. The time horizon covers a period of 20 years. As a reference unit for further analyzes it was assumed that the plant under test produced 1000 MWh per year. The analysis skipped the stage of storage, sales and distribution. The exclusion criterion was less than 0.01%.

3. Results and discussion

During the production of elements for the construction of a 1 MW photovoltaic power plant, the highest level of negative impact on the environment was observed throughout its life cycle assessment. The highest levels of harmful effects were found in the categories of fossil fuel extraction (12252 Pt), mineral extraction (9483 Pt) and inorganic compounds causing respiratory disease (10850 Pt), while the compounds causing the ozone hole (2 Pt) and organic compounds causing respiratory diseases (11 Pt) were the least harmful. The smallest impact was produced during the stage of operation. The highest values of harmful influences were noted for the category of inorganic compounds causing respiratory diseases (11 Pt), and the lowest for ozone depleting compounds (0.013), radioactive compounds (0.639 Pt) and organic compounds causing respiratory diseases (0.737 Pt).
When compared with the assumed forms of post-disposal management, the environmental impact of landfill disposal is more negative. Categories of influences that have the strongest negative impact on the environment are: carcinogenic compounds (2654 Pt), ecotoxic compounds (1507 Pt), climate change compounds (292 Pt) and fossil fuel production (137 Pt).
The use of recycling processes would minimize the negative impact of the life cycle of the surveyed power plant in most of the assessed impact categories. Significant positive impacts would have occurred for fossil fuel extraction processes (-10058 Pt), emissions of inorganic compounds causing respiratory diseases (-7423 Pt), climate change compounds (-2686 Pt), and mining-related processes (-1889 Pt) (Tab. 1).

Table 1 Results of grouping and weighing the consequences of environmental problems in the stages of the life cycle of the material 1 MW photovoltaic power plant, taking into account the category of influence [Pt] (own research)

Impact category	*Produ-ction*	*Exploita-tion*	*Landfill*	*Recycling*
Carcinogens	572	3	2654	-825
Resp. organics	11	0	1	-17
Resp. inorganics	10849	11	72	-7423
Climate change	2055	3	292	-2686
Radiation	28	0	1	0
Ozone layer	2	0	0	-4
Ecotoxicity	856	1	1507	-401
Acidification/ eutrophication	976	1	8	-502
Land use	682	0	18	0
Minerals	9483	9	2	-1889
Fossil fuels	12252	4	137	-10058
Total	37770	32	4691	-23804

The largest emission in the first analyzed area of influence - compounds affecting human health, occurred in the stage of production of plastics, materials and elements of 1 MW photovoltaic power plant. Sulfur dioxide (3194 Pt), nitrogen oxide (3091 Pt), sulfur oxide (1453 Pt), molecules> 2.5 μm and <10 μm (1214 Pt), <2.5 μm Carbon dioxide (871 Pt), total particulates (531 Pt) and arsenic ions (392 Pt). Significant impact on the magnitude of the negative impact of the whole life cycle of the analyzed power plant could be post-harvest utilization, which is an important source of emission of cadmium ions (2005 Pt), biogenic methane (202 Pt), arsenic (104 Pt) and biogenic dioxide Carbon (636 Pt).
The recycling process would make a significant contribution to the reduction of harmful influences, mainly on sulfur oxide emissions (-3274 Pt), total molecules (-2521 Pt), carbon dioxide (-1947 Pt), nitrogen oxide (-1627 Pt), tetrafluoromethane (-606 Pt) and arsenic ions (-514 Pt) (Tab. 2).

Table 2 Results of grouping and weighing environmental consequences for compounds affecting human health, occurring in the 1 MW photovoltaic power plant [Pt] (own research)

Human health	*Produ-ction*	*Exploita-tion*	*Landfill*	*Recycling*
Sulfur dioxide	3194	3	7	0
Nitrogen oxide	3091	2	37	-1627
Sulfur oxide	1453	2	0	-3274
Particulates, > 2.5 μm, and < 10 μm	1214	0	3	0
Parcitulates, < 2,5 μm	1038	3	24	0
Carbon dioxide	891	0	0	-1947

Carbon dioxide, fossil	879	3	14	0
Particulates	531	0	0	-2521
Arsenic, ion	392	3	104	-514
Ammonia	197	0	0	-1
Methane, tetrafluoro-, CFC-14	122	0	0	-606
Particulates, < 10 µm (stationary)	83	0	0	0
Cadmium	59	0	0	-49
Methane	56	0	0	-108
Methane, fossil	53	0	11	0
Metals, unspecified	37	0	0	-148
Nitrogen dioxide	28	0	0	0
Carbon dioxide, biogenic	28	0	63	0
Particulates, < 10 µm (mobile)	23	0	0	0
^{222} Radon	21	0	0	0
Dinitrogen monoxide	19	0	1	0
Cadmium, ion	8	0	2548	-20
Methane, biogenic	2	0	202	0
Total	13372	18	3015	-10814

Another impact area assessed was the relationships and processes influencing the quality of the environment. The highest negative impact was the production of 1 MW of photovoltaic power plants, including mainly
Nitric oxide (596 Pt), nickel (280 Pt) and zinc (263 Pt), and processes related to conversion to minerals (338 Pt) and occupation Through a waste dump (276 Pt). Among the analyzed post-disposal options, recycling processes would be most effective in mitigating adverse effects, primarily by reducing nitric oxide (-313 Pt), nickel (-212 Pt) and metals that may adversely affect environmental quality (-20 Pt). (tab.3).

Table 3 Results of grouping and weighing environmental consequences for compounds affecting human health, occurring in the 1 MW photovoltaic power plant [Pt] (own research)

Ecosystem quality	*Production*	*Exploitation*	*Landfill*	*Recycling*
Nitrogen oxide	596	1	7	-314
Transformation, from mineral extraction site	338	1	14	0
Nickel	280	0	1	-212
Occupation, dump site	276	0	13	0
Zinc	263	0	1	-20
Transformation, to arable, non-irrigated	221	0	0	0
Sulfur dioxide	182	0	0	0
Transformation, from unknown	143	0	0	0
Chromium VI	126	0	1	-8
Transformation, to industrial area, built up	118	0	0	0
Occupation, from mineral extraction site	112	0	4	0
Ammonia	108	0	0	-1
Sulfur oxide	83	0	0	-187
Transformation, to dump site	64	0	0	0
Lead	61	0	26	-30
Transformation, to industrial area	59	0	0	0
Transformation, to forest, intensive	48	0	3	0
Transformation, to water bodies, artificial	47	0	0	0
Land use, II-III	41	0	0	0
Metals, unspecified	41	0	0	-162
Transformation, to dump site, benthos	27	0	0	0
Copper	20	0	0	-1
Occupation, industrial area	17	0	0	0
Nickel, ion	17	0	103	0
Transformation, to water courses, artificial	17	0	0	0
Cadmium	13	0	0	0
Land use, III-IV	10	0	0	0
Land use, II-IV	10	0	0	0
Occupation, traffic area, road network	9	0	0	0
Copper, ion	8	0	1199	0
Nitrogen dioxide	5	0	0	0
Chromium, ion	4	0	0	0
Zinc, ion	0	0	120	0
Cadmium, ion	0	0	51	0
Total	3366	2	1546	-934

The third area of impact analyzed included processes related to depletion of raw materials. The production of plastics, materials and components of photovoltaic power plants has the highest negative impact in the area of impact, mainly in terms of the harmful effects of tin-related processes (6610 Pt), natural gas (5509 Pt), petroleum (2365 Pt) and copper (2230 Pt). Recycling, as a viable option, would reduce adverse effects, primarily by reducing the harmful effects of oil extraction processes (-7794 Pt), bauxite (-1835 Pt) and natural gas (-1476 Pt) (Tab. 4).

Table 4 Results of grouping and weighing environmental consequences for raw material depletion processes occurring in the 1 MW photovoltaic power plant [Pt] (own research)

Resources	*Production*	*Exploitation*	*Landfill*	*Recycling*
Tin, in ground	6610	0	0	0
Bauxites, in ground	367	0	0	-1835
Coal, 18 MJ/kg, in ground	205	0	0	-347
Coal, hard, in ground	53	0	0	0
Copper, in ground	2230	9	0	0
Gas, natural, 30.3 MJ/kg, in ground	170	0	0	0
Gas, natural, 35 MJ/m^3, in ground	141	1	0	-245
Gas, natural, 36.6 MJ/m^3, in ground	823	0	0	-1476
Gas, natural, in ground	5509	1	21	0
Iron, in ground	51	0	0	-54
Nickel, 1.13% w silicates, Ni 0.76% i Cu 0.76% in crude ore, in ground	69	0	0	0
Nickel, in ground	71	0	0	0
Oil, crude, 41 MJ/kg, in ground	66	0	0	-232

Oil, crude, 42.6 MJ/kg, in ground	2167	1	0	-7795
Oil, crude, 42.7 MJ/kg, in ground	661	0	0	0
Oil, crude, in ground	2366	1	115	0
Tin, 79% in cassiterite, 0.1%in crude ore, in ground	37	0	0	0
Total	21593	13	137	-11983

4. Conclusions

The main goal of the study was achieved through the environmental impact assessment of a 1 MW photovoltaic power plant.

The highest level of negative impact on both human health, environmental quality and raw material depletion was noted at the manufacturing stage.

Based on the research conducted, following solutions may be suggested:

- Reducing the negative impact on the environment of production processes (especially PV panels), which are the stage of the most harmful environmental impact cycle by implementing modern technologies with less energy-intensive, material-consuming and emissivity of harmful substances;
- Creation of the most pro-environmental management algorithm with materials, materials and elements of photovoltaic power plants at the end of their operation, taking into account in particular the recycling processes;
- Work on more environmentally friendly construction materials while retaining appropriate technical, mechanical and quality parameters to perform specific roles in photovoltaic power plant components.

References

[1] Anderson E.E, 2002: *Fundamentals of Solar Energy Conversion*, Addison-Wesley Publ. Co., Reading, MA.

[2] Cempel C., Tomaszewski F., Leszek W., 2005: *Diagnostyka maszyn: zasady ogólne: przykłady zastosowań*, Międzynarodowe Centrum Naukowe Eksploatacji Majątku Trwałego, Radom.

[3] Coulson K., 2005: *Solar and Terrestrial Radiation. Methods and Measurements*, Academic Press, New York.

[4] Duffie J.A., Beckman W.A., 2001: *Solar Engineering of Thermal Processes*, John Wiley & Sons, New York.

[5] Flizikowski J., 1998: *Projektowanie środowiskowe maszyn*, Wydawnictwa Uczelniane ATR, Bydgoszcz.

[6] Gaetzberger A., Hebling C., Schock H.W., 2003: *Photovoltaic Materials History. Status and Outlook*, Materials Science and Engineering, no. 40(1).

[7] Goedkoop M., Spriensma R., 2001: *The Eco-indicator 99 – A damage oriented method for Life Cycle Assessment*, Methodology Report Pré Consultants, Amersfoort.

[8] Guineé J.B., Gorree M., Heijungs R., Huppes G., Kleijn R., Koning A., Oers L., Sleeswijk A.W., Suh S., Udo H.A., Bruij H., Duin R., Huijbregts A.J., Lindeijer E., Roorda A.H., Ven B.L., Weidema B.P., 2002: *Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards, Part 1, 2, 3*, Kluwer Academic Publishers, Dordrecht-Boston-London.

[9] Legutko S., 2007: *Ekologia maszyn*, Wydawnictwo Politechniki Poznańskiej, Poznań.

[10] Lynn P.A., 2010: *Electricity from Sunlight. An Introduction to Photovoltaics*, John Wiley & Sons, Ltd. United Kington.

[11] Messenger R., Ventre J., 2000: *Photovoltaic Systems Engineering*, London – New York – Washington DC, CRC Press Boca Raton.

[12] Piasecka I., Tomporowski A., 2013: *Impact of a wind power plants life cycle on the state of the atmosphere*, Ekologia i Technika, nr 5/2013.

[13] Treloar G.J., Love E.D., 2000: *A Hybrid Life Cycle Assessment Method for Construction*, Construction Management & Economics, no. 18.

DUAL – AXIS SOLAR TRACKING SYSTEM

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Abstract: *Among the renewable energy resources, solar energy is the most essential resource of sustainable energy. Solar energy is inexhaustible and eco-friendly and can be converted into elektricity using photovoltaic panels. These panels can be mounted on the surface of the roof or ground at a particular angle or can be used in solar tracking system. In solar tracking system solar panel is made to rotate either in single axis or in dual axis. In a dual axis system the panel is made to rotate in all four directions in accordance with the sun. This paper presents results of experimental measurement of dual axis solar tracker.*

Keywords: *energy, solar panel, dual – axis solar tracker*

1. Introduction

Renewable sources of energy acquire growing importance due to its enormous consumption and exhaustion of fossil fuel. Renewable energy is abundant, free, sustainable, clean and can be harnessed from different sources in the form of solar, wind, geothermal, hydro and biomass.
Solar power has proved to be one of the best alternative power sources since it is abundant in nature.
A photovoltaic panel is a device used to capture the sun´s radiation. These panels consist of an array of solar cells. When the sun rays are incident on the solar cell, due to the photovoltaic effect, light energy from the sun is used to convert it to electrical energy. The solar panels can be mounted as a fixed type or used as a tracker type. In the fixed type, the solar panel is mounted on the surface of the roof or ground irrespective of sun´s direction at a particular angle. In single and dual axis solar tracking type the solar panel moves according to the movement of the sun [2].
This paper presents the efficiences of energy conversion of photovoltaic panel with dual – axis solar tracking system.

2. Dual – axis solar tracking system

In dual – axis tracking system the sun rays are captured to the maximum by tracking the movement of the sun in four different directions. The dual – axis solar tracker follows the angular heigh position of the sun in the sky in addition to following the sun´s east – west movement [2].

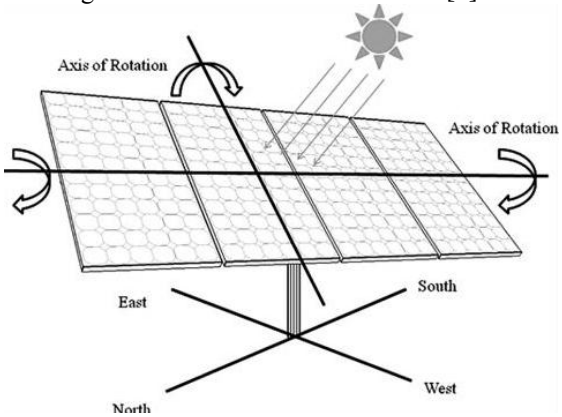

Figure 1: Dual – axis tracking system

The dual – axis tracker works in the same way as the single – axis but measures the horizontal as well as the vertical axis. Figure 1 illustrates an example of a dual axis tracking system that rotates in both east to west and north to south directions accounting for both the daily and seasonal motions of the sun.
We designed and constructed a smaller solar automatic tracking systém (Figure 3). The dual – axis tracker in paper consists of monocrystalline solar panel of high efficiency up to 17,5 and superior cell cutting technology ensure panels outstanding electrical performance and reliable power outcut, actuator, electronic switching clock, timer clock, circuit breaker, two contactors, inverter – transforming DC voltage 12V into AC voltage 230V, accumulator 12V 45Ah.

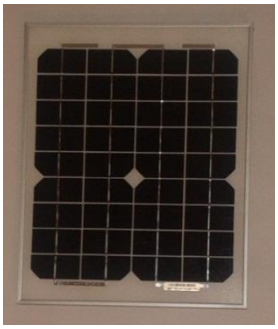

Figure 2: Monocrystalline solar panel

Table 1 Specifications of monocrystalline solar panel

Model	*NETC – M10*
Maximum power at STC (Wp)	10W
Maximum power voltage (Vmp)	17.82V
Maximum power current (Imp)	0.57A
Open circuit voltage (V_{OC})	21.96V
Short circuit current (I_{SC})	0.63A
Power tolerance	± 2 %
Dimensions	360 x 290 x 25 mm
Net weight	1.5 kg

Figure 3: Dual – axis tracker system

2. Results and experimental evaluation

Results were taken in January 29th, 2017 in Hriňová.
Hriňová is situated in central Slovakia. Latitude**:** 48° 34' 40.33", longitude: 19° 31' 32.66" E.
The results were taken from six and a half hours in the morning until a quarter past six in the evening and it even intervals every 15 minutes were recorded value of each of the electrical current, voltage and also power that generated from solar panel, the amount of visible light (illumination), temperature in accordance with the following schedule table 2.

Table 2 Results of tracking solar panel

Time (hour)	*U (volt)*	*I (ampere)*	*P (watt)*	*E (lux)*	*t (°C)*
6:30	0,01	0	0	3,6	-11
6:45	0,06	0,0005	0,00003	29,7	-10,5
7:00	0,27	0,0022	0,000594	324	-10,2
7:15	0,68	0,00604	0,0041072	784	-10,1
7:30	1,17	0,01198	0,0140166	2310	-10
7:45	1,7	0,01712	0,029104	3600	-10,2
8:00	2,47	0,0248	0,061256	5330	-10,2
8:15	22,4	0,215	4,816	19990	-8
8:30	21,9	0,215	4,7085	49600	-3,6
8:45	21,9	0,22	4,818	53500	-2
9:00	21,9	0,225	4,9275	58650	1,2
9:15	21,9	0,225	4,9275	58950	2,1
9:30	21,8	0,1925	4,1965	58003	3,8
9:45	21,7	0,195	4,2315	60580	4,2
10:00	21,6	0,222	4,7952	60986	6,5
10:15	21,4	0,22375	4,78825	70253	6,9
10:30	21,4	0,22275	4,76685	68958	8,2
10:45	21,4	0,223	4,7722	69840	8,8
11:00	21,4	0,22	4,708	55324	9,7
11:15	21,4	0,2195	4,6973	55002	9,9
11:30	21,4	0,21	4,494	56240	11,3
11:45	21,2	0,21	4,452	56450	11,7
12:00	21,3	0,21	4,473	57460	11,8
12:15	21,4	0,22	4,708	58630	11,3
12:30	21,5	0,22	4,73	60586	10,7
12:45	21,5	0,22	4,73	61300	9,3
13:00	21,4	0,22	4,708	62000	9,3
13:15	21,4	0,22	4,708	61540	9
13:30	21,3	0,21	4,473	55784	9,5
13:45	21,1	0,21	4,431	55680	9,9
14:00	21,2	0,21	4,452	49860	9,3

Follow of table 2, results of tracking solar panel

Time (hour)	*U (volt)*	*I (ampere)*	*P (watt)*	*E (lux)*	*t (°C)*
14:15	21,2	0,21	4,452	49500	9,2
14:30	21,0	0,21	4,41	45300	8,8
14:45	20,9	0,21	4,389	40900	8,8
15:00	20,7	0,21	4,347	35500	8,1
15:15	20,3	0,2	4,06	27800	7,1
15:30	19,62	0,2	3,924	19200	6
15:45	16,4	0,16	2,624	12600	5,5
16:00	2,11	0,0213	0,044943	5200	4
16:15	0,89	0,0082	0,007298	1530	3,1
16:30	0,22	0,0021	0,000462	403	1,3
16:45	0,05	0,0005	0,000025	79,4	0
17:00	0,01	0	0	10,49	-0,4
17:15	0	0	0	0,44	-2
17:30	0	0	0	0,14	-4
17:45	0	0	0	0,13	-5
18:00	0	0	0	0,13	-5
18:15	0	0	0	0,12	-4,7

Note from the table that the solar panel records maximum capability of the electrical power of about 4, 9275 watts and also recorded maximum value of voltage and current in the period from 8:15 am to 15:30 pm.

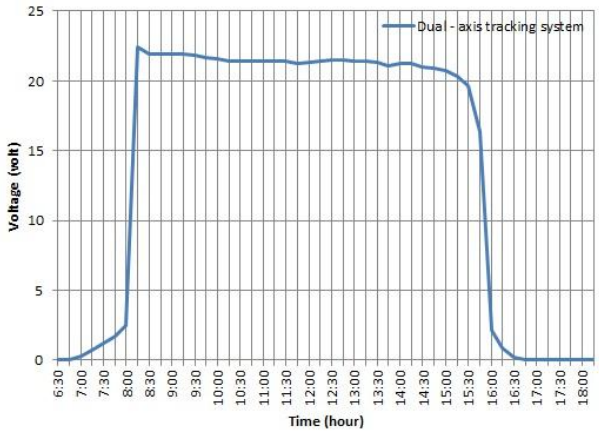

Figure 4: Voltage of solar panel /R = 100Ω/

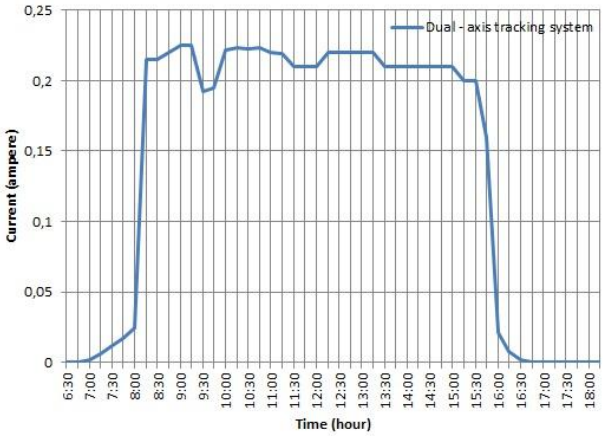

Figure 5: Current of solar panel /R = 100Ω/

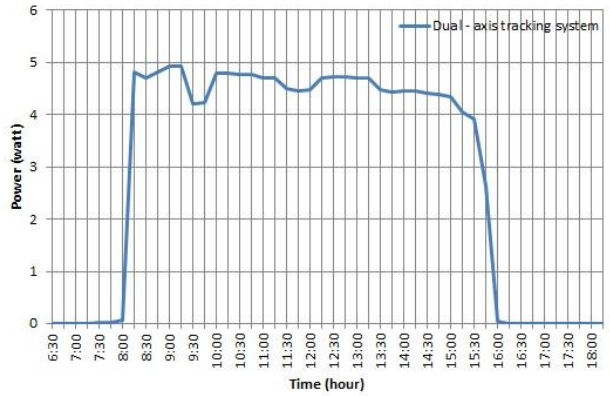

Figure 6: Power generated from solar panel

The generated power of a photovoltaic system is based on the amount of the sun light received by the panel and since the shining angle varies with days and seasons.

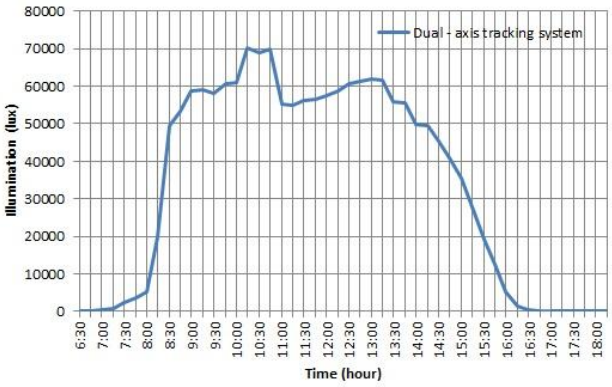

Figure 7: Received sun light in January 29th, 2017

3. Conclusions

In this research, we offered the importance of the work of the tracking system with sun to generate electrical power. Dual – axis tracking system uses the solar panel to track the sun from east to west and north to south. The efficient of dual – axis tracking system is higher than the fixed solar system. We can increase the electric power by using solar cells which can be connected together to use in many applications.

References

[1] Binoy, S., Omkar, S., Siddhesh, S., Abhilash, S., Priya, H., *Comparison Between Different Solar tracking System and Wireless Technology,* International Journal of Advanced Research in Computer Science and Software Engineering, Vol. 4, No. 4, pp. 487-490, 2014

[2] Deepthi, S., Ponni, A., Ranjitha, R., *Comparison of Efficiencies of single – axis tracking system and dual – axis tracking system with fixed mount,* International Journal of Engineering Science and Innovative Technology, Vol. 2, No. 2, pp. 425-430, 2013

[3] Libra, M., Poulek, V., *Fotovoltaika. Teorie i praxe využití solárni energie:* 2. vydanie. Praha: Ilsa, 2010, pp. 165, ISBN 978-80-904311-5-7.

[4] Mustafa, F. M., *Dual – axis solar tracking over fixed solar systems,* International Journal of Advances in Engineering & Technology, Vol. 9, No. 5, pp. 563-568, 2016

[5] Pondušová, N., Naščák, Ľ., *Analysis of technical properties of solar photovoltaic panels,* Interdisciplinary Scientific Conference for PhD students and assistants QUAERE 2015**,** Vol. V, pp. 1504 – 1510, ISBN 978-80-87952-10-8

[6] Pondušová, N., Naščák, Ľ., *Factors affecting efficiency of solar cells,* Proceedings of 4th International Scientific Conference CER, pp. 116-119, Sciemcee, October, 2015

[7] Priya, S., *Energy Harvesting Technologies*. Springer US, 2009, *p*. 517, ISBN 978-0-387-76463-4, e-ISBN 978-0-387-76464-1.

[8] Sayigh, A., *Comprehensive renewable energy*. Amsterdam: Elsevier, 2012. ISBN 978-0-08-087872-0.

Session: Applied Informatics

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DISTRIBUTION TV SIGNAL BETWEEN THE TRANSMITTER AND THE ANTENNA

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Abstract: *In this paper we have presented a formal approach to modeling and analyzing broadcasting UHF Band function using Event B. The abstract model of broadcasting is done abstractly In the refinement of the abstract model, we introduced the notion of a broadcasting function. The system development approach considered is based on Event B, which facilitates incremental development of complex systems. The work was carried out on the Rodin platform. In order to verify our broadcasting model, the initial and refinement model of broadcasting are developed by using Event-B. Each model is analyzed and proved to be correct. Our experience with this case study strengthens our believe that abstraction and refinement are valuable technique for modelling complex system.*

Keywords: *constants, variables, invariants, events, refinement.*

1. Introduction

The purpose of our work is to study and model the spread of DVB-T signal between the transmitter and the antenna using the Event B method and acquire new knowledge measurement.

The primary parameters of the antenna radiation pattern shown in diagrams usually depending on the azimuth (0–360° degrees) and elevation angle. Other important parameters are the beam angle, bandwidth, polarization, etc.,. Antenna gain is different from the amplifier gain because the antenna has no active circuitry and can therefore increase the signal strength. Antenna gain is measured in decibels, the shape of the radiated field differs from the ideal isotropic antenna (dBi unit). The ideal isotropic antenna transmits or receives evenly into (from) all directions, and of course in the real world, it can not be construct. Sometimes also compares the gain of a dipole antenna (isotropic ant.), which can be already constructed and used as a reference.

1.1 Parameters of DVB-T signals

The transmitter transmits a signal into ether with a certain frequency, modulation and power. Physical principles of electromagnetic spreading. waves in the case of digital video broadcasting (DVB-T) is the same as the analog. Reception range of the transmitting antenna (transmitter) is limited in proportion with its performance. Transmitter power is measured in ERP [W], the signal is distributed in a horizontal or vertical polarization. On the receiving antenna signals fall with different polarizations, distant and close transmitters with different levels, quality and modulation. The receiving antenna must have sufficient earnings in [dBi] (to the isotropic radiator), directionality when profits decline by 3 dB directivity angle of 30–50°. YAGI antenna series COLOR and ISKRA need homogeneous electromagnetic. field, ie. fields, which are located in the reception location with no obstructions between the transmitter and the receiving antenna. It is always necessary to follow the rule that the antenna is the best „amplifier.“ Signals with a sufficient level μVdB and quality MER, Post-Ber, captured by the receiving antenna ensures trouble-free TV reception from the perspective of other adjustments – merging, splitting and amplification. In practice, it is necessary to combine more leads antennas receiving signals from different directions. Each element, whether passive or active between the antenna and the TV receiver has a major impact on the quality of the signal.

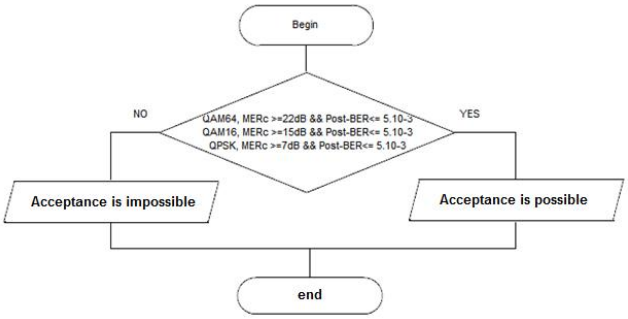

Figure 1: Minimal values of parameters DVB-T

1.2 The design of the antenna

The design of the antenna and its size affects signal reception directivity angle at the lower profits 3–5 dB can receive the signal of remote and local transmitters with different performance. The theoretical basis of the directivity angle while having no significant effect on the quality of the DVB-T except thresholds, compared with the analog. We also found that the antennas Color, Iskra UHF91 have angled reflector, which reflects the signal from the opposite direction, in practice, measurements were found to be not quite. So in reflection acceptance in suppression (anterior-posterior ratio) as this parameter is expressed in tech. specification of the respective antenna is not in actual operation in the case of DVB-T is crucial. Coverage Map gives coverage to the extent of income, but more important is to make measurements at the point of reception, because map does not reflect local conditions

(antenna height above ground, hills, obstacles such. Built up area, ...), should be taken into account terrain profile.

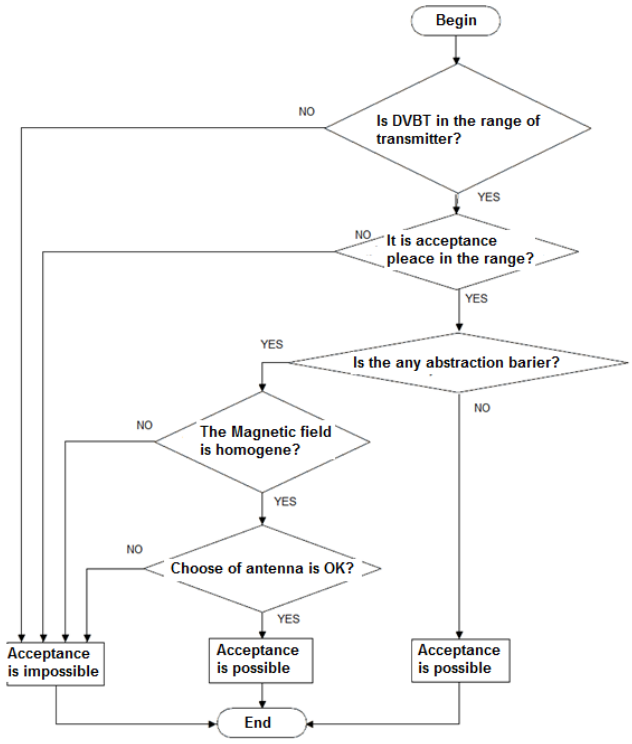

Figure 2: Conditions of accepteans DVB-T

2. Event-B modelling

The subject method of Event-B is an abstract mathematical modeling problem in the progressive refinement to achieve specific systems. We would like to show the possibilities of modeling DVB-T signals in this method compared to using the "B Method," which uses the method of operation.

2.1 Context of Event-B model

Context of Event-B model includes in the static part model. Contains constans, sets and axioms

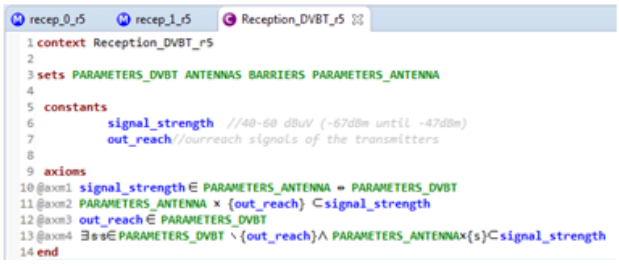

Figure 3: Conditions of accepteans DVB-T

Set PARAMETERS_ANTENNA contains all parameters (length antenna, the antenna type and implementation techniques solution, antenna gain [dBi], etc..).
Set PARAMETERS_DVBT contains all parameters of signals DVB-T (strength [µVdB], Pre-BER, Pos-BER, 5.10^{-3} and lover error, MERc)

2.2 Abstract machine of Event-B model

Abstract machine of Event-B it is the first step in modeling. It is very important because from it depends on further refining model (next machine which is part of the project).

```
machine recep_0_r5 sees Reception_DVBT_r5

variables   reception_DVBT
            b//barrier [e.g. hills, buildings]
            b_out//barrier out reception_DVBT
            r//range
            p//place
            ch // kaint antenna
            vb //magnetic field - post_BER

invariants
  @inv1 ¬(b=TRUE ∧ b_out=TRUE)
  @inv2 reception_DVBT ∈ BOOL
  @inv3 r ∈ PARAMETERS_ANTENNA → PARAMETERS_DVBT
  @inv4 r ⊆signal_strength
  theorem @DLF; ∃s,l·(s↦l ∈ signal_strength ∧ r(s) ≠ l)
  @inv5 p ∈BOOL
  @inv6 ¬(p=TRUE ∧ b=TRUE)
  @inv7 ch ∈ BOOL
  @inv8 vb ∈ BOOL
  @inv9 ¬(vb=TRUE ∧ b=TRUE)
  @inv10 b ∈ BOOL
  @inv11 b_out ∈ BOOL
```

Figure 4: Variables and invariants abstract model

```
events
  event INITIALISATION
     begin
         @act1 b ≔ FALSE
         @act2 b_out ≔ FALSE
         @act3 reception_DVBT ≔ FALSE
         //@act4 r ≔ ∅
         @act5 r ≔ PARAMETERS_ANTENNA×{out_reach}
         @act6 p ≔ FALSE
         @act7 ch ≔ FALSE
         @act8 vb ≔ FALSE
   end
```

Figure 5: Initialisation variables abstract model

Our example – DVB-T will address the range of signal from the transmitter in place of reception (Reception Area), which is distributed from different azimuths various transmitters in remote and local income. Physical principles of electromagnetic spreading. waves is in analog and digital broadcasts the same, but there are some differences. Signal level (its strength) in µVdB (dBm) may be in the case of digital reception of approximately 20 µVdB lower (56 µVdB versus 35 µVdB). Other parameters which indicate the quality of the signal before and after Viterbi correction Viterbi error correction and constellation diagram (QAM) have a significant impact on the possibility of receiving DVB-T.

```
38    event DVBT_range
39         any s l//reception signal
40           when
41              @grd11 s↦l ∈ signal_strength
42              @grd12 r(s) ≠ l
43           then
44              @act11 r(s) ≔ l
45        end
46
47 event acceptance_place //ALLRIGHT
48          any recep_DVBT  //reception signal
49            when
50              @grd1 recep_DVBT ∈ BOOL
51              @grd2 p ∈ BOOL
52              @grd4 b=FALSE ⇒ reception_DVBT=TRUE
53
54            then
55              @act1 reception_DVBT ≔ recep_DVBT
56              @act2 p ≔ TRUE
57        end
```

Figure 6: Event DVBT_range and acceptance_place – solutions of flow chart

It is always necessary to follow the rule that the antenna is the best "amplifier."

```
59 event abstraction_barriers
60         any
61           some_barrier
62         when
63            @grd1 some_barrier∈ BOOL
64            @grd2 b = FALSE ⇒ b_out = TRUE
65            @grd3 b=FALSE ⇒ reception_DVBT = TRUE
66
67          then
68            @act1 reception_DVBT ≔TRUE
69            @act2 b_out≔some_barrier
70            @act3 b ≔ FALSE
71      end
72
73    event magnetic_field  //ALLRIGHT
74         any m
75            when
76               @ged1 m ∈ BOOL
77               @grd2 b=FALSE ⇒ reception_DVBT = TRUE
78               @grd3 p = TRUE
79               //@grd4 r = TRUE
80               @grd5 vb≠b_out
81            then
82               @act1 reception_DVBT≔m
83               @act2 vb≔TRUE
84         end
```

Figure 7: Event abstraction_barriers and magnetic_field – solutions of flow chart

```
86 event choose_antenna  //ALLRIGHT
87          any an
88             when
89                @grd1 an ∈ BOOL
90                @grd2 b=FALSE ⇒ reception_DVBT=TRUE
91                @grd3 p = TRUE
92                //@grd4 r = TRUE
93                @grd5 vb = TRUE
94                @grd6 vb≠b_out
95             then
96                @act1 reception_DVBT ≔ an
97                @act2 ch≔TRUE
98         end
99 end
```

Figure 8: Event choose_antenna – solutions of flow chart

Signals with a sufficient level of quality and µVdB MER, Post-ber, captured by the receiving antenna ensures trouble-free TV reception from the perspective of other adjustments – merging, splitting and amplification. In practice, it is necessary to combine several leads antennas receiving signals from different directions. Each element, whether passive or active between the antenna and the TV receiver has a major impact on the quality of the signal.

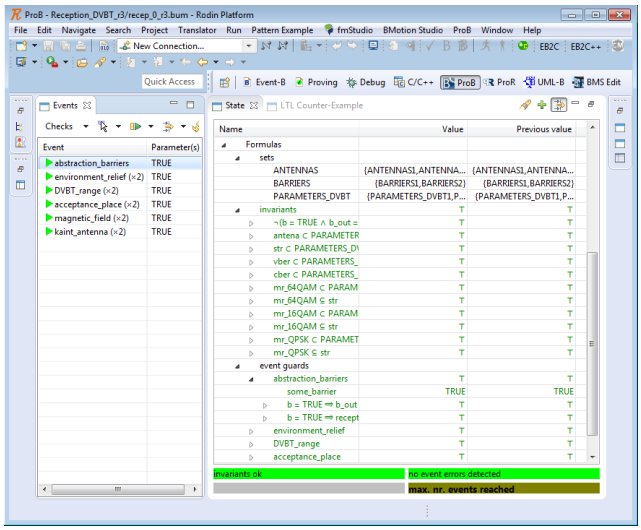

Figure 9: Checking the model in the tool ProB (Rodin)

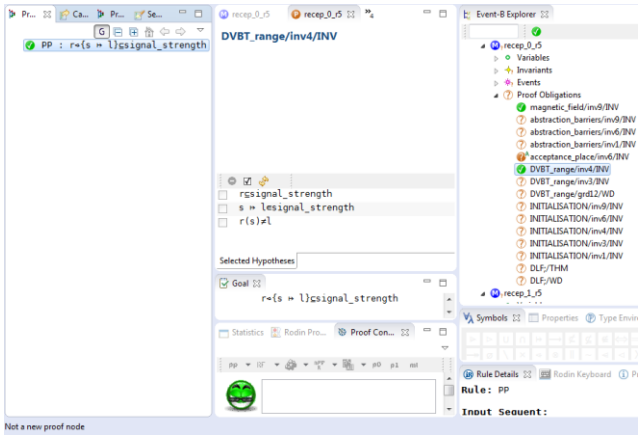

Figure 10: Proving hypotheses in the Rodin

3. Conclusions

The article explains the receiving DVBT signal, depending on the distance from the transmitter, the homogeneity of the elmag fields, antennas and barriers between the place of receipt and the transmitter. DVBT versus analog has their own characteristics resulting from the bit error rate and error rate modulation signal (Pre-BER, Post-BER, QAM). DVBT signal strength for receiving over analog is not a significant factor (compared with 35 µVdB versus 56 µVdB analog). Important is the gain of the antenna and suitably designed antenna system two or more antennas to receive from different angles of azimuth and the directionality of the profit drop max. 3dB for useful signal processing (merge, gain and branching).

By measuring the intake of very short wave shows that the electric field strength at the receiving location varies throughout the year and during the day. Slow fluctuations of the electric field due to the ongoing changes of meteorological conditions in the lower layers of the atmosphere. In spreading in visible distance the atmospheric refraction effects the phase relationships between the direct beam and the reflected beam from the ground, and thus also the resulting amplitude of the electric field. Regular changes in the strength of regular income is explained by changes in atmospheric refraction (day, night, winter, summer), irregular changes are explained by random changes in the weather (storms). When spreading beyond direct visibility is atmospheric refraction effect on the nature of bending and hence the absolute value of the electric field intensity at the reception location.

References

[1] HANDLEY, M. *System Streams*, unpublished (2010).
[2] http://www.etsi.org/deliver/etsi_ts/101100_101199/101154/01.09.01_60/ts_101154v010901p.pdf(2009-09). [1] EuropeanTelecommunicationsStandards Institute 2009, Digital Video Broadcasting (DVB), ETSI TS 101 154 V1.9.1, Accessed on: 2009-09
[3] http://www.etsi.org/deliver/etsi_ts/102500_102599/10259102/01.01.01_60/ts_10259102v010101p.pdf (2010-02). European Telecommunications Standards Institute 2009, Digital Video Broadcasting (DVB), ETSI TS 102 591-2 V1.1.1, Accessed on: 2010-02
[4] http://download.mpo.cz/get/39700/50315/582024/priloha005.pdf, (2008). Czech Telecommunications Office, 163 DECREE on the method for determining terrestrial television broadcasting signal coverage, Accessed on: 2008-04-30
[5] FISHER, W.*Digital Video and Audio Broadcasting Technology*, Springer, 2010. ISBN: 978-3-642-11611-7 (Print) 978-3-642-11612-4 (Online), Springer**.**
[6] FISHER, W., *Measuring DVB-T Signals*, *Springer*, 153Volumes from 2002 – 2017 (March2010), 2010. pp 421-450, ISBN: 978-3-642-11611-7 (Print) 978-3-642-11612-4 (Online).
[7] J.-R. ABRIAL. *Modeling in Event-B*, Swiss Federal University (ETH), Zürich, 2010. ISBN:978-0-521-89556-9
[8] http://www.event-b.org
[9] J.-R. ABRIAL, M. BUTLER, S. HALLERSTEDE, & L. Voisin (2006), An open extensible tool environment for Event-B, *Springer*, Vol. 4260 of*LNCS*, 2006, pp 588–605, ISSN 0302-9743.
[10] ABRIAL, J.-R.*Modeling in Event-B*, Cambridge, 2010. ISBN-13 978-0-511-72976-8, CAMBRIDGE UNIVERSITY PRESS
[11] JASTRAM, M., BUTLER, M.*Rodin User's Handbook*: Covers Rodin v.2.8, CreateSpace Independent Publishing Platform, 2014. ISBN 10: 1495438147 ISBN 13: 9781495438141, USA. https://www3.hhu.de/stups/handbook/rodin/current/pdf/rodin-doc.pdf.
[12] Rodin User's Handbook v.2.8, Accessed on: 2014-02-04https://www3.hhu.de/stups/handbook/rodin/current/html/introduction.html.
[13] HALLERSTEDE, S.,*JustificationsfortheEvent-B Modelling Notation*. B:Formal Specification and Developmentin B, *Springer*, Vol. 4355, 2007., pp 49-63., ISSN 0302-9743
[14] http://wiki.event-b.org/index.php/Rodin_Platform_3.2_Release_Notes *Rodin Platform 3.2 Release Notes*, Accessed on: 2015-11-05

REAL-TIME OPTIMAL SUBSET SIZE SELECTION IN DIGITAL IMAGE CORRELATION

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Abstract: *Digital image correlation is a well-established algorithm for quantitative in-plane deformation measurement of a planar object surface in the field of experimental mechanics. Its results provide full-field displacements, often with sub-pixel accuracy. It has been demonstrated that the choice of subset size significantly influences the quality of results. This paper proposes two novel algorithms on how to choose a proper subset size based on intermediate results from the correlation step. It can be used for initial subset size estimation and also for ongoing size adjustment during the computation.*

Keywords: *DIC, displacement, correlation, quality, size*

1. Introduction

Digital Image Correlation (DIC) is a contact-less technique using a fixed camera to capture the stress test followed by digital image processing and numerical computing to compute full-field displacements and strains. The advantage of DIC is its simplicity of test setup - a single camera and no modification to tested material to obtain results with good quality. It should be also noted that DIC has a wide range of measurement sensitivity and resolution, since its precision is based on the camera used, not the algorithm itself. DIC has been studied extensively and employed in many applications ([1]-[6]).

One of the issues using the DIC method is the choice of subset size. It has been shown that the size directly influences the quality of results ([7]-[9]). The errors can be generally split into two groups. First are so-called random errors, which come from correlation mismatches due to noise and other image corruptions. A second group depicts systematic error that arises from a mismatch of chosen shape function and real deformations. Random errors can be minimized by using larger subset size, thus increasing the count of correlated pixel for one subset, thus reducing the influence of noise errors on results. In order to lower the systematic error, it is recommended to use smaller subset sizes, because they can better describe local deformation features. Further info on how subset size affects quality parameters of results can be found in ([10]-[12]).

In practice, it is essential to choose the best subset size possible in order to provide most accurate results. The best subset size is a compromise between random and systematic errors. However, in real scenarios it can be quite hard or even impossible to determine the best size due to the fact that the deformations are unknown beforehand. In this paper, we present an approach to determine the optimal subset size based on correlation results that balances both errors in order to improve measurement accuracy.

2. Materials and methods

In this chapter we will focus on fundamentals of digital image correlation algorithm. The complete description of DIC can be found in [1], we give only a broad description of algorithm.

2.1 Point matching

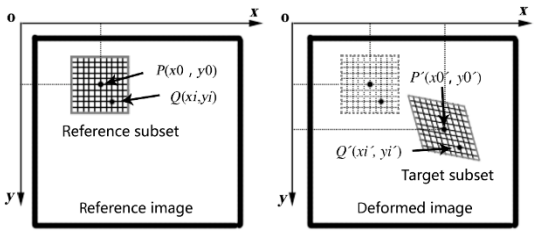

Figure 1 Deformation of subset

The displacement of a point P is computed using a square reference subset of (2M + 1)*(2M + 1) pixels centered on P to track its corresponding location in the deformed image. The subset of points is important because it offers good protection against noise and allows to distinguish the subset from other subsets in case of images with low gray level variations. The similarity is evaluated using correlation criterion (multiple criteria are available) and searching for peak position of the deformed subset. The difference between the position of subsets center before and after the deformation yields the in-plane displacement vector.

2.2 Subset deformation

The deformation of subset is described by a shape function. There are multiple kinds of shape functions, each able to describe different kinds of deformations. The overview of the functions can be found in [1], for us it is sufficient to know that the shape function is a simple equation using pixels absolute positioning, its relative position to subsets centers and deformation coefficients to compute the new position. An example first-order shape function for x coordinate (it allows to describe translation,

rotation, shear, normal strains and their combinations) can be seen in equation 1.

$$\xi(x_i;\ y_j) = u + u_x\,\Delta x + u_y\,\Delta y$$
$$\Delta x = x_i - x_{0,}\Delta y = y_i - y_0$$

Equation 1 First order shape function

2.3 Correlation

As mentioned earlier, to evaluate similarity between original and deformed subset, some kind of correlation criterion needs to be employed. There are multiple classes of correlation criteria available, all of them can be found in [16]. This paper also presents an important result that all criteria are in fact numerically equal, so one can choose any criteria he wants and the result quality will not suffer. In our paper, we have used Zero Normalized Cross Correlation criterion (details can be found in literature such as [16]).

2.4 Test data

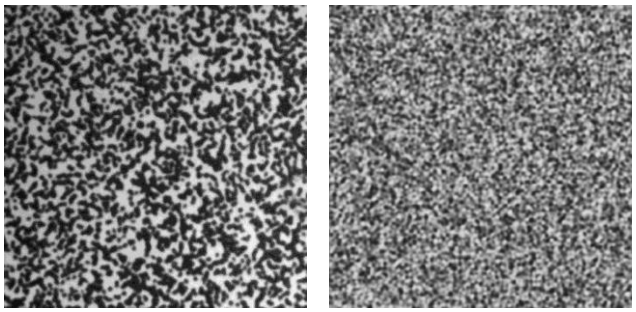

Figure 2 Dataset "Sample 03"(left) and "Sample 10" (right)

To test proposed algorithms we have chosen the DIC Challenge dataset supplied by Society for Experimental Mechanics [18]. It provides several datasets with large variety in surface texture and image noise. We chose dataset "Sample 3" and "Sample 10" (Figure 2) for demonstration in this paper. Sample 3 dataset presents a test case with a constant shift thorough the image, while Sample 10 dataset contains sinusoidal shift.

3. Optimal subset size selection

In subset-based DIC, the users must manually select a subset size varying from several pixels to more than a hundred pixels before the DIC analysis. Since the subset size directly determines the area of the subset being used to track the displacements between the reference and target subsets, it is found to be critical to the accuracy of the measured displacements.

Lecompte et al. ([10]) analyzes the influence of the speckle pattern and subset size on the accuracy of the measured displacement. They show that it is not necessary to obtain the smallest possible speckle pattern to achieve high accuracy, often it is sufficient to use evenly distributed speckle pattern. Another result of their paper is that with larger subset sizes, the results get better, but the subset size must be chosen in accordance with expected deformations. Too large subset size leads to errors due to smoothing of the real material behavior. Wang et al. ([11]) introduces a formula, which can estimate the standard deviation of the displacement measurement error. It can be used to predict the precision of the experiment, but also as a guide for tuning the experimental setup in order to obtain best results (by changing the subset size, filtering out the noise or altering the speckle pattern diversity). Yaofeng et al. ([12]) focuses only on subset size and its effect on result's precision. It the uses subset entropy (average of absolute intensity deviations at any point in the subset from its neighboring points) to define "effective subset size" to allow the comparison of subset sizes in literature.

The first paper offering an automated way of estimating optimal subset size can be found in [13]. It offers an algorithm using a SSSIG criterion (Sum of Square of Subset Intensity Gradients) and the variance of image noise for selecting the optimal subset size based on required standard deviation of displacement error. The SSSIG criterion is loosely related to subset entropy introduced in [12]. The main difference is that while subset entropy is based on intuitive idea, the SSSIG is based on a mathematical concept.

Huang et al. ([14]) introduces a weighting parameter to classical Newton-Raphson sub-pixel registration method to improve the results quality by adaptive weighing the pixel values in the subset. The results show 30% error reduction for small deformations and 60% error reduction in large deformation test case. Yuan et al. ([15]) couples the weighing with ZNSSD correlation criterion to create WZNSSD criterion. The main result of the paper is that the weighed approaches can very effectively diminish the wrong choice of the subset size, both globally (due to poor use choice) and locally (optimal subset size may vary in different parts of the image).

3.1 Subset size vs result quality

[10] and [15] showed that the value of the correlation criterion can be used as a reliable way of selecting the optimal subset size. Both papers, however, need an extra parameter added to the state vector, thus extending the computation time. This can be tolerable in "offline" computations, where quality is the main preference, but for "online" or more complex computation the computation time might play a significant role.

4. Theoretical framework and algorithm

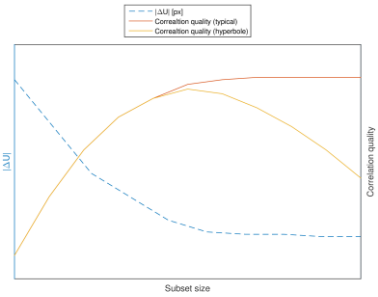

Figure 3 Illustration of typical displacement error function of subset size vs correlation quality function

One type of curve of standard deviation of the displacement error vs. subset size can be found in [12] (illustrated red line in Figure 3. After reaching the lowest point the function usually starts to grow again, mimicking the hyperbole. Other type of the curve can be found in [13] (yellow line in Figure 3. The function is shaped like a logarithm function, after quick initial growth the function reached some maximal value and remains constant. If we overlay the displacement error function and correlation quality function (Figure 3, we can see that the shape of both functions are very similar for the log shaped function. And for the hyperbolic shaped function the lowest point is located in the area where the correlation function reaches the maximal value. Using this knowledge, we have designed two algorithms that can estimate the ideal subset size, which will provide most precise results.

4.1 Iterative approximation

One way of approximation is to use a line to get an estimate of the optimal value. For first approximation we need at least three points; one for larger subset size to estimate the maximal value of correlation function (y_{max}) and two points for small subset size to approximate the initial growth. New subset size is calculated as the intersection of two lines. The first line is horizontal with y equal to y_{max}, the second line is created from the two points computed for small subset sizes. The value of new subset size is then computed using Equation 2. Next subset size is always calculated from last two correlation values. We can view the iterative process as an optimization task and thus we can reuse the termination functions used in optimization. One possible condition of termination is defined by required precision (typically expressed as percentage of maximal precision), second way is to define required slope of the initial growth approximation line.

$$y = m * x + b$$
$$m = \frac{y_2 - y_1}{x_2 - x_1}, \qquad b = y - m * x$$
$$x_{new} = \frac{y_{new} - b}{m}$$

Equation 2 New point computation

4.2 Spline approximation

The advantage of line approximation is the simplicity. However the precision is limited in general and the noise in the image can adversely affect the resulting value of optimal subset size. More precise would be to use some higher order approximation curve. We have chosen spline approximation, because it provides good accuracy with relatively low computational cost. We used third-order polynomials, resulting in cubic spline interpolation (details can be found in [19]).

5. Results and Discussion

In this chapter we will first present the application of approximations on single step of digital image correlation algorithm. Then we will present numerical results comparing the results of classical NR solver with predefined subset size against a NR solver coupled with approximation methods.

Approximation on one step

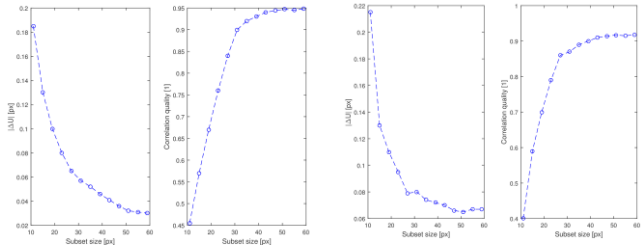

Figure 4 Displacement error and correlation quality

Figure 4 present results (displacement error and correlation quality) obtained by running the DIC algorithm for different subset sizes. We can see that there is a good correlation of functions for correlation quality and absolute displacement error. The result of iterative approximation can be seen in Figure 5.

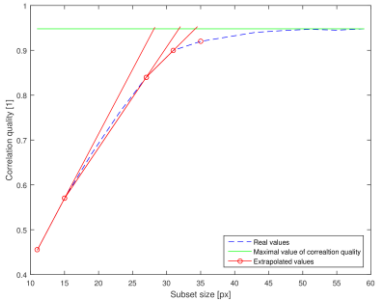

Figure 5 Iterative linear approximation

We can see that the estimate is far from optimal, but after just 3 approximation we have already reached a good precision (97% of maximal correlation quality). The implementation of this iterative scheme into a typical digital image correlation engine is quite straightforward, the only requirement is the ability of the engine to compute each round with different subset size. One way of implementation is to repeat the computation for the same image pair over, which will yield the most accurate result. The second way is to run the computation in classic fashion going through the image pairs one after another and change the subset size according to the computed optimal subset size.

Next we ran the test with spline approximation. First we have tried to approximate the function on three points (Figure 6). The left sub-figure uses the same data points as the initial step in iterative approximation (two values for smallest subset sizes and one for largest). The dashed line shows the full data for comparison. It is clear that the approximation is very bad and practically unusable. Right sub-figure presents the approximation with three points evenly spaced (11, 35 and 59 pixels). While the approximation is slightly better, it is still not suitable for practical use.

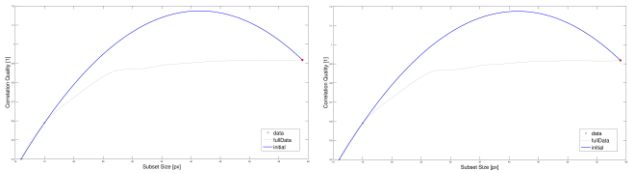

Figure 6 Approximation with cubic spline on same points as linear (left) and on three points (right)

If we provide a value in between the minimal and maximal value, we remove the hill effect (in our case we have chosen the subset size of 31 pixels). The results of such approximation can be seen in Figure 7 the error of the approximation is under 5%, which is enough to allow very precise estimation of optimal subset size.

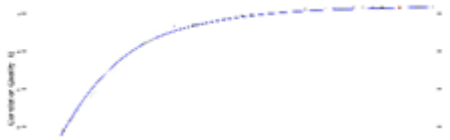

Figure 7 Approximation with cubic spline on five points

After computing the interpolated spline, we can use the same constraints as for iterative approach. The only downside of the spline interpolation is the requirement to compute the values in advance before we can use the interpolation, but as we presented the spline approach requires only 5 points in traditional case to achieve high precision. The iterative approach might require only 4 points, but the number of points needed strongly depends on the termination criterion and the exact shape of the function.

6. Numerical results

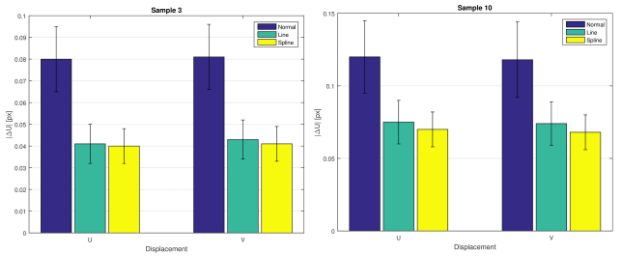

Figure 8 Comparison of statistical errors (mean and standard deviation

Figure 8 presents the numerical results. We ran the computation on both datasets using sub-pixel registration algorithm based on ZNSSD criterion with Newton-Raphson solver. First we have used the solver with preset subset sizes, then we repeated the computation with variable subset size controlled by our algorithms. Both figures clearly show good improvement both in absolute error value and also for standard deviation. If we look at Figure 8 we can see that the performance of our algorithms is very close to best values possible, but they also haven't reached high values of subset size, thus reaching almost optimal values in terms of precision and noise suppression ability.

7. Conclusions

In this work, two new subset size selection algorithms have been presented. By means of line approximation the algorithm can predict a proper subset size, which will maximize result precision while keeping the subset size as small as reasonable. The cubic spline interpolation approach presents a more static approach to optimal subset size selection, where we use means cubic spline interpolation on a small set of points to obtain a very good approximation of the correlation quality function shape.
The main contribution is the use of the results of the solver in order to determine the best size, because while the image statistics can provide a good initial estimate, they have no way to take the information about the deformation and solver configuration into account. This way we can balance the influence the systematic and random errors, in order to obtain the most precise result possible for given recording.

Acknowledgements

This work was supported by the Ministry of Education of the Czech Republic within the SGS project no. 21176/115 on the Technical University of Liberec.

References

[1] Bing Pan, Kemao Qian, Huimin Xie, Anand Asundi, 2009, Two-dimensional digital image correlation for in-plane displacement and strain measurement: a review, Meas. Sci. Technol. 20 062001
[2] Sutton MA, Orteu JJ, Schreier HW (2009) Image correlation for shape, motion and deformation measurements. Springer, New York
[3] Hild F, Roux S (2006) Digital image correlation: From displacement measurement to identification of elastic properties - a review. Strain 42(2):69-80
[4] Pan B, Qian KM, Xie HM, Asundi A (2009) Two-dimensional digital image correlation for in-plane displacement and strain measurement: A review. Meas Sci Technol 20(6):062001
[5] Lu H, Cary PD (2000) Deformation measurements by digital image correlation: Implementation of a second-order displacement gradient. Exp Mech 40(4):393-400
[6] Schreier HW, Braasch JR, Sutton MA (2000) Systematic errors in digital image correlation caused by intensity interpolation. Opt Eng 39(11):2915-2921
[7] Bornert M, Bremand F, Doumalin P, Dupre JC, Fazzini M, Grediac M, Hild F, Mistou S, Molimard J, Orteu JJ, Robert L, Surrel Y, Vacher P,Wattrisse B (2009) Assessment of digital image correlation measurement errors: Methodology and results. Exp Mech 49
[8] Haddadi H, Belhabib S (2008) Use of rigid-body motion for the investigation and estimation of the measurement errors related to digital image correlation technique. Opt Lasers Eng 46(2):185-196
[9] Lava P, Cooreman S, Coppieters S, De Strycker M, Debruyne D (2009) Assessment of measuring errors in

DIC using deformation _elds generated by plastic FEA. Opt Lasers Eng 47(7):747-753
[10] Lecompte D, Smits A, Bossuyt S, Sol H, Vantomme J, Van Hemelrijck D, Habraken AM (2005) Quality assessment of speckle patterns for digital image correlation. Opt Lasers Eng 44 (11):1132-1145
[11] Z.Y. Wang, H.Q. Li, J.W. Tong, J.T. Ruan (2007) Statistical Analysis of the E_ect of Intensity Pattern Noise on the Displacement Measurement Precision of Digital Image Correlation Using Self-correlated Images. Experimental Mechanics (2007) 47:701-707
[12] Yaofeng S, Pang J (2007) Study of optimal subset size in digital image correlation of speckle pattern images. Opt Lasers Eng 45 (9):967-974
[13] Pan B, Xie HM, Wang ZY, Qian KM, Wang ZY (2008) Study on subset size selection in digital image correlation for speckle patterns. Opt Express 16(10):7037{7048
[14] J. Huang, X. Pan, X. Peng, Y. Yuan, C. Xiong, J. Fang, F. Yuan (2012) Digital Image Correlation with Self-Adaptive Gaussian Windows. Experimental Mechanics 53:505-512
[15] Yuan Yuan, Jianyong Huang, Xiaoling Peng, Chunyang Xiong, Jing Fang, Fan Yuan (2013) Accurate displacement measurement via a self-adaptive digital image correlation method based on a weighted ZNSSD criterion
[16] Bing Pan, Huimin Xie, Zhaoyang Wan, 2010, Equivalence of digital image correlation criteria, Applied optics for pattern matching
[17] Bruck H A, McNeil S R, Sutton M A and Peters W H, 1989, Digital image correlation using Newton{Raphson method of partial differential correction Exp. Mech. 29
[18] DIC Challenge data, Society for Experimental Mechanics, https://sem.org/2d-test-image-sets/, 2017
[19] Bartels, R. H.; Beatty, J. C.; and Barsky, B. A., 1998, Hermite and Cubic Spline Interpolation. Ch. 3 in An Introduction to Splines for Use in Computer Graphics and Geometric Modelling, San Francisco, CA

Session: Natural Sciences

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VIABILITY OF *LACTOCOCCUS LACTIS* IN DIFFERENT PROTECTANTS DURING FREEZE DRYING

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Abstract: *Some strains of Lactococcus lactis have probiotic properties and are beneficial for human and animal health. The main problem is a low survival rate of bacteria in food products, animal feed and in the conditions of the digestive tract. An effective method for the protection of microorganisms is the use of substances forming a barrier between the bacteria and an adverse external environment. The scope of the study comprises the formulation of tested strain in the form of powders by using freeze drying. The effect of three protective materials (trehalose, maltodextrin with low saccharification degree and skim milk) and their mixtures on cell viability during drying was described. The highest survival rates of the Lactococcus lactis directly after the drying process were observed when the protectants were trehalose or skim milk at a concentration of 10%.*

Keywords: *freeze drying, microencapsulation, Lactococcus lactis, probiotic bacteria, viability*

1. Introduction

The definition of probiotics specified by FAO and WHO as "live micro-organisms that, when administered in adequate amounts, confer a health benefit on the host" is the most widely accepted [6]. The greatest importance to health benefit have probiotic microorganisms belonging to the group of lactic acid bacteria (LAB) [2]. According to The Scientific Committee on Food of the European Commission (SCFEC), probiotic preparations should contain at least 10^6 CFU g^{-1} viable bacteria during their shelf-life [8].

Probiotic microorganisms taken orally must be resistant to the adverse conditions of the gastrointestinal tract such as low pH, bile salts and gastric enzymes. They need to survive passage through the stomach and small intestine in order to reach the colon, where can grow easily. Thus probiotics must be consumed in foods allowing it [6].

Various techniques have been developed to reduce adverse effects of the gastrointestinal tract on probiotic bacteria. Microencapsulation is considered as one of the most valuable methods. These techniques include mainly spray drying, spray chilling, spray cooling, extrusion coating and freeze drying (lyophilisation) [1]. Lyophilisation is a method of producing stable probiotic bacteria with high viability and activity. The use of proper cryoprotectant improves the viability of microbial cells during this process [10].

The aim of this study was the formation of high viability dry cell preparations of *Lactococcus lactis* in different protectants by using freeze drying as a preservation method.

2. Materials and methods

2.1 Microorganism

The probiotic strain *Lactococcus lactis* was obtained from the own collection of the Department of Biotechnology and Food Microbiology, Poznań University of Life Sciences. The strain was preserved at -20°C in MRS Broth (Oxoid, Australia) with 20% (v/v) glycerol.

2.2 Batch fermentation of *Lactococcus lactis*

The bacterial cultures were performed for 24 h at 37°C in a fermenter with a working volume of 30 litres (Sartorius Stedim, Germany). For this purpose, to a sterile production medium of 26 l (composition per 1 litre of demineralised water: glucose 20 g; yeast extract 10 g; casein hydrolysate 10 g; anhydrous sodium acetate 4.8 g; anhydrous sodium citrate · $2H_2O$ 3.9 g, ammonium sulphate 2 g, magnesium sulphate 0.2 g, manganese chloride · $4H_2O$ 0.157 g) 10% (v/v) of inoculum has been added. The stirring was maintained at 150 rpm. The target pH of 6.5 was controlled by the use of 30% NaOH as the neutralizing agent.

2.3 Separation of biomass from the fermentation broth

The biomass separation has been made by centrifuging in a self-draining disc stack centrifuge Westfalia SA10-01-175 (Gea, Germany). The supernatant was discarded and the precipitate was re-suspended in sterile demineralised water and subjected to centrifugation in a laboratory centrifuge ROTANTA 460R (Hettich Germany) (1.419 x 10^3 g, 30 min). After re-discarding the supernatant, the precipitate was re-suspended in a sterile demineralised water and used to prepare mixtures for freeze drying.

2.4 Preparation of protective material for bacterial cells encapsulation

For the preparation of aqueous solutions of wall material skim milk powder (OSM Czarnków, Poland), trehalose (Hortimex, Poland), and maltodextrin with low saccharification degree (Pepees, Poland) were used. One of three selected individual compounds or their mixtures were used as the protective material (Tab. 1). 250 ml of a bacterial biomass suspension in sterile demineralised

water were mixed with 250 ml of the sterile solution of protectant to create a wall material solution - cell mixture. The final concentration of single protectant or their combination in the drying mixture was 10% (w/w). The mixture was stirred on a magnetic stirrer for 12 h at 4°C before freeze drying.

Table 1: Types of wall materials used in the experiment

Runs	*Skim milk X_1 [%]*	*Trehalose X_2 [%]*	*Maltodextrin X_3 [%]*
1	1.67	6.67	1.67
2	0.00	10.00	0.00
3	6.67	1.67	1.67
4	5.00	5.00	0.00
5	0.00	0.00	10.00
6	5.00	0.00	5.00
7	3.33	3.33	3.33
8	0.00	5.00	5.00
9	0.00	0.00	10.00
10	0.00	10.00	0.00
11	1.67	1.67	6.67
12	10.00	0.00	0.00
13	5.00	5.00	0.00
14	10.00	0.00	0.00

2.5 Freeze drying

The BETA 1-16 freeze-dryer (Martin Christ, Germany) was used to prepare lyophilisates. Conditions of freeze drying are shown in Tab. 2. Finished formulations in the form of powders were collected in a sterile glass jar and directly analysed.

Table 2: Conditions of freeze drying

Time [h]	*Conditions*	*Purpose*
2	-35°C, atmospheric pressure	samples freezing
18	15°C, 22 Pa	main drying
4	22°C, 22 Pa	final drying

2.6 Dry mass content

The dry mass content (% dry mass) of the mixture of bacterial biomass with the selected protectant before and after lyophilisation was determined with gravimetrical method, according to Polish Standard PN 90/A75101/03. All samples were analysed in triplicate.

2.7 Enumeration of *L. lactis*

The number of *Lactococcus lactis* bacteria was determined by pour plate method on selective medium MRS (Oxoid, Australia), in the presence of protectants, directly before and after freeze drying. For this purpose, 1 ml of the mixture of bacterial biomass with the selected protectant before freeze drying or 1 g of finished formulation was added to sterile vessel contains 99 ml of saline solution. After 1 h of stirring on magnetic stirrer at 4°C, a ten-fold serial dilutions were made. The samples (1 ml) of each prepared dilution were transferred and plated onto MRS agar, followed by incubation at 30°C for 72 h. All enumerations were performed in triplicate and the plates after incubation were counted.

2.8 Viability of probiotic bacteria during freeze drying

Cell viability was calculated as:

$$\%\ viability = \frac{N}{N_0}\ x\ 100$$

where, N = cell count after freeze drying and N_0 = cell count before freeze drying (CFU ml^{-1}).

2.9 Statistical analysis

All experiments were carried out in triplicate from three independent runs and the data were expressed as mean ± standard deviation. The data were evaluated by ANOVA ($p < 0.05$) using the Design-Expert 8.0 software (Stat-Ease, USA) and p value of less than 0.05 was considered as statistically significant.

3. Results and discussion

The viability of *L. lactis* encapsulated with different protective materials are given in Tab. 3. Cell viability ranged from 48.0 to 68.0%. During freeze drying probiotic bacteria counts reduced from 10^{10} CFU ml^{-1} to 10^9 CFU ml^{-1}.

Table 3: The cell viability after freeze-drying. Control (C) are cells freeze dried without any protectant

Runs	*Viability Y [%]*
1	53.0±1.5
2	68.0±2.5
3	59.0±9.9
4	65.0±5.3
5	48.0±6.7
6	53.0±3.2
7	50.0±4.0
8	52.0±2.1
9	49.0±2.0
10	66.0±5.7
11	49.0±1.7
12	65.0±4.0
13	63.0±7.6
14	64.0±4.5
C	20.0±2.3

According to the ANOVA results all compounds of the protective material significantly influenced the cells viability ($p < 0.05$, Tab. 4).

Table 4: The analysis of variance (ANOVA) of cell viability model

Source	*SS*	*df*	*MS*	*F*	*p-value*	*AdjR^2*
Model	724.1	6	120.6	115.65	< 0.0001	
Linear Mixture	556.0	2	278.0	266.4	< 0.0001	
X_1X_2	3.350	1	3.350	3.210	0.1165	
X_1X_3	7.960	1	7.960	7.620	0.0280	
X_2X_3	26.37	1	26.37	25.27	0.0015	0.990
$X_1X_2^2X_3$	42.03	1	42.03	40.27	0.0004	
Residual	7.300	7	1.040			
Lack of Fit	2.300	3	0.770	0.610	0.6408	
Pure Error	5.000	4	1.250			
Cor Total	731.4	13				

The goodness of fit of a statistical model describes how well it fits a set of observations (Tab. 4). Fig. 1 shows a high degree of fit between observed and values predicted by the model ($p < 0.05$).

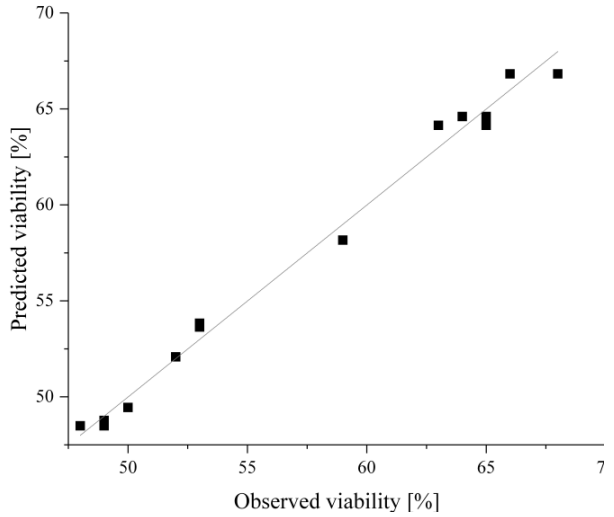

Figure 1: The goodness of fit plot of the ANOVA model. Relationship between observed and predicted values of viability during freeze drying

By applying multiple regression analysis on the experimental data, the final equations of the model for predicted viability of cell during lyophilisation was shown as follows (in the form of coded values):

$$Y = 64.60X_1 + 66.82X_2 + 48.49X_3 - 6.26X_1X_2 - 11.64X_1X_3 - 22.31X_2X_3 - 491.11X_1X_2{}^2X_3$$

The lyophilisates containing 10% of trehalose before freeze drying had a greatest viabilities (68.0 and 66.0%). Trehalose is a disaccharide widely used as a cryoprotectant during freeze drying and a stabilizer during dehydratation [7]. Trehalose forms hydrogen bonds with proteins and polar groups of the cell lipid membrane, which prevents damage to its structure during dehydration [9].

Zhao and Zhang [11] used a 10% concentration of trehalose to protect *Lactobacillus brevis* bacteria, achieving a viability of 56.8%. All disaccharides used in this experiment (sucrose, trehalose, maltose and lactose) allowed survival of > 40% cells during lyophilisation. Higher survival rate in their studies was achieved by using 4% yeast extract as a protective material (cell viability of 67.8%). 10% trehalose was also successfully used as protective material during freeze drying of *Bifidobacterium infantis.* The cell viability was more than 80.0%, as in the case of using 10% cellobiose [3].

Equally high viability was also achieved using 10% skim milk as protectant (65.0 and 64.0%). It is believed that the protective effect of skim milk is based on preventing cell damage by stabilizing the cell membranes and providing a protective coating for LAB cultures [5]. Berner and Viernstein [4] used 10% skim milk and other protectants based on it for freeze drying of *Lactococcus lactis.* Higher viability was obtained when the protective material was 10% skim milk and sucrose (viability > 60%) than only 10% skim milk (viability of 40%).

The lowest viabilities of 48.0 and 49.0% were observed when the protective material was maltodextrin with low saccharification degree. The survival of free cells was 20.0%, thus was lower than that of microencapsulated *L. lactis.* This indicates a certain ability of maltodextrin to protect probiotic bacteria during freeze drying. However, maltodextrin as a polysaccharide exhibits less tendency to bind to the cell membrane, and the ability of the maltodextrin to penetrate the membrane depends on its molecular weight [9].

The interactions between substances affect the survival during drying ($p < 0.05$). When the concentration of skim milk is 0%, as concentration of trehalose increases and concentration of maltodextrin decreases, the expected viability of *L. lactis* during drying is growing (Fig. 2). Semyonov et al. [9] investigated the survival of *Lactobacillus paracasei* during freeze spray drying in the presence of trehalose and maltodextrin as a protective material. High concentrations of trehalose allowed high survival rates during freezing and drying. By changing the mass ratio between low saccharification maltodextrin and trehalose from 2:1 to 1:1, cell viability increased from 64 to 89%.

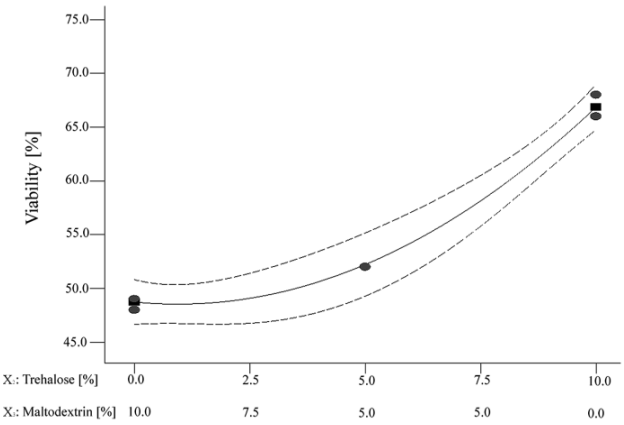

Figure 2: Interaction effect between the concentration of trehalose and maltodextrin on the viability of L. lactis during freeze drying (● – experimental data, ■ – predicted data). Dotted lines define area with a confidence interval of 95% (1 – p)

4. Conclusions

Freeze drying applied as a method of microencapsulation successfully improves the viability of *L. lactis.* The survival of freeze dried bacteria cells during the drying process is higher in the case of using protectants compared to non-microencapsulated cells. The highest viabilities are achieved using 10% of trehalose or skim milk as protective materials in a mixture for freeze drying. The lowest survival rates are obtained by using 10% maltodextrin with low saccharification degree as a protectant.

It has been shown that there is a pronounced interaction between trehalose and maltodextrin used to protect of probiotic bacteria during freeze drying.

References

[1] Arslan S., Erbas M., Tontul I., Topuz A., *Microencapsulation of probiotic Saccharomyces cerevisiae var. boulardii with different wall materials by spray drying*, LWT-Food Science and Technology, 63(1), pp. 685-690, 2015.

[2] Axelsson L. T., *Lactic acid bacteria: Classification and physiology*, In *Lactic acid bacteria*, New York, Marcel Dekker Inc., 1993, pp. 1-64

[3] Basholli-Salihu M., Mueller M., Salar-Behzadi S., Unger F. M., Viernstein H, *Effect of lyoprotectants on β-glucosidase activity and viability of Bifidobacterium infantis after freeze-drying and storage in milk and low pH juices*, LWT-Food Science and Technology, 57(1), pp. 276-282, 2014

[4] Berner D., Viernstein H., *Effect of protective agents on the viability of Lactococcus lactis subjected to freeze-thawing and freeze-drying*, Scientia Pharmaceutica, 74(3), pp. 137-149, 2006

[5] Carvalho A. S., Silva J., Ho P., Teixeira P., Malcata F. X., Gibbs P, *Relevant factors for the preparation of freeze-dried lactic acid bacteria*, International Dairy Journal, 14(10), pp. 835-847, 2004

[6] FAO/WHO, *Report of a joint FAO/WHO Expert consultation on evaluation of health and nutritional properties of probiotics in food including powder milk with live lactic acid bacteria,* Córdoba, FAO/WHO, 2001

[7] Patist A., Zoerb H., *Preservation mechanisms of trehalose in food and biosystems*, Colloids and Surfaces B: Biointerfaces, 40(2), pp. 107-113, 2005

[8] Scientific Committee on Food of the European Commission, *Report of the scientific committee on food on the revision of essential requirements of infant formulae and follow-on formulae*, Brussel, SCFEC, 2003, pp. 154-159

[9] Semyonov D., Ramon O., Kaplun Z., Levin-Brener L., Gurevich N., Shimoni E., *Microencapsulation of Lactobacillus paracasei by spray freeze drying*, Food Research International, 43(1), pp. 193-202, 2010

[10] Shamekhi F., Shuhaimi M., Ariff A., Manap Y. A., *Cell viability of microencapsulated Bifidobacterium animalis subsp. lactis under freeze-drying, storage and gastrointestinal tract simulation conditions*, Folia microbiologica, 58(2), pp. 91-101, 2013

[11] Zhao G., Zhang G., *Effect of protective agents, freezing temperature, rehydration media on viability of malolactic bacteria subjected to freeze‐drying*, Journal of Applied Microbiology, 99(2), pp. 333-338, 2005

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COMET ASSAY AS A TOOL TO MEASURE DNA DAMAGE IN LYMPHOCYTES OF BLUE AND SILVER FOXES

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Abstract: *Environment contamination and thereby its genotoxic character present a risk for animals and people that results, among other things, from changes in a DNA strand. A comet assay is an important tool in evaluating the rank of these changes and sensitivity of genetic material to the effect of these various factors. It allows to evaluate DNA integrity of every single cell. Good research objects that reflect to a certain extent sensitivity of human cells are breeding animals including specimens of Canidae which are blue and silver foxes. The aim of the paper was to evaluate the degree of DNA damage in lymphocytes of farm foxes. The surveys were carried out on lymphocytes isolated from peripheral blood collected from 12 individuals, 6 from every species, by the veterinary surgeon during skin slaughter. The alkaline variant of the comet assay was used and the change of DNA integrity was evaluated in terms of two parameters: percent DNA contents in a comet's head and tail's length. In blue foxes, DNA content in the comet's head was determined at the level of 81.99% and in silver foxes – 85.44%. The length of a comet's tail in blue foxes was 132 μm and for the silver ones it was 89 μm. In each species, differences in values of both parameters between males and females were observed. On the basis of obtained results it was stated that this significant level of damage of genetic material is of clearly induced nature.*

Keywords: *comet assay, DNA damage, induced damage, blue fox, silver fox*

1. Introduction

Both blue and silver foxes are breeding types of the Arctic fox (*Alopex lagopus*) and the red fox (*Vulpes vulpes*), respectively. They belong to *Canidae* family and are related to dogs and wolves.

As breeding animals, they are fed with a fodder of various origin: post-production from food industry, the remains of fish and wastes from butchery. Due to such system of feeding these animals, accumulation of harmful agents - which can damage the genetic material – in food chain is possible. Urbanization and increasing environment pollution have also negative influence although the animal farms are often located outside big agglomerations but at the areas used agriculturally. Therefore, assessment of the state of animal health should be based not only on checking their physical condition but also on determining the rank of sensitivity of genetic material. It is possible by settlement of the level of changes of its integrity as well as statement whether these changes were of spontaneous nature so they took place as a result of endogenous or exogenous factors' activity or these changes were not repaired by DNA corrective mechanisms.

One of the tests which allow to examine the level of cells' damage is the SCGE test, the single cell gel electrophoresis commonly called the comet assay. It is one of cytogenetic biomarkers used for evaluation of genetic material's sensitivity on endo- and exogenous factors. The comet assay allows to detect and assess damages of a single cell which mainly result from breaks of one or both strands of DNA [9]. The fundamental stage of this technique is electrophoresis and depending on conditions in which it is performed it allows to detect bigger or smaller number/types of damages. During this stage, migration of damaged fragments (released from supercoiled DNA structure) took place in agarose gel under the influence of electric current. The result of this stage is obtaining cells with characteristic shape of a comet the tail of which is the damaged part of genetic material separated in agarose [2].

The aim of performed study was to evaluate the level of DNA damage in lymphocytes of blue and silver foxes as well as to determine the nature of these changes.

2. Material and methods

Research material was full peripheral blood collected from 6 blue foxes (3 females and 3 males) and 6 silver ones (3 females and 3 males) that came from the same farm from central Poland. The material was collected by a veterinary surgeon during skin slaughter. Isolation of lymphocytes from full peripheral blood was carried out on Histopaque-1077 medium (Sigma). The isolated fraction of lymphocytes was rinsed several times in PBS solution. The alkaline variant of the comet assay according to the methodology of Singh et al. [8] was used to assess the rank of lymphocytes' damage.

10 μl of isolated fraction of lymphocytes mixed with 75 μl of agarose of low melting point (LMPA) was applied on the basic slides covered with a layer of 0.5% agarose of normal meltability. After solidifying, 75 μl of LMP agarose was applied on this layer. After agarose was solidified, the slides were suffused with cooled lysis buffer (NaCl, NaOH, EDTA, Tris, Sodium Lauryl Sarcosinate, Triton X-100, DMSO – Sigma) with pH 10 and incubated in darkness for 24h in temperature +4^{o}C. After incubation, the slides were delicately transferred to the device for horizontal electrophoresis and suffused with cooled electrophoresis buffer (NaOH, EDTA – Sigma) (pH >13). Relaxation was performed in electrophoresis buffer for 20

minutes in darkness in room temperature. After that, electrophoresis at parameters 25V, 300 mA, 20 minutes, without light access was performed. After electrophoresis was finished, slides were neutralised, dried and dyed with ethidium bromide.
The microscopic analysis of slides was performed under a fluorescent microscope Zeiss Imager.A2 coupled with a camera AxioCam MRc5 at magnification 400x. 20 random pictures of every slide's fields of view were performed for every individual. CASP 1.2.0 programme was used for cells' measurement.

3. Results
In tested cells of both breeding species of foxes, the level of damage of genetic material was analysed taking two parameters of the comet assay: percent content of DNA in the comet's head and the length of tail [μm] into consideration.

Table 1 DNA damage in lymphocytes of blue and silver foxes

		% DNA head	*Tail length [μm]*
Blue fox	female	80.82%	124
	male	84.15%	148
	total	81.99%	132
Silver fox	female	87.99%	75
	male	81.59%	124
	total	85.44%	89

Every value in the table presents a median.

Percent content of DNA in the comet's head is a parameter that indicates integrity of this genetic material and its value should be possibly the biggest. For blue foxes, the value of this parameter in females was 80.82% and in males – 84.15%. The males were characterised by higher DNA integrity than the females as well as the value of this parameter in tested group of blue foxes which was 81.99% of DNA in the comet's head (Table 1).
In case of silver foxes, obtained results were inverted. Females were characterised by greater integrity of genetic material (87.99% of DNA) than males (81.59%) in which the content of DNA in the comet's head was even by a few percent lower than the value of a median for all silver fox individuals which was 85.44% (Table 1).
Observed values of this parameter for both species of foxes testify to significantly big rate of damage of genetic material which in blue foxes was respectively 12% of DNA loss from the comet's head and in silver foxes - almost 15%.
The second analysed parameter was the length of the comet's tail. The tail's length not always results clearly in lower DNA integrity, however, the higher % content of DNA in the comet's head, the tail's length should be lower. In case of lymphocytes' cells that come from blue foxes, it was stated that the median of the tail's length was 124 μm in females and in males it was 148 μm. The length of the comet's tail in lymphocytes of blue foxes was 132 μm (Table 1). In case of silver foxes, values of this parameter are more diverse. For females, the length of the comet's tail is 75 μm which reflects the highest rate of integrity of genetic material in tested groups. Males of that species are characterised by parameter's high value - the tail's length is 124 μm. The median of the tail's length for every silver fox was 89 μm (Table 1).

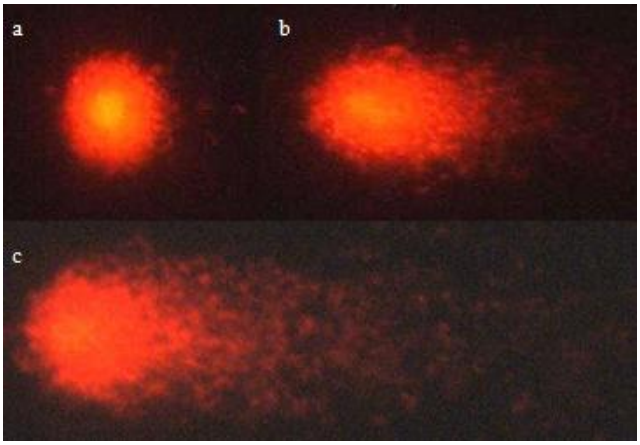

Figure 1: Lymphocytes in the shape of a comet with various rates of DNA damage. Microscopic image, 400x magnification.

Changes of DNA integrity in analysed cells are visible in microscopic image. Lymphocytes coming from foxes which as a result of electrophoretic division took the shape of a comet and the size of a tail depended on the rate of damage of an individual cell were presented in the Figure 1. In the slightly damaged cell (Figure 1a.) with 93.7% of DNA in a comet's head, no clear tail is observed. With the increase of fragmentation of genetic material, the comet's tail becomes more clear because it contains more and more DNA in the comet's head as in case of Figure 1b. with 80% of DNA in the head and Figure 1c. containing 60% of DNA in the comet's head with tail's lengths of 143 μm and 295 μm, respectively.
Conducted surveys testify to the necessity of performing cytogenetic tests on animals with use of biomarkers. Significantly reduced levels of DNA integrity observed in blue and silver foxes which were 81.99% and 85.44% of DNA in the comet's head, respectively, testify to damages of genetic material of induced nature that took place in tested cells.
Increasing level of DNA damage can extend the risk of appearance of mutagenic processes as a result of which permanent change of genetic information would be possible in the place of DNA strands damages that appeared or were not repaired. It seems to be particularly important that such process can lead to further dangerous changes, even teratogenic ones, in the whole body and thereby in gametes causing embryogenesis disorder [5].
According to Moore et al. [7], changes at cellular level of living organisms can result from the phenomenon of environmental stress caused or evoked by numerous factors such as changes of climate, soil erosion, environment urbanisation, excessive using of pesticides or removing dangerous wastes.

The comet assay was applied in numerous surveys conducted in *in vivo* and *in vitro* conditions on plant, animal and human materials. This test is a popular tool used among others in surveying fish to analyse pollution of water and to estimate its genotoxicity. In case of the material that comes from mammals, the comet assay was used for ecotoxicological analyses performed mainly on laboratory animals (mice, rats) [3]. Using SCGE test, Betti and Nigro [1] were testing genotoxic influence of methyl-mercury on lymphocytes of bottle-nosed dolphins (*Tursiops truncatus*). According to da Silva et al. [4], native species and particularly small mammals that live around polluted areas should be used in the surveys of pollution harmfulness. The comet assay was used by Mohamed et al. [6] to evaluate the rate of DNA damages in neutrophils and lymphocytes of blood coming from the cattle with lymphosarcoma.

4. Conclusions

On the basis of results of conducted surveys, it can be stated that the comet assay is an adequate method to evaluate integrity of genetic material in animal and human cells. It allows to estimate sensitivity of cells to various endo- and exogenous factors' influence. Establishing the exact reason of DNA damages needs more expert tests to be performed, including the comet assay with use of cells treated with the specific factor in laboratory conditions.

Acknowledgements

The research financed from DS-3253/ZAZINW.

References

[1] Betti C., Nigro M., The Comet assay for the evaluation of the genetic hazard of pollutants in cetaceans: preliminary result on the genotoxic effects of methyl-mercury on the bottle-nosed dolphin (*Tursiops truncates*) lymphocytes in vitro, Marine Pollution Bulletin, Vol. 32, pp. 545-548, 1996.

[2] Collins A.R., The Comet Assay for DNA Damage and Repair, Molecular Biotechnology, Vol. 26, No. 3, pp. 249-261, 2004.

[3] Cotelle S., Férard J.F., Comet Assay in Genetic Ecotoxicology: A Review, Environmental and Molecular Mutagenesis, Vol. 34, pp. 246-255, 1999.

[4] Da Silva J., de Freitas T.R.O., Marinho J.R., Speit G., Erdtmann B., An alkaline single-cell gel electrophoresis (comet) assay for environmental biomonitoring with native rodents, Genetic and Molecular Biology, Vol. 23, No. 1, pp. 241-245, 2000.

[5] Martins M., Costa P.M., The comet assay in Environmental Risk Assessment of marine pollutants: applications, assets and handicaps of surveying genotoxity in non-model organisms, Mutagenesis, Vol. 30, pp. 89-106, 2015.

[6] Mohamed T., Endoh D., Oikawa S., DNA damege in blood lymphocytes and neutrophils in cattle with lymphosarcoma, Veterinarni Medicina, Vol. 56, No. 10, pp. 504-509, 2011.

[7] Moore M.N., Depledge M.H., Readman J.W. Leonard D.R.P., An integrated biomarker - based strategy for ecotoxicological evaluation of risk in environmental management, Mutation Research, Vol. 552, pp. 247-268, 2004.

[8] Singh N., McCoy M., Tice R., Schneider E., A simple technique for quantitation of low levels of DNA damage in individuals cells, Experimental Cell Research, Vol. 175, No. 1, pp. 184-191, 1988.

[9] Valverde M., Rojas E., Environmental and occupational biomonitoring using the comet assay, Mutation Research, Vol. 681, pp. 93-109, 2009.

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SPEED RESONANCES OF COUPLED SHAFTS IN DRIVES WITH HOOKE'S JOINTS

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Abstract: *When considering some effects on the natural frequency spectrum of propulsion shafts, significant sensitivity of natural frequency spectrum of relative transverse oscillations to the rigidity of propshaft edges bearing appears. Therefore, it is necessary to withdraw from the static understood stiffness of storage of propshaft edges and solve the whole propshafts system, i. e. clutches, propeller shaft, gear shaft. Not only the connecting shaft, but also the clutch shaft and the gear shaft thus being understood as a flexurally oscillating one-dimensional continuum. The basic mechanics method, imaginary cut method being applied not to the rigid bodies, but the system of coupled deformable bodies in a state of steady circular vibration. This approach to solving especially allows that the order of the transfer matrix does not increase with the number of the model segments when using the transfer-matrix method. The dimension of frequency matrix is only determined by the number of shafts of the system.*

Keywords: *shaft, system, bound, resonance, speeds, spectrum, frequency*

1. Introduction

When considering some effects on the natural frequencies spectrum of propulsion shafts, significant sensitivity of natural frequencies spectrum of relative transverse oscillations appears – and thus significant sensitivity of speed resonances, too – to the rigidity of propshaft edges bearing. It should by recalled that speed resonances being considered for the state of system, when natural frequencies of relative transversal oscillations being precisely equal to the angular velocity of a propshaft. With rigidity of bearing decreasing, natural frequencies considerably decrease. This means that it is necessary to leave the assumption of statically perceived rigidity of propshaft edge bearing and to solve the transversal vibration of the whole system, i. e. shaft of the clutch – articulated shaft – shaft of the transmission.

2. Relative bending-gyratory vibration of Cardan shaft system

To solve natural frequencies at small Cardan angles break, accept dynamic model according to the Figure 1.

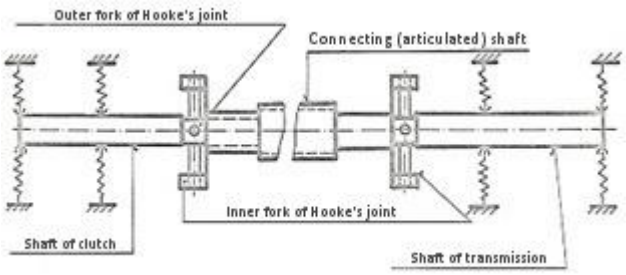

Figure 1

Not only own connecting shaft, but also the clutch shaft and the gear shaft are understood as flexurally oscillating one-dimensional continuum. In real drive, clutch and gear shafts are bound to the frame by rolling, mostly spherical bearings. Bearings pliability in radial direction in dynamic model being respected through isotropic elastic slider shafts bearings. Shaft bearing rigidity is understood statically and determined from center of bearing relocation, under the effect of the known forces, by conventional calculation methods. Let the system making steady combined bending-gyratory vibration in rotating space so it is possible to express state vector at any cross-section in the following form:

$$\mathbf{V}(x, t) = \mathbf{V}(x)\, e^{i\Omega t} \tag{2.1}$$

Then the system can be divided into basic elements, described by the transfer matrices. Marking quantities is obvious from Fig. 2, Fig. 3 and Fig. 4. Afilliation of an element to one of three shafts is distinguished by index top left. Indexes 1, 2, 3 belong, in this order, the clutch shaft, the connecting shaft and the gearbox shaft.

3. Transfer matrix of clutch shaft

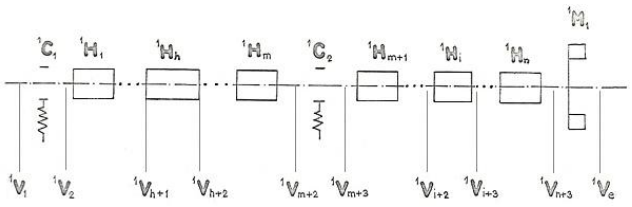

Figure 2

For edge state vectors of clutch shaft the following applies:

$$^1\mathbf{V}_1 = [^1\mathbf{Y}_1, {}^1\mathbf{Z}_1], \; ^1\mathbf{V} = [^1\mathbf{Y}, {}^1\mathbf{Z}], \; e = n + 4, \tag{3.1}$$

where

$$^1\mathbf{Y}_1 = \begin{bmatrix} ^1y_1(0) \\ ^1y_1'(0) \\ 0 \\ 0 \end{bmatrix}, \; ^1\mathbf{Z}_1 = \begin{bmatrix} ^1z_1(0) \\ ^1z_1'(0) \\ 0 \\ 0 \end{bmatrix}, \tag{3.2}$$

$$ {}^{1}\mathbf{Y}_{e} = \begin{bmatrix} {}^{1}y_n(l_n) \\ {}^{1}y'_n(l_n) \\ 0 \\ -{}^{1}Q_{yn+4} \end{bmatrix}, \; {}^{1}\mathbf{Z}_{e} = \begin{bmatrix} {}^{1}z_n(l_n) \\ {}^{1}z'_n(l_n) \\ 0 \\ -{}^{1}Q_{zn+4} \end{bmatrix} $$

The transfer matrix of clutch shaft

$$ {}^{1}\mathbf{P} = \begin{bmatrix} {}^{1}\mathbf{P}_y , & 0 \\ 0 , & {}^{1}\mathbf{P}_z \end{bmatrix} , \text{ kde } {}^{1}\mathbf{P}_y = {}^{1}\mathbf{P}_z = [{}^{1}p_{rs}]_1^4 , \tag{3.3} $$

is obtained by sequential matrix multiplication, using the formula

$$ {}^{1}\mathbf{P} = {}^{1}\mathbf{M}_1 \cdot {}^{1}\mathbf{H}_n \dots {}^{1}\mathbf{H}_i \dots {}^{1}\mathbf{H}_{m+1} \cdot {}^{1}\mathbf{C}_2 \cdot {}^{1}\mathbf{H}_m \dots {}^{1}\mathbf{H}_n \dots {}^{1}\mathbf{H}_1 \cdot {}^{1}\mathbf{C}_1 \; . \tag{3.4} $$

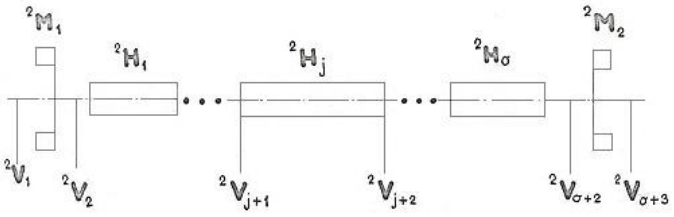

Figure 3

4. Transfer matrix of connecting shaft

Boundary state vectors of the connecting shaft have the form:

$$ {}^{2}\mathbf{V}_1 = \lceil {}^{2}\mathbf{Y}_1, {}^{2}\mathbf{Z}_1 \rceil , \; {}^{2}\mathbf{V}_f = \lceil {}^{2}\mathbf{Y}_f , {}^{2}\mathbf{Z}_f \rceil , \; f = o + 3, \tag{4.1} $$

where

$$ {}^{2}\mathbf{Y}_1 = \begin{bmatrix} {}^{1}y_n(l_n) \\ {}^{2}y'_1(0) \\ 0 \\ -{}^{1}Q_{ye} \end{bmatrix}, \; {}^{2}\mathbf{Z}_1 = \begin{bmatrix} {}^{1}z_n(l_n) \\ {}^{2}z'_1(0) \\ 0 \\ -{}^{1}Q_{ze} \end{bmatrix} $$
$$ \mathbf{Y}_f = \begin{bmatrix} {}^{2}y_o(l_o) \\ {}^{2}y'_o(l_o) \\ 0 \\ -{}^{2}Q_{yf} \end{bmatrix} , \; \mathbf{Z}_f = \begin{bmatrix} {}^{2}z_o(l_o) \\ {}^{2}z'_o(l_o) \\ 0 \\ -{}^{2}Q_{zf} \end{bmatrix} \tag{4.2} $$

Transfer matrix of the connecting shaft

$$ {}^{2}\mathbf{P} = \begin{bmatrix} {}^{2}\mathbf{P}_y , & \mathbf{0} \\ \mathbf{0} , & {}^{2}\mathbf{P}_z \end{bmatrix} , \text{ kde } {}^{2}\mathbf{P}_y = {}^{2}\mathbf{P}_z = [{}^{2}p_{rs}]_1^4 \tag{4.3} $$

is obtained by the formula

$$ {}^{2}\mathbf{P} = {}^{2}\mathbf{M}_2 \cdot {}^{2}\mathbf{H}_o \dots {}^{2}\mathbf{H}_j \dots {}^{2}\mathbf{H}_1 \cdot {}^{2}\mathbf{M}_1 \tag{4.4} $$

5. Transfer matrix of gearbox shaft

For boundary state vectors of the gearbox shaft (see Fig.4) the following applies:

$$ {}^{3}\mathbf{V}_1 = \lceil {}^{3}\mathbf{Y}_1, {}^{3}\mathbf{Z}_1 \rceil , \; {}^{3}\mathbf{V}_g = \lceil {}^{3}\mathbf{Y}_g, {}^{3}\mathbf{Z}_g \rceil , \; g = q + 4, \tag{5.1} $$

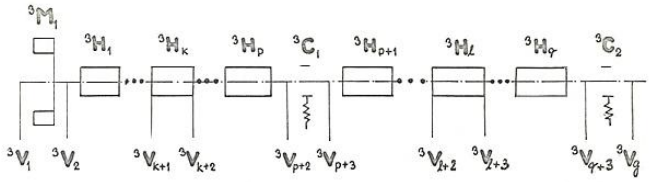

Figure 4

where

$$ {}^{3}\mathbf{Y}_1 = \begin{bmatrix} {}^{2}y_o(l_o) \\ {}^{3}y'_1(0) \\ 0 \\ -{}^{2}Q_{yf} \end{bmatrix}, \; {}^{3}\mathbf{Z}_1 = \begin{bmatrix} z_o(l_o) \\ {}^{3}z'_1(0) \\ 0 \\ -{}^{2}Q_{yf} \end{bmatrix} $$
$$ {}^{3}\mathbf{Y}_g = \begin{bmatrix} {}^{3}y_q(l_q) \\ {}^{3}y'_q(l_q) \\ 0 \\ 0 \end{bmatrix} , \; {}^{3}\mathbf{Z}_g = \begin{bmatrix} {}^{3}z_q(l_q) \\ {}^{3}z'_q(l_q) \\ 0 \\ 0 \end{bmatrix} \tag{5.2} $$

Transfer matrix of the gearbox shaft

$$ {}^{3}\mathbf{P} = \begin{bmatrix} {}^{3}\mathbf{P}_y , & \mathbf{0} \\ \mathbf{0} , & {}^{3}\mathbf{P}_z \end{bmatrix} , \text{ kde } {}^{3}\mathbf{P}_y = {}^{3}\mathbf{P}_z = [{}^{3}p_{rs}]_1^4 , \tag{5.3} $$

is determined by a formula

$$ {}^{3}\mathbf{P} = {}^{3}\mathbf{C}_2 \cdot {}^{3}\mathbf{H}_q \dots {}^{3}\mathbf{H}_l \dots {}^{3}\mathbf{H}_{p+1} \cdot {}^{3}\mathbf{C}_1 \cdot {}^{3}\mathbf{H}_p \dots {}^{3}\mathbf{H}_k \dots {}^{3}\mathbf{H}_1 \cdot {}^{3}\mathbf{M}_1 \tag{5.4} $$

6. Derivation of frequency equation of the system

Boundary state vectors of the shafts are bound by the formulas

$$ {}^{1}\mathbf{V}_e = {}^{1}\mathbf{P} \cdot {}^{1}\mathbf{V}_1 \; , \; {}^{2}\mathbf{V}_f = {}^{2}\mathbf{P} \cdot {}^{2}\mathbf{V}_1 \; , \; {}^{3}\mathbf{V}_g = {}^{3}\mathbf{P} \cdot {}^{3}\mathbf{V}_1 \tag{6.1} $$

Then,the previous relations are expressed using relevant boundary subvectors and transfer sub-matrices. After performing matrix multiplication, the relations between boundary state subvectors of the shafts are obtained:

$$ \begin{aligned} {}^{1}\mathbf{Y}_e &= {}^{1}\mathbf{P}_y \cdot {}^{1}\mathbf{Y}_1 \; , \; {}^{1}\mathbf{Z}_e = {}^{1}\mathbf{P}_z \cdot {}^{1}\mathbf{Z}_1 \\ {}^{2}\mathbf{Y}_f &= {}^{2}\mathbf{P}_y \cdot {}^{2}\mathbf{Y}_1 \; , \; {}^{2}\mathbf{Z}_f = {}^{2}\mathbf{P}_z \cdot {}^{2}\mathbf{Z}_1 \\ {}^{3}\mathbf{Y}_g &= {}^{3}\mathbf{P}_y \cdot {}^{3}\mathbf{Y}_1 \; , \; {}^{3}\mathbf{Z}_g = {}^{3}\mathbf{P}_z \cdot {}^{3}\mathbf{Z}_1 \end{aligned} \tag{6.2} $$

After substituting the subvectors (3.2), (4.2), (5.2) into the relation (6.2) and performing matrix multiplication, two systems of linear homogeneous equations, with the same determinant systems, are obtained. Let's deal only with the system of equations, which is obtained by itemizing subvectors in the plane x, y. It's a system of twelve homogeneous equations for unknown quantities:

${}^1y_1(0)$, ${}^1y_1'(0)$, ${}^1y_n(l_n)$, $y_n'(l_n)$, ${}^1Q_{ye}$, ${}^2y_1'(0)$, ${}^2y_o(l_o)$, ${}^2y_o'(l_o)$, ${}^2Q_{yf}$, ${}^3y_1'(0)$, ${}^3y_q(l_q)$, ${}^3y_q'(l_q)$, which may be written in the matrix form:

$$\mathbf{F} \cdot \bar{\mathbf{V}} = \mathbf{0} \tag{6.3}$$

Vector $\bar{\mathbf{V}}$ is specified in the form

$$\bar{\mathbf{V}} = \left[{}^1y_n(l_n), {}^1y_n'(l_n), {}^1Q_{yn}(l_n), {}^1y_1(0), {}^1y_1'(0), {}^2y_o(l_o), {}^2y_o'(l_o), {}^2Q_{yo}(l_o), {}^2y_1'(0), {}^3y_q(l_q), {}^3y_q'(l_q), {}^3y_1'(0) \right] \tag{6.4}$$

Then, in the case of the matrix of the system, $\mathbf{F} = [f_{rs}]_1^{12}$, the following elements have the nonzero value:

$$\begin{aligned}
&f_{1,1} = 1,\ f_{5,1} = -\,{}^2p_{1,1}\ ,\ f_{7,1} = {}^2p_{3,1}\ ,\\
&f_{8,1} = -\,{}^2p_{4,1}\ ,\ f_{2,2} = 1,\ f_{6,2} = -\,{}^2p_{2,1}\ ,\\
&f_{4,3} = 1,\ f_{5,3} = {}^2p_{1,4}\ ,\ f_{6,3} = {}^2p_{2,4}\ ,\\
&f_{7,3} = {}^2p_{3,4}\ ,\ f_{8,3} = {}^2p_{4,4}\ ,\ f_{1,4} = -\,{}^1p_{1,1}\ ,\\
&f_{2,4} = -\,{}^1p_{2,1}\ ,\ f_{3,4} = {}^1p_{3,1}\ ,\ f_{4,4} = {}^1p_{4,1}\ ,\\
&f_{1,5} = -\,{}^1p_{1,2}\ ,\ f_{2,5} = -\,{}^1p_{2,2}\ ,\ f_{3,5} = {}^1p_{3,2}\ ,\\
&f_{4,5} = {}^1p_{4,2}\ ,\ f_{5,5} = -\,{}^2p_{1,2}\ ,\ f_{5,6} = 1,\\
&f_{9,6} = -\,{}^3p_{1,1}\ ,\ f_{10,6} = -\,{}^3p_{2,1}\ ,\\
&f_{11,6} = -\,{}^3p_{3,1}\ ,\ f_{12,6} = -\,{}^3p_{4,1}\ ,\ f_{6,7} = 1,\\
&f_{8,8} = -1,\ f_{9,8} = {}^3p_{1,4}\ ,\\
&f_{10,8} = {}^3p_{2,4}\ ,\ f_{11,8} = {}^3p_{3,4}\ ,\ f_{12,8} = {}^3p_{4,4}\ ,\\
&f_{6,9} = -\,{}^2p_{2,2}\ ,\ f_{7,9} = {}^2p_{3,2}\ ,\\
&f_{8,9} = -\,{}^2p_{4,2}\ ,\ f_{9,10} = 1,\ f_{10,11} = 1,\\
&f_{9,12} = -\,{}^3p_{1,2}\ ,\ f_{10,12} = -\,{}^3p_{2,2}\ ,\\
&f_{11,12} = -\,{}^3p_{3,2}\ ,\ f_{12,12} = -\,{}^3p_{4,2}\ .
\end{aligned} \tag{6.5}$$

As is apparent from the previous relations, the system matrix contains transfer matrices elements of shaft system (system of Cardan mechanism), which are complicated functions of unknown natural frequency Ω, because these formed as products of repeated multiple matrix multiplication of each cells of considered series. Analytical solution of characteristic equation is not possible. To solve this equation, use a simple numerical method described in [L 9]. Let's look for natural frequencies as determinant zero points of the matrix system.

$$\det \mathbf{F} = 0 \tag{6.6}$$

7. The method of solving frequency equation

Frequency equation, which is obtained from the condition of nontrivial solution of relation ***Chyba! Nenalezen zdroj odkazů.***, has the form

$$\det \mathbf{F} = 0 \tag{7.1}$$

Frequency determinant, $\det \mathbf{F} = D(\Omega)$, is a complex function of frequency Ω. Natural frequencies of the system are found as roots of nonlinear algebraic equation $D(\Omega) = 0$. The roots of this equation (due to the physical nature of the problem, the roots are infinitely many) are found only in the interval $(\Omega_{min}\ ,\ \Omega_{max})$. In this interval, function values of the function $D(\Omega)$ are calculated in points $\Omega_{min}+ j\Delta\Omega$, $j = 0, 1, 2, \ldots$ If between two adjacent points change signa function $D(\Omega)$, it means, that between these points is an odd number of natural frequencies; while between the points where is not a change of signa function, there is an even number of natural frequencies (the number zero is considered for an even number, too). In the case of no close natural frequencies, it is sufficient to take (in the procedure) in the order of hundredths to thousandths of the length of the frequency interval $\Omega_{max} - \Omega_{min}$. The natural frequencies may be calculated with the required accuracy ε. If change of the signa function $D(\Omega)$ occurs during the transition from $\Omega_{min}+ j\Delta\Omega$ k $\Omega_{min}+ (j+1)\ \Delta\Omega$, then the interval $< \Omega_{min}+ j\Delta\Omega;\ \Omega_{min} + (j+1)\ \Delta\Omega >$ is browsed with the step equal to $\Delta\Omega/10$. Refinement process is terminated if the following applies for a given number $\varepsilon < 1$:

$$\left[\frac{D(\Omega)}{D(\Omega_{min})}\right] < \varepsilon \tag{7.2}$$

Then, as natural frequency is taken value of the leftmost point of the interval with the smallest length, where there is a change of signa frequency determinant. The frequency determinant is calculated for a given frequency Ω using the procedure DET (Ω, D), where the formal parameter Ω is as natural frequency and the parameter D is as frequency determinant value for this frequency. The parameters Ω and $\bar{\Omega}$ are the instantaneous frequencies which are spaced about $\Delta\bar{\Omega} = \Delta\Omega/10^i$ for i = 0, 1, 2 … D and $\bar{D}$ are values of the frequency determinant along a row for the frequencies Ω and $\bar{\Omega}$. Parameter D_{min} is a value of the frequency determinant for the frequency Ω_{min}. Parameter Ω is a higher frequency, in which occurres sign change of the function D (Ω) in the initial step of ΔΩ. Output parameters are natural frequencies (in ascending order) of relative lateral vibration, in that interval, found with specified accuracy.

8. Speed resonances of the system

In the formation of a combined bending-gyratory vibration, a propeller shaft makes relative spatial bending vibrations in a system rotating with constant angular velocity ω. The natural frequency of relative spatial bending vibration depends on the angular velocity of rotation of the rotating system. For the system is critical a situation when the natural frequency of relative vibration being equal to the angular velocity of the rotation:

$$\omega_{krit} = \omega = \Omega\ (\omega) \tag{8.1}$$

First, natural frequencies of relative vibration are determined. By changing the parameter ω in the data file of the program, the values $\Omega_i = (\omega_i)$ are obtained at selected points ω_i and the curves $\Omega_i = \Omega_i(\omega)$ are plotted. The values of critical angular velocities are obtained as intersections of the curves $\Omega_i = \Omega_i(\omega)$ with the line $\Omega = \omega$ (Fig. 5). Natural frequencies of relative spatial bending vibrations are obtained by using the transfer-matrix method.

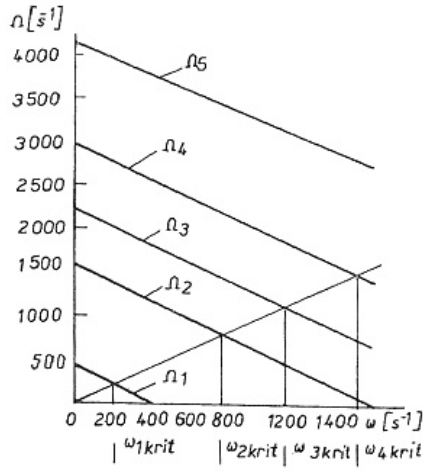

Figure 5

9. Conclusions

Numerical experiments, carried out using a mathematical model of the connecting shaft, show considerable dependence of the frequency spectrum of relative transverse oscillations on parametric change of stiffness of storage of connecting shaft edges, especially in the area of design parameters of normally operated and newly developed vehicles. It should be noted that drive of a vehicle must necessarily operate in the area below the critical speed, throughout the operating speed range. Otherwise, the functionality of the connecting shaft is lost, due to the permanent bending deformations. The paper describes a method allowing to solve a role of the dynamic of the system of Cardan shafts which represents – in its steady state – bound evolutionary system. The method allows to calculate natural frequencies of relative transverse oscillations of system of shafts and consequently to evaluate speed resonances of the system from a diagram. For the system is critical a situation when natural angular frequencies of relative transverse oscillations being equal to the angular velocity of rotation of the system of shafts.

References

[1] HRUBÝ, P. *Bending-gyratory Vibrations of Shafts in Drives with Joints.* The candidate dissertation. Plzeň: ZCU (The University of West Bohemia, Faculty of Mechanical Engineering), 1981.

[2] HRUBÝ, P., HLAVÁČ, Z., ŽIDKOVÁ. P. *Application of the finite element method in determination of modal and spectral properties of propeller shaft´s bending vibrations.* In Michael McGreevy, Robert Rita. *Proceedings of the 5th biannual CER Comparative European Research Conference: International scientific conference for Ph.D. students of EU countries*. London: Sciemcee Publishing, 2016. p. 132-135, 4 pg.

[3] HRUBÝ, P., KMEC, J., KUČERKA, D., ŽIDKOVÁ, P. *Dimensioning of Welded Parts of Rotating Members of Mechanisms in Machine Drives.* In *International Masaryk Conference 2015: collection of papers*. Hradec Králové: Magnanimitas, 2015. p. 2592-2601, 10 pg.

[4] HRUBÝ, P., HLAVÁČ, Z., ŽIDKOVÁ. P. Physical and Mathematical Models of Shafts in Drives with Hook´s Joints. In Michael McGreevy, Robert Rita. *Proceedings of the 5th biannual CER Comparative European Research Conference: International scientific conference for Ph.D. students of EU countries*. London: Sciemcee Publishing, 2016. p. 136-140, 5 pg.

[5] The Transfer-Matrix Method in the Application for an One-Dimensional Linear Continuum Speed Resonance. In Michael McGreevy, Robert Rita. *Proceedings of the 5th biannual CER Comparative European Research Conference: International scientific conference for Ph.D. students of EU countries*. London: Sciemcee Publishing, 2016. p. 141-144, 4 pg.

[6] HRUBÝ, P., HLAVÁČ, Z., ŽIDKOVÁ, P. Cardan Shaft Steady State Response on Rotating Torque Excitation. In Michael McGreevy, Robert Rita. *CER Comparative European Research 2016*. London: Sciemcee Publishing, 2016. p. 136-140, 5 pg.

[7] DUŇ, S., HRUBÝ, P., PAVLENKO A. Analysis of Factors Affecting Technical and Operational Characteristics of Trucks to Transport Grain - KRAZ. In *International Masaryk Conference 2015: collection of papers*. Hradec Králové: Magnanimitas, 2015. p. 1938-1946, 9 pg.

[8] HRUBÝ, P., KLEISNEROVÁ, L., ŽIDKOVÁ, P. Bending Oscillations Analysis of Cinematically Excited Propeller Shaft. In *International Masaryk Conference 2015: collection of papers*. Hradec Králové: Magnanimitas, 2015.
p. 2565-2574, 15 pg.

[9] HRUBÝ, P., KLEISNEROVÁ, L. Critical speeds of shafts. In *International Masaryk Conference 2014: collections of papers*. Hradec Králové: Magnanimitas, 2014. p. 3923-3931, 9 pg.

DYNAMIC STRESS-STRAIN ANALYSIS OF SHAFTS IN DRIVES WITH HOOKE'S JOINTS

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Abstract: *When analyzing transverse vibrations of connecting Cardan shaft, considerable sensitivity of frequency spectrum of relative transverse vibrations and then speed resonances on the stiffness of propshaft edge appears. This paper describes a method allowing to solve steady forced vibration of Cardan shafts. The input and output Cardan shafts are, as well as connecting shaft, seen as transversely oscillating one-dimensional continuum. The system is excited discreetly in structural edges of the propshaft by dynamic bending torques, of which articulated shafts being strained due to the transfer of power flow by Hooke's joints. The essence of the proposed method is the standard method of release, however, applied to one-dimensional deformable bodies, combined with the transfer-matrix method. This method is essentially combination of analytical and numerical approaches.*

Keywords**:** *shaft, system, propeller, vibration, dynamic, torque, excitation*

1. Introduction

In cooperation with manufacturing companies, which was initiated due to problems with Cardan mechanisms in the development of new vehicles, a physical and mathematical model of Cardan coupling shaft was created. The basic support element of the appropriate physical model is an one-dimensional continuum in parts of constant cross-section. On the edges, there are positioned discreet compensations of concentrated masses representing appropriate forks of Hooke's joints. The edges of the coupling shaft are connected to the rotating system via radial isotropic elastic sliding, statically perceived bearing. When analyzing transverse oscillations of the Cardan coupling shaft, considerable sensitivity of the frequency spectrum of relative transverse oscillations and then speed resonances on the sfiffness of bearing of propeller shaft edges appears. This requires a reconstruction of the used physical and mathematical model of the analyzed mechanism. The paper describes a method allowing to solve steady forced vibration of the Cardan shafts system. The input and output shafts of the Cardan mechanism are – as well as the coupling shaft – seen as transversely oscillating one-dimensional continuum. The system is driven discreetly in propshaft structural edges by dynamic bending torques, of which propshafts are strained due to the transfer of power flow by Hooke's joints. The essence of the proposed method is a standard method of release, however, applied to deformable one-dimensional bodies, combined with the transfer-matrix method. The method is by its nature numeric-analytical. This paper describes the procedure for formulation of a mathematical model using the transfer-matrix method, and general solution to the problem is made – as the basic for subsequent processing and debugging software.

2. Physical model of Cardan mechanism

If we begin to deal with circular oscillations of Cardan shafts as a whole (i. e. a clutch shaft and a gear shaft being considered for bending malleable), it is necessary in addition to the bending torques, of which the propshaft is strained, also to consider the action of the bending torques, of which external Cardan shafts, i. e. the clutch shaft and the gear shaft, being strained. The mentioned excitation torques, approximately harmonic, are perpendicular to the outer forks of Hooke's joints and as well as bending torques acting on the propshaft, rotate with the space of the appropriate shaft with the angular velocity, which being considered approximately constant. Let's consider a dynamic model, according to the Figure 1, where also the excitation torques are shown.

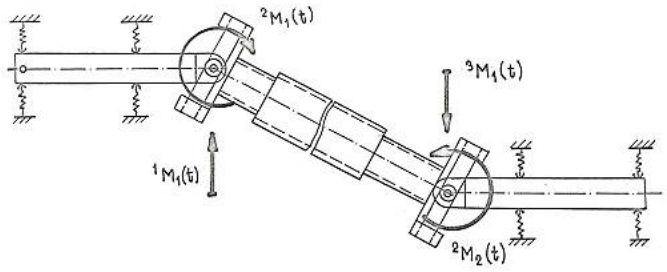

Figure 1

Indices of torques upper left indicate in order belonging to a clutch shaft (1), a propshaft (2) and a gearbox shaft (3). Let's consider the mentioned excitation torques in the following shape:

$$^1M_1(t) = {}^1M_1 e^{i\bar{\omega}t} \;,\; {}^2M_1(t) = {}^2M_1 e^{i\bar{\omega}t}$$
$$^2M_2(t) = {}^2M_2 e^{i\bar{\omega}t} \;,\; {}^3M_1(t) = {}^3M_1 e^{i\bar{\omega}t} \qquad (2.\ 1)$$

3. Transfer matrices of shafts

Assume that the system makes as a result of the described excitation source bending-gyratory oscillations, so that the state vector can be in each cross-section expressed in the following form:

$$\mathbf{V}\,(x, t) = \mathbf{V}\,(x)\, e^{i\bar{\omega}t} \qquad (3.\ 1)$$

Then the system may be divided into basic articles, which are – according to the [L3] – described by transfer matrices. $\bar{\omega}$ is a given excitation frequency. Article affiliation to one of the three shafts is – the same as in case of excitation torques – distinguished by the index of the top left. Boundary state vectors of a clutch shaft have a shape

$$ {}^{1}\mathbf{V}_1 = \lceil {}^{1}\mathbf{Y}_1 , {}^{1}\mathbf{Z}_1 \rceil \ , \ {}^{1}\mathbf{V}_e = \lceil {}^{1}\mathbf{Y}_e , {}^{1}\mathbf{Z}_e \rceil \ , \ e = n + 4, \tag{3. 2} $$

where

$$ {}^{1}\mathbf{Y}_1 = \begin{bmatrix} {}^{1}y_1(0) \\ {}^{1}y_1'(0) \\ 0 \\ 0 \end{bmatrix} , \ {}^{1}\mathbf{Z}_1 = \begin{bmatrix} {}^{1}z_1(0) \\ {}^{1}z_1'(0) \\ 0 \\ 0 \end{bmatrix} $$
$$ {}^{1}\mathbf{Y}_e = \begin{bmatrix} {}^{1}y_n(l_n) \\ {}^{1}y_n'(l_n) \\ 0 \\ -{}^{1}Q_{yn}(l_n) \end{bmatrix} , \ {}^{1}\mathbf{Z}_e = \begin{bmatrix} {}^{1}z_n(l_n) \\ {}^{1}z_n'(l_n) \\ -{}^{1}M_1 \\ -{}^{1}Q_{zn}(l_n) \end{bmatrix} \tag{3. 3} $$

Transfer matrix of the clutch shaft

$$ {}^{1}\mathbf{P} = \begin{bmatrix} {}^{1}\mathbf{P}_y \ , \ \mathbf{0} \\ \mathbf{0} \ , \ {}^{1}\mathbf{P}_z \end{bmatrix} \ , \ \text{kde } {}^{1}\mathbf{P}_y = {}^{1}\mathbf{P}_z = [{}^{1}p_{rs}]_1^4 \tag{3. 4} $$

may be obtained by sequential matrix multiplication according to the following relation:

$$ {}^{1}\mathbf{P} = {}^{1}\mathbf{M}_1 \cdot {}^{1}\mathbf{H}_n \ \dots \ {}^{1}\mathbf{H}_i \ \dots \ {}^{1}\mathbf{H}_{m+1} \cdot {}^{1}\mathbf{C}_2 \cdot {}^{1}\mathbf{H}_m \ \dots \ {}^{1}\mathbf{H}_n \ \dots \ {}^{1}\mathbf{H}_1 \cdot \mathbf{C}_1 \tag{3. 5} $$

Boundary state vectors of a clutch shaft are bound by the relation ${}^{1}\mathbf{V}_e = {}^{1}\mathbf{P} \cdot {}^{1}\mathbf{V}_1$, respectively for the boundary vectors the following applies:

$$ {}^{1}\mathbf{Y}_e = {}^{1}\mathbf{P}_y \cdot {}^{1}\mathbf{Y}_1 , \ {}^{1}\mathbf{Z}_e = {}^{1}\mathbf{P}_z \cdot {}^{1}\mathbf{Z}_1 \tag{3. 6} $$

Boundary state vectors of a propshaft

$$ {}^{2}\mathbf{V}_f = \lceil {}^{2}\mathbf{Y}_f , {}^{2}\mathbf{Z}_f \rceil \ , \ {}^{2}\mathbf{V}_1 = \lceil {}^{2}\mathbf{Y}_1 , {}^{2}\mathbf{Z}_1 \rceil \tag{3. 7} $$

where

$$ {}^{2}\mathbf{Y}_1 = \begin{bmatrix} {}^{1}y_n(l_n) \\ {}^{2}y_1'(0) \\ -{}^{2}M_1 \\ -{}^{1}Q_{yn}(l_n) \end{bmatrix} , \ {}^{2}\mathbf{Z}_1 = \begin{bmatrix} {}^{1}z_n(l_n) \\ {}^{2}z_1'(0) \\ 0 \\ -{}^{1}Q_{zn}(l_n) \end{bmatrix} $$
$$ {}^{2}\mathbf{Y}_f = \begin{bmatrix} {}^{2}y_o(l_o) \\ {}^{2}y_o'(l_o) \\ -{}^{2}M_2 \\ -{}^{2}Q_{yo}(l_o) \end{bmatrix} , \ {}^{2}\mathbf{Z}_f = \begin{bmatrix} {}^{2}z_o(l_o) \\ {}^{2}z_o'(l_o) \\ 0 \\ -{}^{2}Q_{zo}(l_o) \end{bmatrix} \tag{3. 8} $$

are bound together by the relation

$$ {}^{2}\mathbf{V}_f = {}^{2}\mathbf{P} \cdot {}^{2}\mathbf{V}_1 \tag{3. 9} $$

Transfer matrix of the propshaft

$$ {}^{2}\mathbf{P} = \begin{bmatrix} {}^{2}\mathbf{P}_y \ , \mathbf{0} \\ \mathbf{0} \ , \ \mathbf{P}_z \end{bmatrix} \ , \ \text{kde } {}^{2}\mathbf{P}_y = {}^{2}\mathbf{P}_z = [{}^{2}p_{rs}]_1^4 \tag{3. 10} $$

may be obtained according to the relation

$$ {}^{2}\mathbf{P} = {}^{2}\mathbf{M}_2 \cdot {}^{2}\mathbf{H}_o \ \dots \ {}^{2}\mathbf{H}_j \ \dots \ {}^{2}\mathbf{H}_1 \cdot {}^{2}\mathbf{M}_1 \tag{3. 11} $$

For boundary state vectors of a gearbox shaft

$$ {}^{3}\mathbf{V}_1 = \lceil {}^{3}\mathbf{Y}_1 , {}^{3}\mathbf{Z}_1 \rceil \ , \ {}^{3}\mathbf{V}_g = \lceil {}^{3}\mathbf{Y}_g , {}^{3}\mathbf{Z}_g \rceil \tag{3. 12} $$

where

$$ {}^{3}\mathbf{Y}_1 = \begin{bmatrix} {}^{2}y_o(l_o) \\ {}^{3}y_1'(0) \\ 0 \\ -{}^{2}Q_{yo}(l_o) \end{bmatrix} , \ {}^{3}\mathbf{Z}_1 = \begin{bmatrix} {}^{2}z_o(l_o) \\ {}^{3}z_1'(0) \\ -{}^{3}M_1 \\ -{}^{2}Q_{zo}(l_o) \end{bmatrix} $$
$$ {}^{3}\mathbf{Y}_g = \begin{bmatrix} {}^{3}y_q(l_q) \\ {}^{3}y_q'(l_q) \\ 0 \\ 0 \end{bmatrix} , \ {}^{3}\mathbf{Z}_g = \begin{bmatrix} {}^{2}z_q(l_q) \\ {}^{3}z_q'(l_q) \\ 0 \\ 0 \end{bmatrix} \tag{3. 13} $$

the following may be written:

$$ {}^{3}\mathbf{V}_g = {}^{3}\mathbf{P} \cdot {}^{3}\mathbf{V}_1 \tag{3. 14} $$

Transfer matrix of the gearbox shaft

$$ {}^{3}\mathbf{P} = \begin{bmatrix} {}^{3}\mathbf{P}_y \ , \ \mathbf{0} \\ \mathbf{0} \ , \ {}^{3}\mathbf{P}_z \end{bmatrix} \ , \ \text{kde } {}^{3}\mathbf{P}_y = {}^{3}\mathbf{P}_z = [{}^{3}p_{rs}]_1^4 \tag{3. 15} $$

may be obtained by sequential matrix multiplication according to the following relation:

$$ {}^{3}\mathbf{P} = {}^{3}\mathbf{C}_2 \cdot {}^{3}\mathbf{H}_q \ \dots \ {}^{3}\mathbf{H}_l \ \dots \ {}^{3}\mathbf{H}_{p+1} \cdot {}^{3}\mathbf{C}_1 \cdot {}^{3}\mathbf{H}_p \ \dots \ {}^{3}\mathbf{H}_k \ \dots \ {}^{3}\mathbf{H}_1 \cdot {}^{3}\mathbf{M}_1 \tag{3. 16} $$

4. Calculating elements of boundary state vectors

Based on previous relations, the following may be obtained for boundary subvectors of individual shafts:

$$ \begin{aligned} {}^{1}\mathbf{Y}_e &= {}^{1}\mathbf{P}_y \cdot {}^{1}\mathbf{Y}_1 \\ {}^{1}\mathbf{Z}_e &= {}^{1}\mathbf{P}_z \cdot {}^{1}\mathbf{Z}_1 \\ {}^{2}\mathbf{Y}_f &= {}^{2}\mathbf{P}_y \cdot {}^{2}\mathbf{Y}_1 \\ {}^{2}\mathbf{Z}_f &= {}^{2}\mathbf{P}_z \cdot {}^{2}\mathbf{Z}_1 \\ {}^{3}\mathbf{Y}_g &= {}^{3}\mathbf{P}_y \cdot {}^{3}\mathbf{Y}_1 \\ {}^{3}\mathbf{Z}_g &= {}^{3}\mathbf{P}_z \cdot {}^{3}\mathbf{Z}_1 \end{aligned} \tag{4. 1} $$

The appropriate subvectors and submatrices may be substituted to previous relations. After performing matrix multiplication, two independent systems of linear inhomogeneous equations may be obtained for unknowns:

1) ${}^1y_1(0)$, ${}^1y_1'(0)$, ${}^1y_n(l_n)$, $y_n'(l_n)$, ${}^1Q_{ye}$,
${}^2y_1'(0)$, ${}^2y_o(l_o)$, ${}^2y_o'(l_o)$, ${}^2Q_{yf}$, ${}^3y_1'(0)$, ${}^3y_q(l_q)$,
${}^3y_q'(l_q)$ in the plane $\widehat{xy}$;
2) ${}^1z_1(0)$, ${}^1z_1'(0)$, ${}^1z_n(l_n)$, ${}^1z_n'(l_n)$, ${}^1Q_{ze}$, ${}^2z_1'(0)$, ${}^2y_o(l_o)$, ${}^2y_o'(l_o)$, ${}^2Q_{zf}$, ${}^3z_1'(0)$, ${}^3z_q(l_q)$, ${}^3z_q'(l_q)$ in the plane $\widehat{xz}$,

which may be written in the following matrix form:

$$\mathbf{A}_y \cdot \mathbf{B}_y = \mathbf{D}_y \ , \ \mathbf{A}_z \cdot \mathbf{B}_z = \mathbf{D}_z \tag{4. 2}$$

Nonzero elements of the vector

$$\mathbf{D}_y = \left[d_{yr}\right]_1^{12} \tag{4. 3}$$

have the following shape:

$$\begin{aligned} &d_{y5} = -{}^2M_1 \cdot {}^2p_{13} \ , \ d_{y6} = -{}^2M_1 \cdot {}^2p_{23} \\ &d_{y7} = {}^2M_2 - {}^2M_1 \cdot {}^2p_{33} \ , \ d_{y8} = -{}^2M_1 \cdot {}^2p_{43} \end{aligned} \tag{4. 4}$$

In the case of the vector

$$\mathbf{D}_z = [d_{zr}]_1^{12} \tag{4. 5}$$

nonzero elements have the form:

$$\begin{aligned} &d_{z3} = -{}^1M_1 \ , \ d_{z9} = -{}^3M_1 \cdot {}^3p_{13} \\ &d_{z10} = -{}^3M_1 \cdot {}^3p_{23} \\ &d_{z11} = -{}^3M_1 \cdot {}^3p_{33} \ , \ d_{z12} = -{}^3M_1 \cdot {}^3p_{43} \end{aligned} \tag{4. 6}$$

The elements of the vector

$$\mathbf{B}_y = \left[b_{yr}\right]_1^{12} \tag{4. 7}$$

consist of the following variables:

$$\begin{aligned} &b_{y1} = {}^1y_1(0), \ b_{y2} = {}^1y_1'(0), \ b_{y3} = {}^1y_n(l_n), \\ &b_{y4} = {}^1y_n'(l_n), \ b_{y5} = {}^1Q_{yn}(l_n), \ b_{y6} = {}^2y_1'(0), \\ &b_{y7} = {}^2y_o(l_o), \ b_{y8} = {}^2y_o'(l_o), \ b_{y9} = {}^2Q_{yo}(l_o), \\ &b_{y10} = {}^3y_1'(0), \ b_{y11} = {}^3y_g(l_g), \ b_{y12} = {}^3y_g'(l_g). \end{aligned} \tag{4. 8}$$

The elements of the vector

$$\mathbf{B}_z = [b_{zr}]_1^{12} \tag{4. 9}$$

include:

$$\begin{aligned} &b_{z1} = {}^1z_1(0), \ b_{z2} = {}^1z_1'(0), \ b_{z3} = {}^1z_n(l_n), \\ &b_{z4} = {}^1z_n'(l_n), \ b_{z5} = {}^1Q_{zn}(l_n), \ b_{z6} = {}^2z_1'(0), \\ &b_{z7} = {}^2z_o(l_o), \ b_{z8} = {}^2z_o'(l_o), \ b_{z9} = {}^2Q_{zo}(l_o), \\ &b_{z10} = {}^3z_1'(0), \ b_{z11} = {}^3z_g(l_g), \ b_{z12} = {}^3z_g'(l_g). \end{aligned} \tag{4. 10}$$

Nonzero elements of the matrix

$$\mathbf{A}_y = \left[a_{yrs}\right]_1^{12} \tag{4. 11}$$

have the shape:

$$\begin{aligned} &a_{y11} = {}^1p_{11} \ , \ a_{y12} = {}^1p_{12} \ , \\ &a_{y13} = -1, \ a_{y21} = {}^1p_{21} \ , \\ &a_{y22} = {}^1p_{22} \ , \ a_{y24} = -1, \\ &a_{y31} = {}^1p_{31}, \ a_{y32} = {}^1p_{32} \ , \\ &a_{y41} = {}^1p_{41} \ , \ a_{y42} = {}^1p_{42} \ , \\ &a_{y45} = 1, \ a_{y53} = -{}^2p_{11} \ , \\ &a_{y55} = {}^2p_{14} \ , \ a_{y56} = -{}^2p_{12} \ , \\ &a_{y57} = 1, \ a_{y63} = -{}^2p_{21} \ , \\ &a_{y65} = {}^2p_{24} \ , \ a_{y66} = -{}^2p_{22} \ , \\ &a_{y68} = 1, \ a_{y73} = -{}^2p_{31} \ , \\ &a_{y75} = {}^2p_{34} \ , \ a_{y76} = -{}^2p_{32} \ , \\ &a_{y83} = -{}^2p_{41} \ , \ a_{y85} = {}^2p_{44} \ , \\ &a_{y86} = -{}^2p_{42} \ , \ a_{y89} = -1, \\ &a_{y97} = -{}^3p_{11} \ , \ a_{y99} = {}^3p_{14} \ , \\ &a_{y9,10} = -{}^3p_{12} \ , \ a_{y9,11} = 1, \\ &a_{y10,7} = -{}^3p_{21} \ , \ a_{y10,9} = {}^3p_{24} \ , \\ &a_{y10,10} = -{}^3p_{22} \ , \ a_{y10,12} = 1, \\ &a_{y11,7} = -{}^3p_{31} \ , \ a_{y11,9} = {}^3p_{34} \ , \\ &a_{y11,10} = -{}^3p_{32} \ , \ a_{y12,7} = -{}^3p_{41} \ , \\ &a_{y12,9} = {}^3p_{44} \ , \ a_{y12,10} = -{}^3p_{42} \ . \end{aligned} \tag{4. 12}$$

As regards to the matrix $\mathbf{A}_z$, you get the following:

$$\mathbf{A}_z = [a_{zrs}]_1^{12} = \mathbf{A}_y \tag{4. 13}$$

5. Calculation of state vectors in the selected sections of the system

By solution of the described systems of equations and gradual matrix multiplication, according to the following relations, you may get previously unknown elements of boundary state vectors of individual shafts:

$${}^1\mathbf{V}_e = {}^1\mathbf{M}_1 \cdot {}^1\mathbf{H}_n \ldots {}^1\mathbf{H}_i \ldots {}^1\mathbf{H}_{m+1} \cdot {}^1\mathbf{C}_2 \cdot {}^1\mathbf{H}_m \ldots {}^1\mathbf{H}_n \ldots {}^1\mathbf{H}_1 \cdot {}^1\mathbf{C}_1 \cdot {}^1\mathbf{V}_1 \tag{5. 1}$$

6. Conclusions

The paper describes a method following to solve steady forced vibration of Cardan shafts system as a whole, which in its essence is a dynamic evolutionary bound system. Input and output Cardan shafts, as well as a coupling shaft, being seen as a transversely oscillating one-dimensional continuum. The system is actuated discreetly in construction margins of a propshaft by dynamic bending moments, of which propshafts being strained due to the transfer of power flow by Hooke's joints. The essence of the proposed method is the standard method of release applied to deformable bodies, formed by an one-dimensional linear continuum and combined with the transfer-matrix method. The method is inherently numeric-analytical. The actual problem is solved analytically, but over the fields formed by transfer matrices elements of individual articles, and thus the shafts. The paper describes the process how to formulate a mathematical model using the transfer-matrix method; the problem is solved

gradually, as the basis for subsequent processing and debugging software.

References

[1] HRUBÝ, P. *Bending-gyratory Vibrations of Shafts in Drives with Joints.* The candidate dissertation. Plzeň: VŠSE (The University of West Bohemia, Faculty of Mechanical Engineering), 1981.

[2] DUŇ, S., HRUBÝ, P., PAVLENKO A. *Analysis of Factors Affecting Technical and Operational Characteristics of Trucks to Transport Grain - KRAZ.* In *International Masaryk Conference 2015: collection of papers*. Hradec Králové: Magnanimitas, 2015. p. 1938-1946, 9 pg.

[3] HRUBÝ, P., KLEISNEROVÁ, L., ŽIDKOVÁ, P. Bending Oscillations Analysis of Cinematically Excited Propeller Shaft. In *International Masaryk Conference 2015: collection of papers*. Hradec Králové: Magnanimitas, 2015.
p. 2565-2574, 15 pg.

[4] HRUBÝ, P., HLAVÁČ, Z., ŽIDKOVÁ. P. *Application of the finite element method in determination of modal and spectral properties of propeller shaft´s bending vibrations.* In Michael McGreevy, Robert Rita. *Proceedings of the 5th biannual CER Comparative European Research Conference: International scientific conference for Ph.D. students of EU countries*. London: Sciemcee Publishing, 2016. p. 132-135, 4 pg.

[5] HRUBÝ, P., KMEC, J., KUČERKA, D., ŽIDKOVÁ, P. *Dimensioning of Welded Parts of Rotating Members of Mechanisms in Machine Drives.* In *International Masaryk Conference 2015: collection of papers*. Hradec Králové: Magnanimitas, 2015. p. 2592-2601, 10 pg.

[6] HRUBÝ, Petr, Zdeněk HLAVÁČ and Pavla ŽIDKOVÁ. Physical and Mathematical Models of Shafts in Drives with Hook´s Joints. In Michael McGreevy, Robert Rita. *Proceedings of the 5th biannual CER Comparative European Research Conference: International scientific conference for Ph.D. students of EU countries*. London: Sciemcee Publishing, 2016. p. 136-140, 5 pg.

[7] HRUBÝ, P., KLEISNEROVÁ, L. Critical speeds of shafts. In *International Masaryk Conference 2014: collections of papers*. Hradec Králové: Magnanimitas, 2014. p. 3923-3931, 9 pg.

[8] HRUBÝ, P., HLAVÁČ, Z., ŽIDKOVÁ. P. *The transfer-matrix method in the application for an one-dimensional linear continuum speed resonance.* In Michael McGreevy, Robert Rita. *Proceedings of the 5th biannual CER Comparative European Research Conference: International scientific conference for Ph.D. students of EU countries*. London: Sciemcee Publishing, 2016. p. 141-144, 4 pg.

[9] HRUBÝ, P., HLAVÁČ, Z., ŽIDKOVÁ, P. Cardan Shaft Steady State Response on Rotating Torque Excitation. In Michael McGreevy, Robert Rita. *CER Comparative European Research 2016*. London: Sciemcee Publishing, 2016. p. 136-140, 5 pg.

[10] DILLINGER, J. *Modern Engineering for School and Practice.* Prague: Europa-Sobotáles, 2007. 612 pg.

[11] LEINVEBER, J., VÁVRA P. *Mechanical Tables. The Auxiliary Textbook for Technical School.* 3rd updated edition. Prague: Albra, 2006. 986 pg.

[12] SHIGLEY, J., E., MISCHKE Ch., R., BUDYNAS R., G. *Machine Components Designing.* Brno: VUTIUM, 2010. 1159 pg.

[13] ŘEŘÁBEK, A. *Designing and Operation of Machines: Machine Components I.* Prague: Scientia, 2006. 224 pg.

[14] ŘEŘÁBEK, A. *Designing and Operation of Machines: Machine Components II.* Prague: Scientia, 2009. 256 pg.

CALCULATION METHODS OF PARAMETERS OF DYNAMIC MODELS OF SHAFTS IN DRIVES WITH HOOKE'S JOINTS

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Abstract: *Mathematical model of connecting Cardan shaft described in* [*L*3], [*L*8] *and* [*L*12] *allows to solve three basic problems of lateral vibration - namely calculating natural frequencies of relative transverse vibrations, analysis of so called steady response to rotating torque and kinematic excitation. The torque excitation is formed due to the power flow by Hooke's joints, the kinematic excitation is formed due to the spatial oscillations of a drive unit. The software was created and debugged for these tasks. Subsequently, design variants of articulated drive shafts of real vehicles were analyzed, namely variant where disturbances - i. e. permanent bending deformations - occurred, and variant sufficiently durable to lateral oscillations during operation, too. This paper describes methods of determining input parameters of the model for both mentioned variants and individual solved problems.*

Keywords: *model, mathematical, parameter, input, shaft, propeller, connecting*

1. Introduction

The literature [L3], [L8] and [L12] describes a mathematical model of Cardan coupling propeller shaft. The model allows to solve three basic problems of lateral vibration of the coupling propshaft, namely calculation of natural frequencies of relative transverse vibration, analysis of steady-state response to rotating torque excitation and analysis of steady-state response to kinematic excitation. The torque excitation arises due to power flow transmission by Hooke's joints; kinematic excitation arises due to spatial oscillations of a drive unit. To solve this tasks, the software was created and debugged. Then, propshafts constructional variants of real vehicles drives were analyzed, namely variant of deformation (permanent bending deformation) and variant of sufficient resistance to transverse oscillations during the operation. The paper describes methods of calculating the input parameters of the created software. Leaning program parameters can be divided on the parameters defining natural vibration of the system and excitation functions parameters. During calculation, you must specify the geometric parameters, material properties, mass properties and mounting rigidity parameters. During preparing the parameters, the usual procedures within the elasticity, strength and dynamism of rigid body are used.

2. Geometrical model parameters

First, we deal with approximate calculation of the input parameters that appear in the data files of programs VFOKP, EMBUZ and KINBUZ. Real Hooke's joints at edges of the propshaft are in the dynamic model represented by discrete masses (see Fig. 1).

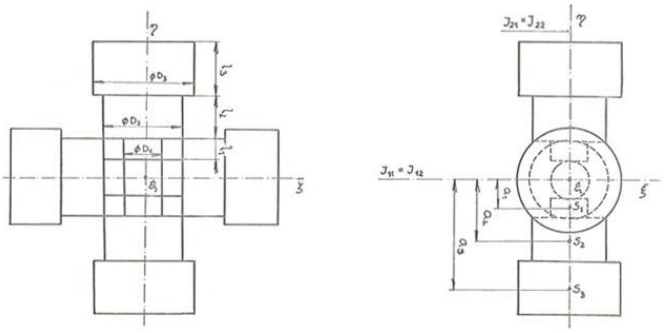

Figure 1

To calculate the weight and inertia matrix of discrete masses, the substitution is used, according to Fig. 2. The substitution is formed by elements having a cylindrical shape. The weight and axial moments of inertia of the individual elements of substitution against the main central axes of inertia o_1, o_2, o_3 (see Figure 2) can be expressed as:

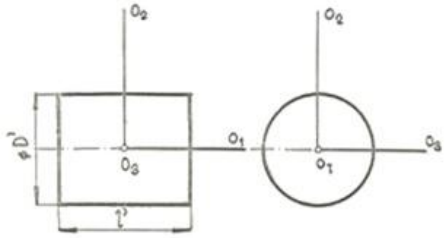

Figure 2

$$m = \frac{\pi\rho}{4} \cdot D'^2 \cdot l' \,,\; J_{o_1} = \frac{1}{8} m D'^2$$
$$J_{o_2} = J_{o_3} = \frac{m}{4}\left(\frac{l'^2}{3} + \frac{D'^2}{4}\right) \qquad (2.\ 1)$$

Then, the weight of μ-th discrete material can be expressed in the form:

$$m_\mu = 4 \sum_{i=1}^{3} m_{i\mu} \, , \; \mu = 1, 2 \qquad (2.\ 2)$$

Axial moments of inertia (the inertia matrix elements) can be written in the form

$$J_{o\mu} = 4 \cdot \sum_{i=1}^{3} \left(J_{o_1 i\mu} + m_{i\mu} a_{i\mu}^2 \right) \qquad (2.\ 3)$$

$$J_{1\mu} = J_{2\mu} = 2 \cdot \sum_{l=1}^{3} \left(J_{o_1 i\mu} + J_{o_2 i\mu} + + m_{i\mu} a_{i\mu}^2 \right)$$

$$\mu = 1, 2$$

After substituting the values shown in the Table 1 to relations (2. 1), (2. 2) a (2. 3)

Table 1

i	D' m	l' m	a m
1	0,022	0,014	0,018
2	0,050	0,025	0,0375
3	0,068	0,035	0,0675

you get the following:

$m_\mu = 5{,}663$ [kg], $J_{o\mu} = 2{,}2 \cdot 10^{-2}$ [kg m^2]
$J_{1\mu} = J_{2\mu} = 1{,}25 \cdot 10^{-2}$ [kg m^2]
$\mu = 1, 2$

3. Mounting rigidity of connecting shaft edges

The approximate calculation of translational, static understood rigidities is performed according to the documents referred in [L 1]. The resulting stiffness of the relevant propshaft edge is determined by the relation

$$c = \frac{1}{\Delta y_o + \Delta y_s} \qquad (3.\ 1)$$

To the total deformation, the deformation caused by bending

$$\Delta y_o = \frac{1}{3E} \left[\left(\frac{a}{l} \right)^2 \sum_{i=1}^{S} \frac{x_i^3 - x_{i-1}^3}{J_i} + \sum_{j=1}^{k} \frac{x_j^{-3} - x_{j-1}^{-3}}{J_j} \right] \qquad (3.\ 2)$$

and the deformation caused by shear are included.

$$\Delta y_s = \frac{1}{G} \left[\left(\frac{a}{l} \right)^2 \sum_{l=1}^{S} \frac{\beta_i}{F_i} (x_i - x_{i-1}) + \right. \qquad (3.\ 3)$$

$$\left. + j{=}1 k \beta j F j x j - x j - 1, \right.$$

where: E – the tensile – pressure modulus, J_i – the moment of inertia between supports, J_j – the moment of inertia of cross-section at the free end, G – shear modulus, F_i – cross-section area between supports, F_j – cross-section at the free end, β_i – shape cross-section coefficient between supports, β_j – shape cross-section coefficient at the free end. The significance of the other variables is shown in Fig. 3.

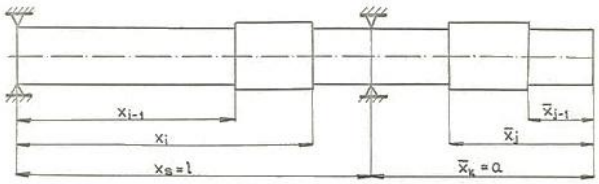

Figure 3

The shape factor is determined from the following relation:

$$\beta^* = \frac{1}{2} \left(1 + \frac{d}{D} \right)^2 \cdot \left(1 + \frac{d^2}{D^2} \right)^{-1} \qquad (3.\ 4)$$

In the case of full circular cross-section, the value $\beta^* = 1{,}18$ is considered, the moment of inertia of the cross-section is determined from the relation

$$J = \frac{\pi}{4} (r_2^4 - r_1^4) \qquad (3.\ 5)$$

The replacement model of the shaft coupling is shown in Fig. 4, the transmission shaft model in Fig. 5. After substituting values into (3. 1), (3. 2) and (3. 3) you get the following:

$$c_1 = 3{,}89 \cdot 10^7 \text{ [Nm}^{-1}\text{]}, \; c_2 = 7{,}22 \cdot 10^7 \text{ [Nm}^{-1}\text{]}$$

4. Parameters of connecting shaft body

The propshaft is replaced by one-dimensional continuum via portions of constant cross-section. Geometrical parameters for variant V1 are shown in Fig. 6, geometrical parameters for variant V2 in Fig. 7. Let's consider a density $\rho = 7{,}8 \cdot 10^3$ [kgm^{-3}], tensile modulus $E = 2{,}1 \cdot 10^{11}$ [Nm^{-2}] for all fields of both variants.

5. Input parameters of the program VFOKP

Input parameters of the program VFOKP are summarized for variant V1 in Table 2, for variant 2 in Table 3. Besides the parameters whose calculation was described in Chapters 2, 3 and 4, it is necessary to specify the relative accuracy ε.

Regarding the tested cases, as optimal showed (in terms of the accuracy of determining the natural frequency and consumption of the machine time) to choose ε in the range from 0,1 to 0,01. Natural frequencies are searched in the interval $\Omega_{min} = 10$ [s^{-1}], $\Omega_{max} = 5000$ [s^{-1}] with the step $\Delta\Omega = 10$ [s^{-1}], at the angular velocity $\omega = 200$ [s^{-1}]. The influence of the angular velocity is examined in the interval $\omega \in \langle 10; 1500 \rangle$.

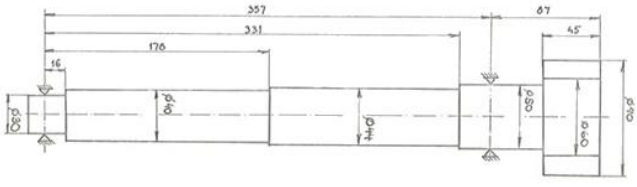

Figure 4

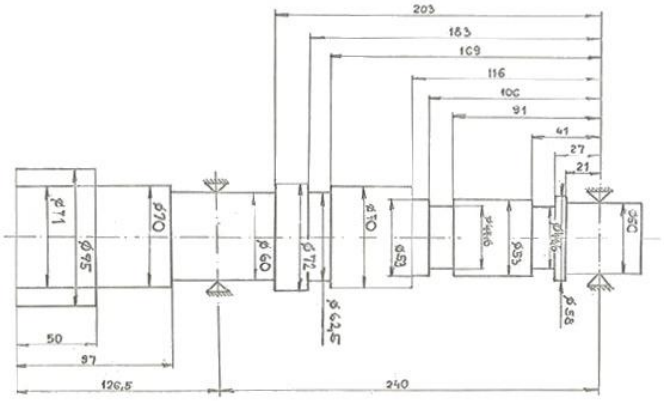

Figure 5

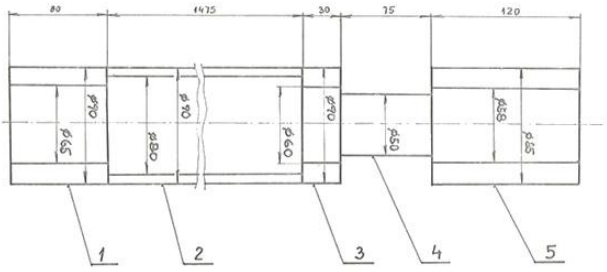

Figure 6

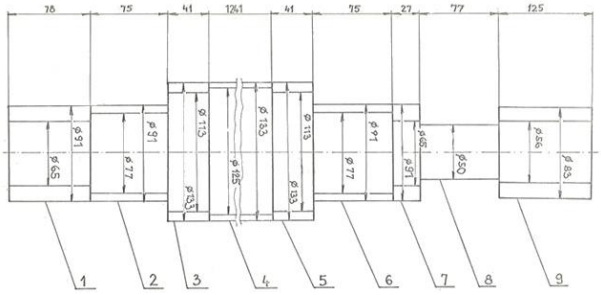

Figure 7

Table 2

Basic input parameters of the program VFOKP, V1					
designation	*dimension*	*value*	*designation*	*dimension*	*value*
N		5	L (I)		$1475 \cdot 10^{-3}$
RO	kgm^{-3}	$7,8 \cdot 10^{3}$	L (I)	m	$30 \cdot 10^{-3}$
E	Nm^{-2}	$2,1 \cdot 10^{11}$	L (I)		$75 \cdot 10^{-3}$
C1	Nm^{-1}	$3,89 \cdot 10^{7}$	L (I)		$120 \cdot 10^{-3}$
C2	Nm^{-1}	$7,22 \cdot 10^{7}$	R1 (I)		$32,5 \cdot 10^{-3}$
M1, M2	kg	5,663	R1 (I)		$40 \cdot 10^{-3}$
JD1, JD2	$kg\,m^2$	$1,25 \cdot 10^{-2}$	R1 (I)	m	$30 \cdot 10^{-3}$
JE1, JE2	$kg\,m^2$	$1,25 \cdot 10^{-2}$	R1 (I)		0
JK1, JK2	$kg\,m^2$	$2,2 \cdot 10^{-2}$	R1 (I)		$29 \cdot 10^{-3}$
OMIN	s^{-1}	10	R2 (I)		$45 \cdot 10^{-3}$
OMAX	s^{-1}	5000	R2 (I)		$45 \cdot 10^{-3}$
DOM	s^{-1}	10	R2 (I)	m	$45 \cdot 10^{-3}$
EPS		0,1	R2 (I)		$25 \cdot 10^{-3}$
OJ	s^{-1}	200	R2 (I)		$42,5 \cdot 10^{-3}$
L (1)	m	$80 \cdot 10^{-3}$			

Table 3

Basic input parameters of the program VFOKP, V2					
designation	*dimension*	*value*	*designation*	*dimension*	*value*
N	-	9	L (I)		$27 \cdot 10^{-3}$
RO	kgm^{-3}	$7,8 \cdot 10^{3}$	L (I)		$77 \cdot 10^{-3}$
E	Nm^{-2}	$2,1 \cdot 10^{11}$	L (I)		$125 \cdot 10^{-3}$
C1	Nm^{-1}	$3,89 \cdot 10^{7}$	R1 (I)		$32,5 \cdot 10^{-3}$
C2	Nm^{-1}	$7,22 \cdot 10^{7}$	R1 (I)		$33,5 \cdot 10^{-3}$
M1, M2	kg	5,663	R1 (I)		$56,5 \cdot 10^{-3}$
JD1, JD2	$kg\,m^2$	$1,25 \cdot 10^{-2}$	R1 (I)	m	$62,5 \cdot 10^{-3}$
JE1, JE2	$kg\,m^2$	$1,25 \cdot 10^{-2}$	R1 (I)		$56,5 \cdot 10^{-3}$
JK1, JK2	$kg\,m^2$	$2,20 \cdot 10^{-2}$	R1 (I)		$33,5 \cdot 10^{-3}$
OMIN	s^{-1}	10	R1 (I)		$32,5 \cdot 10^{-3}$
OMAX	s^{-1}	5000	R1 (I)		0
DOM	s^{-1}	10	R2 (I)		$28 \cdot 10^{-3}$
EPS	-	0,1	R2 (I)		$45,5 \cdot 10^{-3}$
OJ	s^{-1}	200	R2 (I)		$45,5 \cdot 10^{-3}$
L (I)		$78 \cdot 10^{-3}$	R2 (I)		$66,5 \cdot 10^{-3}$
L (I)		$75 \cdot 10^{-3}$	R2 (I)	m	$66,5 \cdot 10^{-3}$
L (I)		$41 \cdot 10^{-3}$	R2 (I)		$66,5 \cdot 10^{-3}$
L (I)		$1241 \cdot 10^{-3}$	R2 (I)		$45,5 \cdot 10^{-3}$
L (I)	m	$41 \cdot 10^{-3}$	R2 (I)		$45,5 \cdot 10^{-3}$
L (I)		$75 \cdot 10^{-3}$	R2 (I)		$25 \cdot 10^{-3}$
L (I)			R2 (I)		$41,5 \cdot 10^{-3}$

6. Input parameters of the program EMBUZ

Input parameters of the program EMBUZ include besides the above-described geometry, weight, stiffness and material parameters also excitation parameters. It is necessary to specify amplitudes of the excitation moments at the edges. According to [L1] it is contemplated $M_1 = M_2 = 90$ [Nm]. The excitation frequency is varied in the range $\bar{\omega}_{min} = 10\ s^{-1}$, $\bar{\omega}_{max} = 2500\ s^{-1}$ with the step $\Delta\bar{\omega}$ =

$10\ s^{-1}$. $\omega = 200\ s^{-1}$ is considered as the basic angular velocity of the connecting shaft.

7. Input parameters of the program KINBUZ

Input parameters of the program KINBUZ include besides the above-described geometry, weight, stiffness and material parameters also excitation parameters. Especially for the data file of the program KINBUS, it is necessary to provide amplitudes of excitation deflections in the basic area y_s, z_s and the phase shift φ, too. In determining these variables, you may use the results in [L 1]. Let's consider the following:

$$y_s = 8 \cdot 10^{-3}\ [m],\ z_s = 4 \cdot 10^{-3}\ [m],\ \varphi = 0{,}7\ [rad].$$

The frequency interval and the angular velocity of propshaft rotation considering similarly to the program EMBUZ.

8. Conclusions

This paper builds on the published papers [L3], [L8] and [L12], which describe physical and mathematical models of propshafts in the state of transverse, combined, bending-gyratory vibration. Practical application of the models requires the preparation of input parameters of the processed programs. The presented paper is devoted just to this issue. There are methods and procedures for determining the parameters of the mathematical model from the known parameters of the engineering design. Those parameters were used in the analysis of the causes of operational failures of an articulated connecting shaft and subsequent prediction of the behavior of the reconstructed Cardan drive mechanism in a real vehicle.

References

[1] HRUBÝ, P. *Bending-gyratory Vibrations of Shafts in Drives with Joints.* The candidate dissertation. Plzeň: ZCU (The University of West Bohemia, Faculty of Mechanical Engineering), 1981.

[2] DUŇ, S., HRUBÝ, P., PAVLENKO A. Analysis of Factors Affecting Technical and Operational Characteristics of Trucks to Transport Grain - KRAZ. In *International Masaryk Conference 2015: collection of papers*. Hradec Králové: Magnanimitas, 2015. p. 1938-1946, 9 pg.

[3] HRUBÝ, P., KLEISNEROVÁ, L., ŽIDKOVÁ, P. Bending Oscillations Analysis of Cinematically Excited Propeller Shaft. In *International Masaryk Conference 2015: collection of papers*. Hradec Králové: Magnanimitas, 2015.
p. 2565-2574, 15 pg.

[4] HRUBÝ, P., HLAVÁČ, Z., ŽIDKOVÁ. P. *Application of the finite element method in determination of modal and spectral properties of propeller shaft´s bending vibrations.* In Michael McGreevy, Robert Rita. *Proceedings of the 5th biannual CER Comparative European Research Conference: International scientific conference for Ph.D. students of EU countries*. London: Sciemcee Publishing, 2016. p. 132-135, 4 pg.

[5] HRUBÝ, P., KMEC, J., KUČERKA, D., ŽIDKOVÁ, P. *Dimensioning of Welded Parts of Rotating Members of Mechanisms in Machine Drives.* In *International Masaryk Conference 2015: collection of papers*. Hradec Králové: Magnanimitas, 2015. p. 2592-2601, 10 pg.

[6] HRUBÝ, Petr, Zdeněk HLAVÁČ and Pavla ŽIDKOVÁ. Physical and Mathematical Models of Shafts in Drives with Hook´s Joints. In Michael McGreevy, Robert Rita. *Proceedings of the 5th biannual CER Comparative European Research Conference: International scientific conference for Ph.D. students of EU countries*. London: Sciemcee Publishing, 2016. p. 136-140, 5 pg.

[7] HRUBÝ, P., HLAVÁČ, Z., ŽIDKOVÁ. P. *The transfer-matrix method in the application for an one-dimensional linear continuum speed resonance.* In Michael McGreevy, Robert Rita. *Proceedings of the 5th biannual CER Comparative European Research Conference: International scientific conference for Ph.D. students of EU countries*. London: Sciemcee Publishing, 2016. p. 141-144, 4 pg.

[8] HRUBÝ, P., KLEISNEROVÁ, L. Critical speeds of shafts. In *International Masaryk Conference 2014: collections of papers*. Hradec Králové: Magnanimitas, 2014. p. 3923-3931, 9 pg.

[9] DILLINGER, J. *Modern Engineering for School and Practice.* Prague: Europa-Sobotáles, 2007. 612 pg.

[10] LEINVEBER, J., VÁVRA P. *Mechanical Tables. The Auxiliary Textbook for Technical School.* 3rd updated edition. Prague: Albra, 2006. 986 pg.

[11] SHIGLEY, J., E., MISCHKE Ch., R., BUDYNAS R., G. *Machine Components Designing.* Brno: VUTIUM, 2010. 1159 pg.

[12] HRUBÝ, P., HLAVÁČ, Z., ŽIDKOVÁ, P. Cardan Shaft Steady State Response on Rotating Torque Excitation. In Michael McGreevy, Robert Rita. *CER Comparative European Research 2016*. London: Sciemcee Publishing, 2016. p. 136-140, 5 pg.

[13] ŘEŘÁBEK, A. *Designing and Operation of Machines: Machine Components I.* Prague: Scientia, 2006. 224 pg.

[14] ŘEŘÁBEK, A. *Designing and Operation of Machines: Machine Components II.* Prague: Scientia, 2009. 256 pg.

Session: Pedagogy, Psychology

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CREATIVITY AND COMMUNITY COMPETENCIES: ON THE BASIS OF THE ANALYSED GROUP OF UNIVERSITY STUDENTS

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Abstract: *The objective of the paper is verification of connections between creativity and community competencies that are the results of education during university studies. We have assumed we strive in the university to achieve the highest level of development of creativity/creative action (in the area of divergent, visual and spatial and exploratory thinking) with the simultaneous development of social competencies, ethical standards (in one of their aspects: community competencies).*

Keywords: *creativity, social competencies, higher education.*

1. Introduction

The modern world features a high rate of changes in various areas of social, economic, and technological life. Considering the Flynn effect of the increase of intelligence in Western communities [1], it seems that we live in the best of possible times. The result of intelligence [2], creativity, as the grounds for technological development are breakthrough discoveries that change our daily life. Manifestations of creativity are visible everywhere: in daily smart behaviour of children, in art and science, in business [3].

2. Theoretical context/Background

Creativity in literature is defined in various ways, with majority of definitions of creativity including three components [4]: creative ideas must include something new or innovative, must be of high quality and must be appropriate to the executed task or some redefinition of this task. Creativity defined by M. Boden is understood as the ability to generate novel, and valuable, ideas. Valuable, here, has many meanings: interesting, useful, beautiful, simple, richly complex, and so on. Ideas covers many meanings too: not only ideas as such (concepts, theories, interpretations, stories), but also artifacts such as graphic images, sculptures, houses, and jet engines [5]. E. Charzyńska and E. Wysocka [6] refer in the structure of the items related to creative thinking (in the KOMT - personality and creative thinking questionnaire) to the concept of creativity by M. Boden [7] and list the three main creative processes and the three corresponding types of creativity: 1. exploration: exploratory creativity (interrogative thinking) 2. combinations: combinational creativity (association thinking) 3. transformations: transformational creativity (transformational thinking). We have based our research on this understanding of creativity / creative activity. We have also assumed in them that we strive in the university to achieve the highest level of development of creativity with the simultaneous development of social competencies, ethical standards. However, we are aware that the actual situation is not always like this. If academic teachers generate a high level of creativity in the listeners without reinforcing whether creating high competencies and ethical standards, creativity may be wrongly focused (e.g. to exploit people, to act on the borderline of the law, in violation of the legal order in force). It follows from the research conducted that universities / higher studies facilities run training activities in manipulation and affecting people focused on some form of manipulation of people, and such training events such are most often run by psychologists. Training events and courses assume taking advantage of other people to pursue one's own objectives. For this reason, it is worth remembering that creativity has also its dark side, as it may determine the so-called shortcut actions, that is pursuing objectives in a way that breaks certain standards. The relationship between creativity and dishonesty was proven by, e.g., Francesca Gino and Dan Ariely [8]. The so-called negative creativity related to various features of personality clearly constitutes the characteristics of modern times, thus being a determinant of effects of education not envisioned by the educational system, but – due to its quality – related to the characteristics of the modern world (post-modernism), is more and more often appearing in social life and in individual features of personality. No doubt, the sources of the stated features are complex and multidimensional, however, one of them may be the features of education with various levels that do not "bridle", and often reinforce the dark side of creativity (machiavellisation and psychopatisation of personality).

Social competencies in international reports on education systems, recommendations of the European Parliament and worldwide trends of the 21st century are presented as the key element of the education. Key competencies are those which every person needs for self – fulfillment and personal development, being an active citizen, and also for social integration and employment. Within Recommendations, there have been eight key competencies established: communication in mother tongue, communication in foreign languages, mathematical competencies and basic socio – technical competencies, informatic competencies, the ability to learn, social and civic competencies, showing initiative

and enterprise, cultural awareness and expression [9]. Their shaping, improving is approached as the objective or the result to be pursued in the adopted programmes of education on all levels of education, as well as in daily expectations of parents, guardians, class tutors and teachers. Social competencies, irrespective of their structure, are often identified with the instruction that determines success in interpersonal relations. This instruction may be understood, however, as a sum of certain intellectual capacities or a set of personality traits. The modal combining these approaches is provided in the concept by S. Greenspan [10] and the model by A. Matczak [11] developed on this basis. S. Greenspan assumes that correctly developed social competencies are determined with both character traits, such as social activity and kindness, some temperament features (thoughtfulness and self composure), and social consciousness that is also called social intelligence. A. Matczak expands the above concept with interactions of personality and intellectual factors with the environment in which a person is functioning. This forms the theoretical base of the Questionnaire of Social Competencies developed by A. Matczak, which we have used in the study. A. Matczak defines social competencies as acquired skills that determine effectiveness of functioning of the person in various social situations. In the process of university-level education, we expect from the students mostly skills in making proper social interactions, ethical behaviour, cooperation with specialists and non-specialists in educational processes, constructive communication of own intentions and executed plans, programmes of work with subordinates, as well as responsibility for one's own behaviour, critical thinking, as well as creative resolution of tasks. Along this way, we meet more and more frequent "input" problems for university level education, so the question arises about the possible neglect in the earlier stages of education. An academic teacher begins to take care of, in the first stage of making up for competence deficits of the lower rank, the so-called basic skills in relations with other people. Just like other authors, we perceive increasing awareness that teachers make a significant contribution to the social and emotional development of their pupils [12] and this generated result permanently affects their adult life [13]. Context factors play a significant role in this process, such as the climate of the class, family support, as well as the quality of relationship with the teacher, which we emphasise.

3. Methodological aspects of research

The study included students of universities and colleges from the area of the Silesian and Małopolskie voivodeships (sample N = 577). They were studying pedagogy, mostly women (n = 547). The study was conducted in 2015 and 2016. The sample was selected randomly.

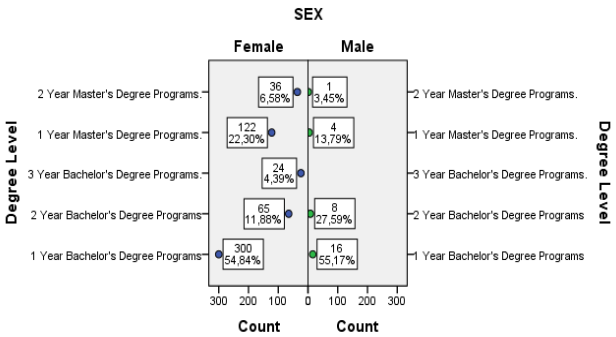

Figure 1: Characteristics of the research sample (N=577)

3.1 We have assumed the following hypotheses

H1: On the basis of theoretical analyses, significant differences are expected in the level of creativity in the aspect of divergent thinking in students of pedagogy between the average values in the compared groups, varied in terms of the community competencies.

H2: On the basis of theoretical analyses, significant differences are expected in the level of creativity in the aspect of visual-spatial thinking in students of pedagogy between the average values in the compared groups, varied in terms of the community competencies.

H3: On the basis of theoretical analyses, significant differences are expected in the level of creativity in the aspect of exploratory thinking in students of pedagogy between the average values in the compared groups, varied in terms of the community competencies.

These hypotheses determine the space of variables that we conventionally call:

Dependent variables:

X1 (level of divergent thinking). Indicator: the result obtained in the scale of Personality and Creative Thinking Questionnaire (KOMT) [14].

X2 (level of visual-spatial thinking). Indicator: the result obtained in the scale of Personality and Creative Thinking Questionnaire (KOMT).

X3 (level of exploratory thinking). Indicator: the result obtained in the scale of Personality and Creative Thinking Questionnaire (KOMT).

Independent variable:

Y1 – level of community competencies. Indicator: the level of community competencies declared in the The Social Competencies Profile (PROKOS) [15].

4. Results

Divergent thinking and Community Competencies

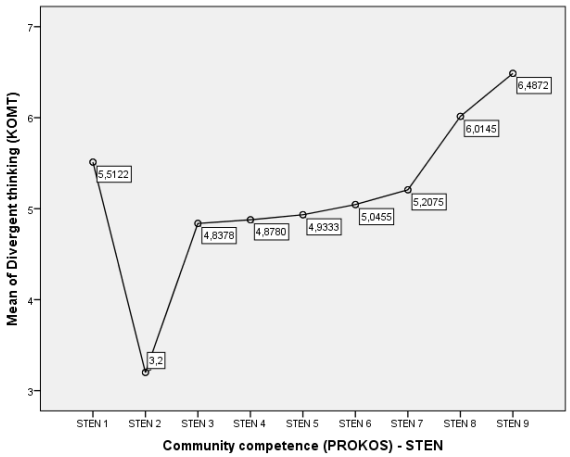

Figure 2: Divergent thinking and community competencies (n=561)

To confirm the differences between the average values in the compared groups varied in terms of the level of education, the Kruskal-Wallis test was conducted as a nonparametric alternative to the one way ANOVA. The test was used to compare the average values whose distribution is not similar to normal distribution (the variables were tested with the Kolmogorov-Smirnov test – the zero hypothesis about parametric distribution the variables was rejected). There was statistically significant difference between the Divergent thinking (KOMT) by Community Competencies (PROKOS) (H(2)=40.360, p= .00; η_H^2= .057), with a mean rang of 269.09 for STEN 1, 141,80 for STEN 2, 238.58 for STEN 3, 256.37 for STEN 4, 261.65 for STEN 5, 267.38 for STEN 6, 277.54 for STEN 7, 354.75 for STEN 8, 365.05 for STEN 9. Due to finding differences in the compared groups, the H1 test hypothesis is to be confirmed that the level of creativity in the aspect of divergent thinking in students of pedagogy is statistically significantly varied by the community competencies.

Visual and spatial Thinking and Community Competencies

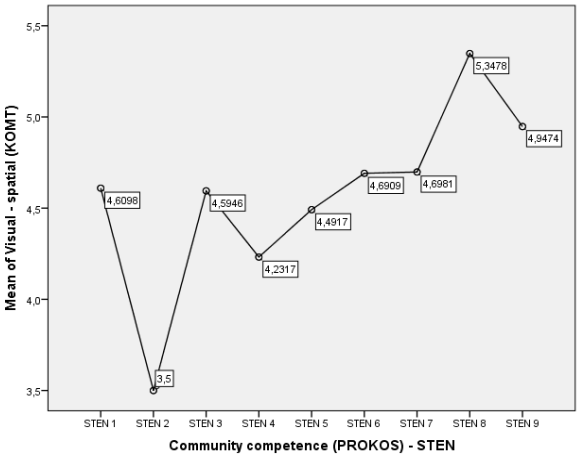

Figure 3: Visual – spatial thinking and community competencies (n=560)

To confirm the differences between the average values in the compared groups varied in terms of the level of education, the Kruskal-Wallis test was conducted as a nonparametric alternative to the one way ANOVA. The test was used to compare the average values whose distribution is not similar to normal distribution (the variables were tested with the Kolmogorov-Smirnov test – the zero hypothesis about parametric distribution the variables was rejected). There was statistically significant difference between the Visual and Spatial Thinking (KOMT) by Community Competencies (PROKOS) (H(2)=30.821, p= .00; η_H^2= ,04), with a mean rang of 269.89 for STEN 1, 178.75 for STEN 2, 272.18 for STEN 3, 234.66 for STEN 4, 266.64 for STEN 5, 281.63 for STEN 6, 288.06 for STEN 7, 358.57 for STEN 8, 313.95 for STEN 9. Due to finding differences in the compared groups, the H2 test hypothesis is to be confirmed that the level of creativity in the aspect of visual - spatial thinking in students of pedagogy is statistically significantly varied by the community competencies.

Exploratory thinking and Community Competencies

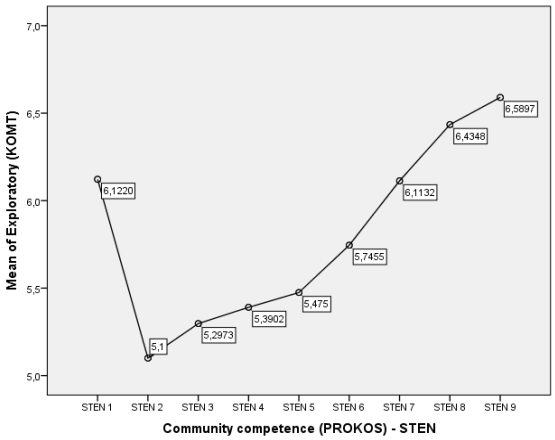

Figure 4: Exploratory thinking and community competencies (n=561)

To confirm the differences between the average values in the compared groups varied in terms of the level of education, the Kruskal-Wallis test was conducted as a nonparametric alternative to the one way ANOVA. The test was used to compare the average values whose distribution is not similar to normal distribution (the variables were tested with the Kolmogorov-Smirnov test – the zero hypothesis about parametric distribution the variables was rejected). There was statistically significant difference between the Exploratory Thinking (KOMT) by Community Competencies (PROKOS) (H(2)=27.618, p= .00; η_H^2= .034), with a mean rang of 294.13 for STEN 1, 239.10 for STEN 2, 233.88 for STEN 3, 249.02 for STEN 4, 255.11 for STEN 5, 275.50 for STEN 6, 311.33 for STEN 7, 333.75 for STEN 8, 350.49 for STEN 9. Due to finding differences in the compared groups, the H3 test hypothesis is to be confirmed that the level of creativity in the aspect of exploratory thinking in students of pedagogy is statistically significantly varied by the community competencies.

5. Summary

The level of creativity in the aspect of divergent thinking, visual and spatial and exploratory thinking in students of pedagogy is statistically significantly varied by the community competencies. We could change the scheme which is popular in polish education system: assigned, learned, passed, if we based on developing competencies. The future wants us to turn the education system pyramid in such a way that everyone could start from gaining life skills such as efficiency, creativity, the basics of communication, understanding oneself and other people, creating values, etc. Those more gifted, with academic ambitions, could later on go through appropriate education system which would enable them to go to another level of education. Such way of thinking about education may be compared to a situation when everyone is taught how to walk and special training is given to those, who showed skills in running. Now it is just the other way about: everyone is taught how to run, neglecting those who will only walk in life [16]. Students must face lots of problem situations where – solving problems more and more independently – they will master skills and build the expected attitudes, creativity and social competiencies,

References

[1] Flynn, J. R., What Is Intelligence ? – Beyond the Flynn Effect, Cambridge University Press, New York 2009, p.18

[2] Wechsler, D., The measurement of adult intelligence. Journal of Nervous & Mental Disease, 4(91), Wolters Kluwer, Illinois, p. 548, 1940

[3] Moran, S., The roles of creativity in society. The Cambridge handbook of creativity, Cambridge University Press, New York, p. 74, 2010

[4] Kaufman, J. C., Sternberg, R. J., Resource review: creativity, Change, 39(4), Philadelphia 2007.

[5] Boden M., Computer Models of Creativity, http://www.aaai.org/ojs/index.php/aimagazine/article/view/2254/2100, p. 24

[6] Charzyńska E., Wysocka E., Kwestionariusz osobowości i myślenia twórczego, FPON, Stróże 2015.

[7] Boden M. What is creativity? W: M. Boden (red.), Dimensions of creativity, pp. 75–117, 1996 Cambridge-London: The MIT Press/Bradford Books. Boden M. Creativity and knowledge. W: A. Craft, B. Jeff Rey, M. Leibling (red.) Creativity in education,pp. 95–102, 2001. London-New York: Continuum. Boden M. The creative mind: myths and mechanisms. London-New York: Routledge 2004. Boden M. Creativity and art. Three roads to surprise. Oxford-New-York: Oxford University Press 2010.

[8] Francesca Gino of the Harvard Business School and Dan Ariely of the Fuqua School of Business present the research results in the paper entitled "The Dark Side of Creativity: Original Thinkers Can Be More Dishonest" 2012. The results of their studies prove the relationship between creativity and dishonesty, in this way emphasising the dark side of creativity. McLaren (1993) also stated that creativity may be wrongly used, e.g. in advertisements, where the objective of creativity is to promote selling unhealthy food, hazardous products, alcohol, drugs, entertainment, "repugnant" values or even glorification of crime. It is used in politics to promote, e.g., race and religious hatred, and in science and technology to develop and build weapons of mass destruction or its products that cause contamination of the environment. What is interesting is that McLaren stated that damages generated by technological creativity are not limited only to physical destruction (in: Cropley A.J. The Side of Creativity: What Is It?, (in:) Cropley, D. H., Cropley, A. J., Kaufman, J. C., & Runco, M. A. (eds.). The dark side of creativity. New York: Cambridge University Press: p. 3, 2010).

[9] European Parliament and Commission directive from 18 December 2006 on key competences in the process of lifelong learning, 2006/962/WE.

[10] Greenspan S. Defining childhood social competence: a proposed working model. W: Keogh B.K. (red.). Advances in special education. JAI Press, Greenwich; 3:pp. 1–39, 1981

[11] Matczak A. Kwestionariusz Kompetencji Społecznych (KKS). Podręcznik. Pracownia Testów Psychologicznych Polskiego Towarzystwa Psychologicznego, Warszawa, pp. 6–10, 2001

[12] Birch, S. H., & Ladd, G. W. Children's interpersonal behaviors and the teacher- child relationship. Developmental Psychology, 34, 934-946, 1998 / Hamre, B., & Pianta, R. C. Student-teacher relationships. In G. Bear & K. M. Minke (Eds.), Children 's needs III: Development, prevention, and intervention, pp. 59-72, 2006. Bethesda, MD: NASP. / Murray, C, & Greenberg, M. T. Children's relationship with teachers and bonds with school: An investigation of patterns and correlates in middle childhood. Journal of School Psychology, 38,pp. 423-45, 2000/Pianta, R. C, Hamre, B., & Stuhlman, M. Relationships between teachers and children. In W. M. Reynolds & G. E. Miller (Eds.), Comprehensive handbook of psychology, Vol. 7, pp. 199-234, 2003. New York: Wiley. / Jennings P. A., Greenberg M. T., The Prosocial Classroom: Teacher Social and Emotional Competence in

Relation to Student and Classroom, Review of Educational Research, Vol. 79, No. 1, pp. 491- 525, Mar., 2009
[13] Pederson, E., Fatcher, T. A., & Eaton, W. W. A new perspective on the effects of first grade teachers on children's subsequent adult status. Harvard Educational Review, 48, pp. 1-31, 1978
[14] Charzyńska E., Wysocka E., Kwestionariusz osobowości i myślenia twórczego, FPON, Stróże 2015
[15] Matczak A., Markowska K., Profil Kompetencji Społecznych. Podręcznik, PTP, Warszawa 2013
[16] de Bono E., Z nowym myśleniem w nowe tysiąclecie, Poznań, p. 7, 2001

RELATIONSHIP BETWEEN CREATIVITY AND RESILIENCE IN UNIVERSITY STUDENTS

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Abstract: *The objective of our research was to explore a relationship between creativity and resilience (namely individual capacities, relational resilience and contextual factors) in university students. The sample consisted of 492 first year students of nine faculties of universities in Bratislava with various study focus (mean age = 19.98, SD = 1.57). We used the Torrance Test of Creative Thinking and the Child and Youth Resilience Measure CYRM-28. Although gender did not differentiate the level of creativity, women scored higher in relational resiliences. We found a weak negative relationship between flexibility and education and a weak positive relationship between originality and spirituality in contextual factors of resilience. Creative power weakly correlated with overall resilience, contextual factors and education. Differences between participants with high and low resilience were shown only in indicators of creative power. Yet, the differences were very small. On the basis of our findings we conclude that there is no significant relationship between creative production and resilience.*

Keywords: *creativity, resilience, individual capacities, relational resilience, contextual factors*

1. Introduction

Creativity refers to the courage to move his/her own boundaries, the ability to learn and acquire new information and skills, to enjoy new knowledge and to use it in practical life or to develop and transform it in various ways. Creativity level can be defined by its novelty, resolution and impact of ideas in different contexts: the creator, reference group or population [1]. In the empirical research, creativity is usually evaluated by the basic attributes of creative production - fluency (production quantity), flexibility (the ability to find more directions in solving the problem) and originality (unique ideas) [2]. Currently, research is also focused on the relationship of creativity with resilience [3], which can be defined as the capability that allows an individual or a group to prevent, minimize or cope with the adverse events or their consequences. We applied Ungar´s conception of resilience [4] which takes into account the cultural and contextual aspects of resilience. Ungar defines resilience as the ability of an individual to obtain the resources necessary for experiencing of subjective well-being and the possibility of social and cultural backgrounds to provide these resources in ways that are culturally understandable.

In this study we assume that creativity is an important protective factor and it can be seen as a flexible response to the disaster, which promotes healing and growth [5]. Highly creative and highly resilient people share a number of common features to which we include the ability to produce alternative ideas, acceptance of challenges, the ability to reassess the situation in a positive way [6]. Traditional attributes of creativity - flexibility, initiative, spontaneity, invention and originality are essential for successful problem solving and coping with difficult situation [3]. Resilient individual is flexible in adapting to the changed conditions, retains optimism, subjective well-being and high self-efficacy [7]. The empirical evidence of this relationship is ambiguous and does not support the theoretical assumptions about the relationship between resilience and creativity [8,9].

The model of creativity stated by Metzl and Morrell [3] formed the basis of our research. It presumes that managing adverse situations is conditioned by creativity (or rather creative thinking), personality (especially personality traits in the Big5 model) and contextual factors. In our previous research [10], we empirically verified the relationship between resilience and personality traits. We found a moderate positive relationship of resilience with extraversion, agreeableness and conscientiousness, and a negative relationship with neuroticism. In this research, we focus on the relationship between resilience and creative thinking characterized by the production of new and unusual ideas. We formulate the following research questions:

RQ1: Is there a relationship between resilience and fluency in creative production?
RQ2: Is there a relationship between resilience and flexibility in creative production?
RQ3: Is there a relationship between resilience and originality in creative production?
RQ4: Is there a relationship between resilience and indicator of creative power?

2. Methods

2.1 Research sample

Our research sample consisted of 492 university students from eight universities in Bratislava, Slovakia. Frequency and percentage of participants of each university (faculty) are stated in table 1. Age of participants ranged from 18 to 31 years (M = 19.98; SD = 1.57). Age of the men (M = 20.04, SD = 1.68) and the women (19.95, SD = 1.55) did not differ. The sample included 162 of male students (32.9%) and 330 of female students (67.1%).

Tab. 1 Division of participants according to the faculties

	Frequency	Percent
Faculty of Physical Education and Sports, CU	91	18.5
Faculty of Education, CU	46	9.3
Faculty of Arts, CU	147	29.9
Faculty of Management, CU	59	12.0
University of Economics	39	7.9
Faculty of Social and Economic Sciences, CU	14	2.8
Faculty of Psychology, PEU	50	10.2
Faculty of Architecture, SUT	46	9.3
Total	492	100

CU- Comenius University, PEU- Paneuropean University, SUT- Slovak University of Technology

2.2 Methods of data collection

2.2.1 Torrance Test of Creative Thinking

The level of creativity was measured by the Slovak adaptation of the subtest Incomplete Figure Test from Torrance Test of Creative Thinking [2]. The task is to finish 10 submitted figures in 10 minutes. Creative production is evaluated by four aspects; higher score indicates increased aspect of creative production:

a) Fluency- number of completed pictures in all tasks (theoretical range: 0-10 points);
b) Flexibility- change of directedness of thought or the number of content categories in which it was possible to classify the different responses of participants (theoretical range: 0- 9 points);
c) Originality- frequency of drawing compared to the reference group: answers with frequency above 5% gained 0 points, answers with frequency less than 1% gained 3 points (theoretical range: 0- 30 points);
d) indicators of creative power: emotions and feelings expression, expressivity of name of the drawing, illustration of movement, unusual perspective, inner visualization, abstraction, humour, fantasy, boundary crossing (theoretical range: 0-10 points).

2.2.2 Child and Youth Resilience Measure CYRM-28

The level of resilience was determined by the questionnaire Child and Youth Resilience Measure CYRM-28 [11] that considers common as well as specific aspects of resilience across different cultures. 28 items are scored on a 5-point scale from 1 = "does not describe me at all" to 5 = "describes me a lot". Shortened 28- item version measures resilience in three dimensions [11]:

a) Individual capacities (theoretical range: 11-55 points) - three sub-dimensions: personal skills, peer support, social skills;
b) Relationships with primary caregivers or relational resilience (theoretical range: 7-35 points) two sub-dimensions: physical and psychological caregiving;
c) Contextual factors (theoretical range: 10-50 points) - three sub-dimensions: spirituality, education, culture.

From primary data, three summary indices (individual capacities, relational resilience, contextual resilience) and overall resilience are computed. Higher score indicates increased presence of each dimension or overall resilience. Reliability index in the present study was high: $\alpha = .847$ for the whole questionnaire, $\alpha = .760$ for individual capacities, $\alpha = .810$ for relationship to caregiver and $\alpha = .693$ for contextual factors.

3. Results

3.1 Creativity

Distribution of fluency of the Torrance Test of Creative Thinking was apparently negatively skewed. The majority of participants (74.6%) finished all 10 submitted figures (Mdn = 9.69). The theoretical range of flexibility was consistent with the empirical range (0-9 points). Half of the participants scored between 7-9 points in this dimension. Originality of creative production was compared to the production of reference group [2] and participants gained 0-30 points (Mdn = 14.26). 366 participants gained from 1 to 10 points for indicators of creative power. 67% of these participants gained 1 or 2 points. Basic descriptive statistics are displayed in table 2.

Tab. 2 Descriptive statistics of the creative production

		1	*2*	*3*	*4*
Minimum		1.00	.00	.00	1.00
Maximum		10.00	9.00	30.00	10.00
Mode		10.00	8.00	14.00	1.00
Grouped median		9.69	7.16	14.26	1.88
Mean		9.31	6.87	14.48	2.38
Standard deviation		1.49	1.79	5.88	1.73
Skewness		-2.65	-.89	.09	1.68
Kurtosis		7.70	.63	-.15	3.04
Percentiles	25.	9.00	6.00	10.75	1.00
	50.	10.00	7.00	14.00	2.00
	75.	10.00	8.00	18.25	3.00

1 Fluency, 2 Flexibility, 3 Originality, 4 Creative power

Fluency strongly correlated with flexibility ($r_s = .51$, $p < .01$) and originality ($r_s = .41$, $p < .01$), and weakly with creative power ($r_s = .13$, $p < .05$). Flexibility positively correlated with originality ($r_s = .14$, $p < .01$) and negatively with creative power ($r_s = -.15$, $p < .01$). The relationship between originality and creative power was strong ($r_s = .54$, $p < .01$).

Creative production did not correlate with age ($r_s = -.04$ - $.08$, $p > .05$). Moreover, gender did not differentiate creativity. Men in the research group obtained higher scores in originality, but the difference was negligible as to the effect size (tab. 3).

Tab. 3 Gender differences of the creative production

	Men	*Women*	*p*	r_m
Fluency	9.66	9.70	.56	.03
Flexibility	6.86	7.30	.06	.08
Originality	15.21	13.88	.05	.09
Creative power	2.00	1.82	.22	.07

p - significance, r_m – correlation measure of effect size

3.2 Resilience

Among protective factors in resilience (e.g. participants expressed agreement with the item with the highest fifth degree on the scale) we include: ability to solve problems without using drugs and alcohol (75.9 %), family that supports participant in hard times (72.9%), parental control (60.2%), feeling of safety in the presence of family members (59.5%) and education (58.8%). On the other hand, 62.6 % of participants did not consider organized religious activities to be important and 34.2 % totally disagreed that spiritual belief is the source of their power.

Tab. 4 Descriptive statistics of the resilience

		1	*2*	*3*	*4*
Minimum		20.00	9.00	18.00	60.00
Maximum		55.00	35.00	49.00	134.00
Mode		48.00	30.00	31.00	109.00
Grouped median		44.66	28.64	33.42	106.57
Mean		43.95	27.64	33.99	105.69
SD		5.42	5.00	5.84	12.71
Skewness		-.83	-.91	.04	-.56
Kurtosis		.93	.49	-.21	.24
Percentiles	25.	41.00	30.00	25.00	98.00
	50.	45.00	33.00	29.00	106.00
	75.	48.00	38.00	31.00	115.00

1 Individual capacities, 2 Relationships with primary caregivers, 3 Contextual factors, 4 Overall resilience

From primary data, we calculated three summary indices: individual capacities (Mdn = 44.66), relationships with primary caregivers (Mdn = 28.64) and contextual factors (Mdn = 33.42). Descriptive statistics are displayed in table 4.

Tab. 5 Gender differences of the resilience

	Men	*Women*	*p*	r_m
Resilience	104.62	107.37	.08	.09
Individual capacities	43.80	45.00	.06	.09
Relationships with primary caregivers	27.64	29.12	.002	.14
Contextual factors	34.07	33.08	.04	.04

p- significance, r_m – correlation measure of effect size

We did not find any relationship between age of the participants and either overall resilience (r_s = .05, p >.05), or any of its dimensions (r_s = - .02 - .06, p >.05). Women scored higher in one dimension- relationships with primary caregivers- than men (p = .002, r_m = .14). The scores of women and men in CYRM-28 are displayed in table 5.

3.3 Relationship between creativity and resilience

Relationships between creativity and resilience were negligible or very weak. We found a weak negative relationship of flexibility to education (r_s = - .13, p <.01) and a weak positive relationship to spirituality (r_s = .10, p <.05). Creative power correlated with the overall resilience, contextual factors and education (r_s = .12, p <.05). The values of correlation coefficients are presented in table 5.

Tab. 5 Correlation matrix between the resilience and the creative production

	Fluency	*Flexibility*	*Originality*	*Creative power*
1	-.03	-.03	-.002	.09
2	.01	-.01	.02	.05
3	.03	-.05	.09	**.12***
4	-.02	-.006	.03	.08
5	-.02	-.02	-.01	.05
6	-.03	-.04	.008	.09
7	.04	.01	.01	.01
8	-.003	-.03	.07	.07
9	.03	-.05	**.101***	.01
10	-.06	**-.13****	.05	**.12***
11	.07	-.006	.05	.06
12	.05	-.02	.08	**.12***

1 - Individual capacities, 2 - Relationships with primary caregivers, 3 - Contextual factors, 4 - Personal skills, 5 - Peer support, 6 - Social skills, 7 - Physical caregiving, 8 - Psychological caregiving, 9 – Spirituality, 10 – Education, 11 – Culture, 12 – Overall resilience
* p< .05, ** p< .01

Further analysis concentrated on differences between groups of participants with very high and very low degree of resilience. Based on 25th and 75th percentile, we divided our participants into three categories. Then we compared the level of creativity in the extreme groups (tab. 6).

Tab. 6 Differences of the creative production in very low and very high resilient participants

	Resilience (Mdn)			
	Very low	*Very high*	*p*	r_m
Fluency	9.62	9.72	.32	.07
Flexibility	7.05	7.12	.64	.03
Originality	13.82	15.13	.29	.07
Creative power	1.81	2.26	.08	**.14**

p - significance, r_m – correlation measure of effect size

Participants with very high resilience scored higher in every dimension of the creativity test, but just in the case of creative power there was shown any noticeable correlation measure of effect size, though small (r_m = .14).

4. Discussion

Every day brings new challenges, possibilities, joys, but also problems whose solutions require learning of new behaviours, knowledge and skills. Problematic and difficult situations help us move forward and often allows us to express our creativity. The aim of our study was, therefore, to explore the relationship between creativity and resilience. The results of our research, however, showed that there is no relationship between the creative production of the participants and their resilience. Participants with very high overall resilience obtained higher scores in the dimension of creative power, suggesting that their drawings were enriched with an unusual perspective, emotional expression, humour, fantasy and abstract themes. The differences between the extreme groups were still very small. Similarly, partial results which showed a weak relationship between indicators of creativity and dimensions of resilience

(contextual factors, education, spirituality) do not allow us to conclude relationships between the variables. Thus, our findings do not provide empirical support for the model of creativity and resilience [3], which formed the theoretical basis of our research. Another Slovak research [9] does not provide empirical support either, even though, in this case, Urban test of creative thinking was applied. Moreover, another study was with the same result [8], although this focused on coping with difficult life situations (loss of home and property due to natural disasters).

We suppose that our findings could be the result of the research design, participant selection or choise of methods. We probably did not reveal the real creative potential of the university students. Therefore, in the future it would be more appropriate to use more tests of creativity (including verbal one) or questionnaires disclosing traits of the creative personality. Furthermore, authors of CYRM-28 [11] understand resilience as a dynamic process of coping with burden or adversity. The question thus remains whether the questionnaire is a suitable form for measuring the resilience of people who have neither survived a traumatic event nor been jeopardized. Our research focuses on young people in transition that is considered to be a stressful situation. Arrival at the university is associated with adaptation to new conditions, increased requirements and problem solving. Although all of these challenges could become a potential source of stress, this period may not be stressful for all first year students.

There are several qualitative studies exploring usage of creative activities in the therapeutic approach for people who have experienced trauma or a difficult life situation. Based on the therapeutic collaboration with people who survived the Holocaust [5] or with refugees and members of minority groups [12], the authors found a positive effect of creativity, mainly artistic activities, on coping with adversity. We see a challenge for future research of creativity in a preference for qualitative over quantitative approach, mainly because creativity is understood as an important source of creative solutions to problems and possibilities to cope with stress and long-term consequences of adverse situations.

Acknowledgements

VEGA no. 1/0392/11: Životný štýl, tvorivosť a reziliencia slovenských adolescentov v kontexte adlerovskej psychológie (Life style, creativity and resilience in Slovak adolescents in the context of Adlerian psychology).

References

[1] Piffer, D. (2012). Can creativity be measured? An attempt to clarify the notion of creativity and general directions for future research. *Thinking Skills and Creativity, 7*(3), 258–264.

[2] Jurčová, M., & Szobiová, E. (2008). *Torranceho figurálny test tvorivého myslenia – príručka*. Bratislava: Psychodiagnostika.

[3] Metzl, E.S., & Morrell, M.A. (2008). The Role of Creativity in Models of Resilience: Theoretical Exploration and Practical Applications. *Journal of Creativity in Mental Health, 3*(3), 303-318.

[4] Ungar, M. (2008). Resilience across Cultures. *Bristish Journal of Social Work Development, 38*(2), 218-235.

[5] Corley, C. (2010). Creative Expression and Resilience Among Holocaust Survivors. *Journal of Human Behavior in the Social Environment, 20*(4), 542-552.

[6] Haglund, M.E., Nestadt, P.S., Cooper, N.S., Southwick, S.M., & Charney. D.S. (2007). Psychobiological Mechanisms of Resilience : Relevance to Prevention and Treatment of Stress-related Psychopathology. *Development & Psychology, 19*(3), 889-920.

[7] Mennely, J., & Portillo, M. (2005). The Adaptable Mind in Design: Relating Personality, Cognitive Style, and Creative Performance. *Creativity Research Journal, 17*(2/3), 155-166.

[8] Metzl, E. S. (2009). The Role of Creative Thinking in Resilience After Hurricane Katrina. *Psychology of Aesthetics, Creativity, and the Arts, 3*(2), 112-123.

[9] Szobiová, E. (2011). Tvorivosť, vplyv rodiny a reziliencia adolescentov. In K. Bartošová, M. Čerňák, P. Humpolíček, M. Kukaňová, A. Slezáčková. (Eds.). *Sociálne procesy a osobnosť. Člověk na cestě životem: Křižovatky a mosty – sborník příspěvků* (pp. 316-323). Brno: Tribun EU.

[10] Greškovičová, K., Boleková, V., Szobiová, E. (2016). Relationship between personality traits and resilience in university students. *CER Comparative European Research 2016 – Proceedings* (pp. 178-181). London: Sciemcee Publishing.

[11] Ungar, M., & Liebenberg, L. (2016). *The Child and Youth Resilience Measure (CYRM) – 28.* Halifax, NS: Resilience Research Centre, Dalhousie University.

[12] Alayarian, A. (2007). Trauma, Resilience and Creativity: Examining Our Therapeutic Approach in Working with Refugees. *European Journal of Psychotherapy & Counselling, 9*(3), 313-324.

ART-PHILETIC PRINCIPLES IN THE CONTEXT OF HELPING PROFESSION

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Abstract: *Art-philetic includes arts and creative drama; it is methodically based on a psychodidactic use of two activities – expressive creation and a view of experience of the creative process. Art-philetic activities are based on art therapy and focus on an adequate personality development of children and adolescents with conduct disorders. Author points out the significant use of art-philetic principles in the context of helping profession of a social worker in the residence. Author also highlights the important role of art-philetic activities in institutional care. Expressive creation is also beneficial for the clients in terms of self-reflection. The paper emphasize the importance of the expressive creation in promoting self-awareness and developing ideas about oneself.*

Keywords: *Art-philetic, creative expression, art-philetic activities, adolescent, institutional care*

1. Introduction

Artistic creativity has a strong educational potential. Art-philetic provides space for clients in the residential to express themselves through both the actual creation and also a discussion. For clients to be enable to express themselves creatively in the art works, they must be tuned onto an idea and should also learn and know certain rules of how to use art medium (for example: tempera paints, brush, charcoal drawing, dry pastel).

Art-philetic principles are built on experience and allow the development of the emotional, social and creative personality of the individual pages. The main objective of art-philetic activities are: learn to express symbolically, and at the same time sensitively perceive surroundings and the world through artistic experiences based on own creative expression. Art-philetic encourages mental strength and prevents mental or social failure [1].

Art-philetic art activities can serve as a non-violent tool for building a healthy sense of self and social skills. In institutional care is among children and adolescents large personality differences, therefore social worker must invest in developing social skills of clients many energy and psychic force. Firstly, for troubled clients is need to create a solid foothold in their structure of personality. Secondly, the client in the institutional care must get a sense of what is and what is not acceptable in society.

1.1 The Objectives of art-philetic

The nature of artistic activities in art-philetic is determined by the state and mood of the client. Artistic expression is a natural reaction to experience, attitudes, values and emotional states. These artistic reactions are based on a highly personal. Art-philetic for individuals in institutional care is beneficial also for the reason that this artistic process lets us reflect on final work and supports self-discovery, develops thoughts about the self. Art-philetic provides an opportunity to discover own psychological possibilities and limits. Art-philetic through own artistic experimentation and experience allows client to authentic knowledge and understanding the culture of the community.

The aim of the art-philetic is to encourage the client to dialogue, that is developing around the expression of creative expressions. Client in creative activities discovers his motivation to thinking and cognition. Another aim of the art-philetic in the field of education is to teach the client to symbolically express and sensitively perceive the world through a strong spontaneously artistic experience that coming out of own creative process (see Tab. 1).

Table 1 The objectives of the art-philetic

	The objectives of the art-philetic	
Development Spatial orientation; Haptic and visual perception; Social and communication competency	**Support:** Relaxation; Concentration and attention; Autonomy and an initiative; Healthy self-assessment and self-esteem	**Other objectives** Prevention of social and psychological disorders; Reduce stress and frustration

1.2 Individual in institutional care

The individual in institutional care has to face various types of mental burdens whether they are exams in the school, stressful moments or conflicts in themselves or in relations with family and people around. Among mentions about personality problems are considered these factors membership in gangs, alienation from family, drug addiction, alcoholism, drug dealing, tendencies towards violent behavior, low IQ or mental disorders, etc. [2]. Client in institutional up-bringing is suffering from reduced psychological resistance and prone to depressions. The aim of the educational personnel and social worker is to expand social competence of these individuals and build in them a strong moral support that would have contributed to the mental wellbeing of children and adolescents with conduct disorder.

Art-philetic principles and art therapy techniques teaches clients perceive, artistically capture their inner experiences and mental states which helps to reveal their inner confusion and disorientation. Art-philetic art activities

have prevention, intervention and integration character through them is developed positive thinking, support self-esteem and self-confidence, the reduction of cultural and social differences, development of the ability and deepening of interpersonal relationships.

2. Expressive creation and reflection in art-philetic

Expressive creation in art-philetic means an artistic activity in which client emotional states are expressed through movement, artistic tools and sound, also singing. This allows an client to authentically project his experience in the creative and artistic way onto an art work. In expressive artifact there are three elements: expression (attention devoted to the artistic process), communication (sharing client's experience in creative expression), art form (variations of works and art technique). Creative expression in art-philetic is used to release and develop the productive potential of the client and encourages him to self-discovery. Expressive creation is an expression of the author's relationship to the visible representation of reality where are the extensive psychological processes and experiences. Reflection in art-philetic runs over the final artistic product and provides clients insight into the problem and a preview of own personality (see Tab. 2).

Table 2 The expressive creation and reflection in art-philetic

	Expression creation	***Reflection***
Psychic objective	Spontaneous expression	Knowledge
Experiential function	Aesthetic	Theoretical
Mental activity	Feeling Intuition	Discourse Thinking

3. The personality of a social worker in art-philetic

A social worker who will hear the children and young people with behavioural disorders, who can advise in an acceptable manner and direct them to such a lifestyle, which gives their life meaning – only such a social worker is able to adequately evoke the creative atmosphere and creative motivation in art-philetic. Social worker has to be the one who teaches problematic individuals to appreciate yourself. Social worker is person who teaches clients to resist the various forms of addiction and self-destruction through art and artistic activities [3]. The behavior of a social worker during the art-philetic activities – respects the client's communication and his artistic openness, respects the personality of the individual and the authentic experience of artistic creation, appreciates the work and the creative process (because each client's personality is unique and unique is its creative manifestation and experiences), no emphasis on the aesthetic aspect of artifact (attention is given to the process of developing the art work and the method of reflection), adequately motivates the client to artistic creation and encourages him to interview. Social worker in art-philetic activities should choose proper words and questions, because a crucial mistake to look down on the clients in institutional care and talk extremely correctly during the motivation. As well as that, it is necessary to organize the art-philetic activity and adapt the enviroment in a way that the clients will feel relaxed during their artistic creativity. Motivation in art-philetic activity not only for artistic process but also for finding client's own identity through creative activity is not supposed to be an effort for a perfect and beautiful art result, but also a tool for understanding individuals in institutional care.

4. Preparing for art-philetic situation

Concept of preparation for the art-philetic situation is very important and should be created based on the following phases:

1. Topic – is the core of the expressive creation and also happens to be a motivating tool between the social worker and the client. Interesting topic creates experiences that call for art action and encourages the client to the creative process;
2. Art task – defines the method of working with the theme. In the field of expressive forms must art task also include information about the art form and the artistic technique;
3. Motivation – the aim of the motivation in art-philetic is to bring clients to a separate search of art themes. Appropriate motivation may induce and maintain the interest of the client about learning, about the subject and about a certain learning activity [4]. It is necessary to create such conditions that they become a source of motivation. Not only a friendly and artistic atmosphere but also the title of the art task will become a motivation. A relaxation exercise before art task is usually beneficial and helps one to calm down and think about one's feelings and thoughts. Client should understand motivation and art task as a relaxing creativity activity. It is also supposed to detract from destructive tendencies and play a significant role in overcoming mental problems [5];
4. Realization – creative process should not be a methodical, but it should contain the elements experimentation and curiosity;
5. Reflective dialogue – discursive endings of art-philetic the situation that is discussed above the artifact. Reflective dialogue with the client allows experiencing appreciation and acceptance of criticism through reviews of the art work in the group, and it develops a communication and tolerance in clients.

4.1 Sample case situation

1. Topic/Title of an art action in art-philetic situation: "The power of the moment"
   The relationship between content and form:
   a) The plane of the imagination and thinking – the ability to think about feelings, the development of self-knowledge, the desire for finding creative personality;
   b) The plane of the principles of expressive creation – personal artistic expression, capture impressions, open artistic expression, free creative process;
2. Art task – Action painting

The plane of knowledge and activity: the creation and life of the artist J. Pollock, the importance of the symbolism of colours, the use of non-traditional art methods (for example: painting hands, splashing, experimentation with colour).
Resources for creating – papers of various sizes, paints, water, brushes, sponges, work wear, adhesive tape;

3. Motivation – motivation during the relaxing moments (before entering to the art action), dialogue between social worker and client;
4. Realization – 1. The client works separately on own creation, experimenting and recognizing the possibilities of artistic tools for action painting. Client examines the coloured changes and his individual painting manifestation (see Fig. 1 and Fig. 2), social worker emphasis on the psychological balance of the client and also on relax during the creation. 2. Collective work – a common artistic creation, work in a team and the perception of creative situation (see Fig. 3);
5. Reflective dialogue – examples of input questions or stimuli to the dialogue of type: "Look at your art work and tell me what do you see?", "What is it?", "Search association and similarities in various artistic works". Clients should be taught a cultivated speech and name the different symbols in their art works.

Figure 1: Expressive creation

Figure 2: Action painting

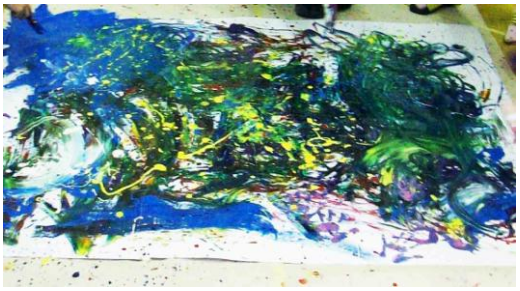

Figure 3: Collective art work

5. Conclusions

The aim of art-philetic is to train and positive shaping of individuals with conduct disorder in the institucional care. Art-philetic activities to work not only with artistic expression and reflection of the clients, but also with mental activity, such as intuition and feeling. Psychic objective of art-philetic activities is feeling and artistic experiencing. Art-philetic therefore fulfils the function of a sensory experience, the client perceives the aesthetically and emotions are expressed through symbols and artistic expression. Art-philetic contains relaxing activities, for example was mentioned a case study where the clients achieved muscular and mental release through creative activity. For clients in institutional care is the necessity to develop and consolidate the internal structure of their personality (self-concept, self-esteem) and subsequently to teach clients the group skills (tolerantion, cooperation). Art-philetic in institucional care is important for the development of client's personality, it contributes to a better self-image and give one some kind of new internal energy. The expression creation that is evident in a client's artifact is unique and also predicates some kind of power of expression and artistic spontanoues. Art works of expressive creations reveal throught its contents, art form and expression. After art-philetic activity a discursive finish-off should be done.

References

[1] Slavík J., *The Art of Experience, The experience of Art I.: theory and practice of Art-Philetic*, Prague, Charles University, 2001, pp. 13-14.
[2] Ondicová M., The Youth Crime in the context Slovak Republic. In *Criminology – Current issues*, Prague, Police Academy of the Czech Republic in Prague, 2013, pp. 214.
[3] Jedlička R., *The children and young people in difficult life situations: new perspectives on the issue of life crises, deviation, and the role of the helping professions*, Prague, Themis, 2004, pp. 323.
[4] Lokša J. and Lokšová I., *The attention, motivation, relaxation and creativity of children in school: theoretical background and practical procedures, games and exercises*, Praha, Portál, 1999, pp. 9.
[5] Campbell J., *The Art therapy techniques in education, social work and clinical practice: group art-therapeutic activities for children and adults*, Prague, Portál, 2002, pp. 13.

BILINGUALISM AS AN EFFICIENT WAY OF TEACHING CHILDREN

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Abstract: *Opportunity for being bilingual is one of the most noticeable social changes in the last two decades. Nowadays, it is generally believed that more than half of the world's population is bilingual. Weir (2000) asserts, one in three of the world's population routinely uses two or more languages for work, family life, and leisure. It has never been easier for people to encounter and learn new languages, in schools, through professional contacts, on the Internet, through music, arts and other forms of entertainment, and in everyday social interaction. Being bilingual has also given life experiences. What is more, bilingual students have higher level in ability to learn new words easily, spotting rhymes and other associations between words, ability to use possessed information in new way, word categorization, coming up with solutions to problems, good listening skills, improved communication skills.*

Keywords: *bilingualism, teaching, children, language, culture*

1. Introduction

Bilingualism is a term that has many definitions, which fluctuate also in research – depending on the study, different groups of individuals might be considered bilingual. In the most common sense, bilingualism refers to a situation when a child grows up and is confronted with two distinct languages [1]. According to Edwards (2006), everyone is bilingual; that is, there is no one in the world who does not know at least a few words in languages other than the maternal variety [2].

1.1 Bilingualism

Traditionally, bilingualism has been loosely defined as the ability to speak and understand two or more languages. Today's more complex world requires a more exact definition and analysis of the competencies needed by any given speech community when its members interact with speakers of another language. According to Baker, bilingualism is not simply the ability to speak two languages but also must include the components of written expression. Most recent research into bilingualism focuses on oracy and literacy—the four basic abilities of listening, speaking, reading, and writing. Cummins (2000) develops the concept of a cognitive competency, the ability to reason and think, as a fifth ability factor in bilingualism[3].

1.2 Opportunities of being bilingual

Researches have shown that the brains of children who grew up speaking two different languages develop better cognitive functions. Scientists who examined the phenomenon gave it a specific name, the bilingual advantage[4].

Bilingualism provides the opportunity to experience two or more cultures more directly, to participate and become involved in the core of a culture, and to appreciate the different systems of behaviour, rituals, religious traditions, beliefs and values, histories, and literatures. Those who became bilingual by moving to a new linguistic and cultural environment such as immigrants, refugees, educational and professional transients, have an opportunity to reflect on their linguistic and cultural heritage and, as many of such bilinguals claim, discover and develop new identities[5].

Strazny (2005) points out, bilingual speakers have one dominant language; that is, they are more proficient in the processing aspects of one language over the other. In most cases, the dominant language is the native or the first language spoken. However, balanced bilinguals can be equally proficient in both languages[6].

Bilingualism brings opportunities not only to the individual but also to the society as a whole. In today's world, the economic strength of a nation on the world market is not associated with how many monolingual speakers it may have but how many bi- and multi-linguals it has. The number of bi- and multi- lingual speakers a country produces is often seen as an indicator of the educational standard, economic competitiveness and cultural vibrancy of the country[7].

What is more, bilingualism offers the society a bridge-building potential, bridges be- tween different groups within the nation, bridges with groups beyond the artificial borders of a nation, and bridges for cross-fertilization between cultures. Bilingualism also prompts the society to rethink about the relationship be- tween unity and diversity, to come round for the idea of peaceful co-existence between different linguistic and cultural groups and to observe the rights and obligations of each other. It has been shown that tolerance and co-operation be- tween groups is possible only when linguistic diversity is respected[8]. There is now a wide-spread realization that bilingualism is the norm for both the individual and society. Moreover, bilingualism in turn brings new opportunities to both the individual and society. For the bilingual individual, the ownership of two languages has increasingly become seen as an asset as the 'communication world' gets smaller. With the dramatically increased amount of information available, and the ease of delivering it around the world, bilinguals may have become more important in the employment market. These days, bilinguals are highly useful in the competitive international trade [9].

Several studies have suggested that bilinguals show certain advantages when it comes to social understanding. In some ways, this is not surprising, as bilinguals must navigate a complex social world where different people have different language knowledge. For example, bilingual preschoolers seem to have somewhat better skills than monolinguals in understanding others' perspectives, thoughts, desires, and intentions [10]. Young bilingual children also have enhanced sensitivity to certain features of communication such as tone of voice[11].

To sum up, "bilinguals do sometimes have an advantage in inhibition, but they also have an advantage in selection; bilinguals do sometimes have an advantage in switching, but they also have an advantage in sustaining attention; and bilinguals do sometimes have an advantage in working memory, but they also have an advantage in representation and retrieval. Together, this pattern sounds like "mental flexibility", the ability to adapt to ongoing changes and process information efficiently and adaptively"[12].

1.3 Qualified teachers

Currently, at the various stages of teacher preparation, certification, and evaluation, there is insufficient information on what teachers should know about teaching A multisubject elementary school teacher candidate, for example, may be required to take courses in child development, English language arts, math, science, social studies, art, behavior management, and assessment, but not in the pedagogy of teaching. Without specific required coursework relating to the unique learning needs, teachers will not be able to teach these students adequately. Additionally, completion of the state approved teacher-preparation program must often be accompanied by a passing score on the state teacher exam. Often, these exams do not specifically assess for teacher knowledge or skills relevant to teaching[13].

Research has suggested that successful teachers of bilingual learners need knowledge of the students, the content, the language, and effective practices. They also must understand and have experienced second language learning and have positive attitudes toward bilingual learners [14]. Well prepared teachers need to demonstrate knowledge of the language of instruction to levels consistent with the demands of the literacy and content standards. They need to be prepared to support students when analyzing and producing texts of increasing cognitive and linguistic demand. They need to use the language of the content areas to support historical, mathematical, or scientific conversations, as well as understand and produce texts in these content areas[15].

Teachers must have a working knowledge of academic language and of the particular type of language used for instruction as well as for the cognitively demanding tasks typically found in textbooks, classrooms, assessments, and those necessary for engagement in discipline-specific areas. Recognizing the differences between conversational language and academic language is crucial in that conversational language proficiency is fundamentally different from academic language proficiency, a reality that poses cognitive and linguistic challenges. Classroom teachers must be prepared to teach and have an understanding of the linguistic demands of academic tasks and skills to address the role of academic language in their instruction[16].

These teachers speak a foreign language and use different methods to get students to use that same language[17].

Teachers must have a working knowledge and understanding of language as a system and of the role of the components of language and speech, specifically sounds, grammar, meaning, coherence, communicative strategies, and social conventions. Teachers must be able to draw explicit attention to the type of language and its use in classroom settings, which is essential to first and second language learning. The recognition of language variation and dialectical differences and how these relate to learning is also necessary. Teachers must have a working knowledge and understanding of the role of culture in language development and academic achievement. Cultural differences often affect students' classroom participation and performance in several ways [18].

1.4 Bilingual programming

The main purpose of the bilingual program is to teach English as soon as possible and integrate the children into the mainstream of education;" or to place emphasis on cultural goals: "The main purpose of the program should be to maintain the native language and culture while the children learn English." By placing emphasis on the linguistic and cultural side of bilingual education, confusion and controversy often arise. Although transition to the mainstream and maintenance of the native culture are both important, neither should be the central theme of the bilingual program. A bilingual program with a transitional linguistic and cultural goal is one that uses the native language and culture of the student only to the extent necessary for the child to acquire English and thus function in the regular school curriculum. This program does not stress the child's native language (L1) and thus, does not teach the student to read or write in the native language[19].

Bilingual education programs are in fact more expensive than English language only programs. However, does the cost of running such programs outway the benefit they provide? Bilingual education appears to be the most effective way to teach students whose dominant, or native, language isn't English. The only other alternative to bilingual education is immersion–and studies have shown that immersion isn't cheap either. When students are taught math, science, history and other skills in a language they don't understand, content learning is completely lost and little meaningful progress is made[20].

1.5 Difficulties of bilingual education

Although they often have smaller vocabularies in each language than their monolingual peers, initial vocabulary size differences are not detrimental to academic achievement[21]. However, since words of the unwanted language compete with those of the intended

language, lexical selection for bilinguals is a more demanding process than for monolinguals. The lexicons of both languages are activated in bilingual production at all stages of the production process, even when speakers are in monolingual model [22]. As a result, retrieval of words is slower in bilinguals of all ages than in monolinguals.

2. Conclusions

Being bilingual, student will find it easier to pick up new languages once they're adult. All in all, bilingualism is something that will help them to lead richer lives and develop understanding towards different cultures[23]. Bilingual education that is high quality and that promotes full development of two languages goes beyond just leveraging the native language of students in service of better English. Finally, bilingual schooling prepares individuals to function in a global society, which has become a cornerstone of education in the twenty first century[24].

References

[1] http://www.omniglot.com/language/articles/bilingualadvantages.html
[2] Edwards, J., Foundations of bilingualism. In T. K. Bhatia , W. C. Ritchie (Eds.), *The handbook of bilingualism*, 2006, pp. 7-31, Oxford: Blackwell.
[3] Easthouse, Linda Orr, Becoming bilingual is a way of life, pp. 1-9, Proceedings of Conference on language development, language revitalization and multilingual education in minority communities in Asia, 6-8 November 2003, Bangkok, Thailand.
[4]http://www.omniglot.com/language/articles/bilingualadvantages.html
[5] Housen, A., Dewaele, J., Li, W, *Opportunities and Challenges of Bilingualism.* Berlin, 2002, pp. 3.
[6] Strazny, P., Encyclopedia of linguistics (Vol. 1). New York: Taylor, Francis Group, 2005.
[7] Housen, A., Dewaele, J., Wei, L., *Opportunities and Challenges of Bilingualism.* Berlin, 2002, pp. 3.
[8] Auer, P.,Wei, L., *Handbook of Multilingualism and Multilingual Communication,* 2007, p.12.
[9] Housen, A., Dewaele, J., Wei, L., *Opportunities and Challenges of Bilingualism.* Berlin, 2002, pp. 3.
[10] Krista Byers-Heinlein, Casey Lew-Williams Bilingualism in the Early Years: What the Science Says, Concordia University, *Learning Landscapes*, Vol. 7, No. 1, Autumn 2013, 95-112.
[11] http://files.eric.ed.gov/
[12] Bialystok, E., Fergus I.M. Craik., Luk, G., Bilingualism: Consequences for Mind and Brain, *Trends Cogn Sci*. 2012 Apr; 16(4): 240–250.
[13] Lucas, T., Villegas, A. M. A framework for preparing linguistically responsive teachers. In T. Lucas (Ed.), Teacher preparation for linguistically diverse classrooms: A resource for teacher educators, New York, NY: Routledge. 2011, pp. 55-72.
[14] Brisk, M. E., Proctor, C. P., *Challenges and Supports for English Language Learners in Bilingual Programs*, Stanford University, pp. 6.
[15] http://ell.stanford.edu/sites/default/files/pdf/academic-papers/
[16] http://files.eric.ed.gov/
[17] http://www.topeducationdegrees.org/faq/what-teaching-jobs-are-in-bilingual-education/
[18] http://files.eric.ed.gov/
[19] http://www.ascd.org/publications/curriculum_handbook/413/chapters/Bilingual_Education@_Effective_Programming_for_Language-Minority_Students.aspx
[20] http://www.educationcorner.com/k12-bilingual-education.html
[21] Sorace, A., Cognitive advantages in bilingualism: Is there a "bilingual paradox"? In P. Valore (ed.)*Multilingualism. Language, Power, and Knowledge*, 2011, pp. 335-358. Pisa: Edistudio.
[22] Grosjean, F., Studying bilinguals: methodological and conceptual issues. *Bilingualism: Language and Cognition* 1, 1998, 131-149.
[23] http://www.omniglot.com/language/articles/bilingualdvantages.html
[24] Brisk, M. E., Proctor, C. P., *Challenges and Supports for English Language Learners in Bilingual Programs*, Stanford University, pp. 6.

FURTHER VALIDATION OF SINGLE-ITEM SELF-REPORT MEASURE OF SATISFACTION WITH LIFE

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Abstract: *Valid, reliable and easily applied measures of well-being are essential in large surveys concerning public health, education and psychology. General satisfaction with life is often measured in such surveys. Previous studies showed that single-item self-report measure of satisfaction with life could be sufficient in terms of validity and reliability in certain research contexts. To provide more data on its psychometric properties convergent validity with Satisfaction With Life Scale (SWLS)(Diener et al., 1985) was investigated. Furthermore, correlation pattern of both measures with criterion variables was investigated. A total of 195 students took part in the study. When correction for attenuation was included, correlation between single-item measure of satisfaction with life and SWLS was .68. Correlations of both measures with criterion variables, including sex, well-being indicators and personality, did not differ significantly statistically. Issues related to convergent and divergent validity of single-item satisfaction with life measure are discussed.. Due to its convenience of use compared to multi-item scales, the use of single-item self-report measure in large surveys in which many other variables have to be measured should be considered. Nevertheless, future studies on large samples should provide more data on convergent validity as well as in relation to other facets of validity, such as predictive validity.*

Keywords: *life satisfaction, single-item measure, validity*

1. Introduction

In the recent years, a lot of effort has been put into investigating the factors influencing life satisfaction. The concept is closely related to happiness and has great impact on all spheres of life, especially health, education, work, family and community [1]. Analyses in that area contribute to finding an answer to the question of what determines the sense of living a satisfying life within the context of research on well-being and happiness through searching for its predictors. Measurement issues are crucial to capture the usefulness of different indicators of the satisfaction with life. Satisfaction with life has been defined as a "global evaluation by the person of the quality of his or her life"[2] and is conceptualized as the evaluative component of well-being [3]. Researchers often take it into account as the main component of mental health or adjustment conceptions [4].

Satisfaction with life functions both as dependent variable and predictor in different research contexts. Stress has a significant impact on perceptions of satisfaction with life [5]. Perceived stress was found to be a better predictor of life satisfaction for younger adults than for middle aged and older adults [6]. Life satisfaction in college students is adversely influenced by college stress [7]. Overall life satisfaction was found to be positively associated to seeking social support and problem-focused coping [8]. What is more satisfaction with life has been shown to be related to measures of mental health and to be predictive of future behaviors such as suicide attempts [9].

Multiple researches show that there are significant relationships between personality traits and satisfaction with life. Previous study showed that Big Five personality traits predispose people to experiencing stable levels of subjective well-being [10]. Personality dispositions such as neuroticism and extraversion can markedly influence levels of subjective well-being [11]. Students (5th–7th graders') who reported high level of satisfaction with life tended to rate themselves higher on measures of extraversion and lower on measures of neuroticism and anxiety. Neuroticism and extraversion are strong predictors of life satisfaction [12]. However, the results also suggest that conscientiousness is an additional dimension of personality relevant to understanding subjective well-being [13]. Depression significantly affects levels of satisfaction with life. There is also substantial amount of research concerning the negative relationship of loneliness and lack of social support with life satisfaction [14]. Satisfaction with family life was more strongly associated with high level of overall satisfaction with life than satisfaction with friends [15]. What is more, studies consistently show more proclivity of women towards rumination and depressiveness than men [16].

Initial study on a single-item self-report measure of satisfaction with life provided data supporting its validity and reliability. It should be noted that even though obtained reliability was very good, the reliability coefficients measured with simple test-retest measures underestimate reliability of single-item tools [17].

There are several measures of emotional and cognitive aspects of well-being, with those focused on cognitive sphere conceived as satisfaction with life measures [18]. There are both multi-item and single item measures of satisfaction with life. One of the most commonly used multi-item methods to assess satisfaction with life is *Satisfaction with Life Scale* [19]. It showed very good psychometric properties in different samples [20].

2. Single-item scales

Single-item scales are considered reliable and valid tools in certain research contexts, and they seem especially practical in large surveys which measure many variables [21][22][23]. In some situations they can be even more

adequate than multi-item measures [24] as they are less time-consuming and reduce the monotony of long surveys. To use these measures properly and to minimize the possible errors, recommendations for the application of single-item scales are being constantly developed [25]. Nonetheless, despite all the benefits, it is important to emphasise that the use of single-item measures is not always advisable. Some situations require multidimensional assessment which can only be reliable by applying a multi-item method. One of the reasons that make single-item measures useful tools applicable in statistical testing of complex models, is the fact that analysis of Likert response format data at the item level is statistically robust [26]. Nevertheless, in cases in which single-item measures are used it is recommended to use more stringent alpha level in order to make cautious statistical decisions.

On the basis of previous theoretical frameworks and empirical research into life satisfaction, the aims of the current study were to: (1) assess convergent validity of single-item life satisfaction scale with SWLS; (2) compare correlation pattern of single-item life satisfaction scale and SWLS with measures of perceived stress, depressiveness, anxiety, loneliness, and Big Five personality traits. It is expected to obtain similar strong correlations with other measures of well-being, and somewhat weaker correlations with extraversion, neuroticism and conscientiousness, and gender.

3. Methods

Participants. A total of 195 students from different universities in Pomerania Region in Poland took part in the study, 85 men (43.6%) and 98 women (50.3%), 12 (6.2%) persons did not report gender, with mean age of 21.13 years (*SD* = 1.82). Students were from different faculties, courses of study, years and modes of study.

Measures. A self-report, single-item measure of life satisfaction was developed on the basis of item from *WHOQOL Brief scale* [27]. Originally used 5-point response scale has been modified to 9-point response scale, in compliance with recommendations to use at least 7-point Likert format response data when conducting statistical analyses on single item measures [26]. Life satisfaction was measured by question "How much do you enjoy your life?" with 9-point response scale, from 1 - "Not at all" to 9 – "An extreme amount". Initial studies provided data supporting its validity and reliability [21]. Other measures were widely used valid and reliable scales adapted in Poland. Satisfaction with life was measured with *Satisfaction With Life Scale* (SWLS), a 5-item, 7-point Likert response format scale with reliability of α = .81 in the present sample. Perceived stress was measured with *Perceived Stress Scale (PSS-4)*, a 4-item, 5-point Likert response format scale [28] (α = .75). Depressiveness and anxiety were measured by *Hospital Anxiety and Depression Scale*, which includes 14 items with 4-point response format, seven items for anxiety (α = .84) and seven for depression (α = .78) [29]. Loneliness was measured by *Short Loneliness Scale*, which includes three items with 3-point response format (α = .80) [30]. Personality was measured by *Ten Item Personality Inventory*, which includes 10 items with 7-point response format, two items for each Big Five personality trait. Reliability of each trait was examined in test-retest procedure in previous research [31]. Spearman-Brown reliability coefficients in this sample were .53 for extraversion, .17 for agreeableness, .63 for conscientiousness, .62 for emotional stability, and .39 for openness for experience.

Procedure. Data collection used convenience sampling. Students were invited to participate anonymously in the study during lectures or classes. More than 90% of all present students agreed to do so. Ninety one percent of participants filled in 'paper and pencil' questionnaires and nine percent of students completed online versions of the questionnaires. Participation in the study was anonymous and no monetary or other material rewards were offered to the participants.

Statistical analyses. Means, standard deviations, percentages and correlation coefficients were calculated. Differences between correlation coefficients where calculated using z statistic. All statistical analyses were conducted in IBM SPSS 24.

4. Results

Distribution of the results is presented in figure 1. The results are slightly negatively skewed but still to a large extent are close to a normal distribution. One-item life satisfaction scale (M = 5.80, SD = 2.01) and *SWLS* (M = 20.95, SD = 5.70) were moderately correlated, r = .57, p < .001. After correction for attenuation, using previously reported reliability coefficient for single-item measure obtained from a subsample (ICC = .87) [21] and Cronbach's alpha for SWLS measured in the present sample (α = .81), the correlation coefficient between measured constructs was r = .68. Both of them are also correlated similarly to the criterion variables, with conscientiousness showing largest difference, however, statistically non-significant Means, standard deviations and correlations of SWLS and single-item life satisfaction scale with studied variables are presented in table 1. Comparison of correlation coefficients of single-item measure and SWLS with criterion variables showed no statistical differences across all variables.

Figure 1. Distribution of the single-item life satisfaction scale results

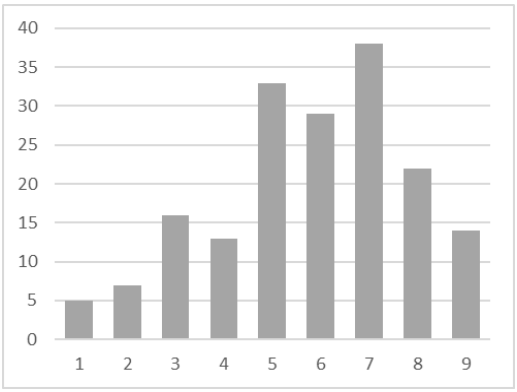

Table 1. Means, standard deviations and correlations of SWLS and one-item life satisfaction with perceived stress, depressiveness, anxiety, loneliness and Big Five personality traits

Scale	*M (SD)*/%	SWLS	single-item life satisfaction	*Z*
SWLS	20.95 (5.70)	-	.57**	-
Single-item life satisfaction	5.80 (2.01)	-	-	-
Gender	50.3% women	–.26**	–.22**	0.38
Age	21.13 (1.82)	–.07	–.08	–0.14
Perceived stress	10.51 (3.02)	–.53**	–.50**	0.38
Depressiveness	14.28 (4.55)	–.54**	–.59**	–0.69
Anxiety	12.17 (3.97)	–.39**	–.39**	0.01
Loneliness	4.85 (1.76)	–.42**	–.42**	–0.07
Extraversion	9.32 (2.57)	.35**	.30**	–0.52
Agreeableness	9.36 (2.17)	.20**	.16**	–0.33
Conscientousness	8.94 (2.58)	.27**	.14	–1.29
Openness to experience	10.47 (2.13)	.15	.10	–0.48
Emotional Stability	8.01 (2.62)	.17*	.22**	0.47

Gender: 0 – women, 1 – men.
*$p < .05$; **$p < .01$.

5. Discussion

The obtained results showed some level of convergent validity between single-item measure of satisfaction with life and SWLS, however, it could be considered insufficient when taking into account more stringent recommendations [32]. To further examine the validity, correlation coefficients of both measures with criterion variables theoretically related to satisfaction with life were compared. The comparison showed no statistically significant differences and the relationships with most of the criterion variables were very similar for single-item measure and SWLS (in many cases being almost identical up to two decimal places). It should be noted that correlations of both measures with stress and depressiveness were very similar in magnitude to correlation between the two measures themselves, which raises divergent validity questions. The measures were related with the theoretical framework as predicted. Both were related positively with extraversion, conscientousness (single-item measure marginally non-significantly) and emotional stability. Also, both were related with sex (lower satisfaction among women), and negatively with perceived stress, depressiveness, anxiety, and loneliness.

Obtained results are good premises to continue research concerning the relationship between *SWLS* and single-item satisfaction with life measure. Main limitation of this study is a relatively small and homogenous sample of students. Another one is the cross-sectional data, and therefore the predictive validity of studied measures was not tested. Main strength of this study is the use of widely applied, valid, and reliable measures of criterion constructs. That choice facilitates interpretation of the results, as well as its replication. Future studies should further investigate convergent validity of single-item measure with other measures of satisfaction with life, as well as similarity of correlation patterns of *SWLS (and possibly other standard measures of life satisfaction)* and single-item life satisfaction measure, mainly how much of the explained variance of criterion variables is common for both of the life satisfaction measures and how much of it is unique for each measure. The future studies should also investigate validity of studied measure using different methods of measurement, such as observation or experience sampling methodology. There is also need for data on predictive validity of single-item measure.

The aim of this study was to provide empirical evidence of the psychometric properties of single-item life satisfaction scale. So far the obtained data suggest that single-item measure of satisfaction with life is a promising option for survey situations in which ultra-short scale to measure this construct is necessary.

Acknowledgements

Grant: Grant badawczy w ramach projektu młodych naukowców i uczestników studiów doktoranckich Uniwersytetu Gdańskiego. Number of grant: 538-7422-B121-13 in 2013 and 538-7422-B450-14 in 2014. On the basis of decision number DEC-2013/08/T/HS6/00403 the author (Paweł Andrzej Atroszko) received funds from National Science Centre Poland within doctoral scholarship for preparing PhD dissertation.

Grant: The publication was funded by a grant of the Faculty of Social Sciences of the University of Gdansk on the projects of young scientists and doctoral students in 2016 (Bartosz Atroszko). Grant No: 538-7300-B273-16.

References

[1] Peterson, C., Park, N., & Seligman, M. E., *Orientations to happiness and life satisfaction: The full life versus the empty life*. „Journal of happiness studies“, 6(1), pp. 25-41. 2005.

[2] Pavot, W. G., Diener, E., Colvin, C. R., Sandvik, E., *Further validation of the Satisfaction with Life Scale: Evidence for the cross-method convergence of well-being measures*, “Journal of Personality Assessment”, Vol. 57, No. 1, pp. 149-61, 1991.

[3] Andrews, F. M., Withey, S. B., *Social indicators of well-being: America's perception of life quality*, New York (USA), Plenum Press, 1976.

[4] Sells, S. B., *Ecology and the science of psychology*. [In:] Willems, E. P., Raush, H. L., (Eds.), „Naturalistic viewpoints in psychological research“, New York (USA), Holt, Rinehart and Winston, pp. 15-30, 1969.

[5] Caleb, T., Hayes, B., Weathington, L., *Optimism, Stress, Life Satisfaction, and Job Burnout in Restaurant Managers*, „The Journal of Psychology Interdisciplinary and Applied“, Vol. 141, Issue 6, 2007.

[6] Hamarat E., Thompson D., Zabrucky K. M., Steele D., Matheny K. B., Aysan F., *Perceived Stress and Coping Resource Availability as Predictors of Life Satisfaction in Young, Middle-Aged, and Older Adults*, „Experimental Aging Research“, Volume 27, 2001 - Issue 2, pp. 181-196.

[7] Weinstein, L.; Laverghetta, A., *College Student Stress and Satisfaction with Life*, „College Student Journal Mobile“ 43.4 (Dec 2009): pp. 1161-1162.

[8] Deniz, M. Engin, *The Relationships among Coping with Stress, Life Satisfaction, Decision-Making Styles and*

Decision Self-Esteem: an Investigation with Turkish University Students, „Social Behavior and Personality", Volume 34, Number 9, pp. 1161-1170(10), 2006.
[9] Pavot W., Diener E., *The Satisfaction With Life Scale and the emerging construct of life satisfaction*, „The Journal of Positive Psychology", Volume 3, Issue 2, pp. 137-152, 2008.
[10] Headey, B., Wearing, A., *Personality, life events, and subjective well-being: Toward a dynamic equilibrium model*, „Journal of Personality and Social Psychology", Vol 57(4), pp. 731-739,October 1989.
[11] Diener, E., Shigehiro O., and Lucas, R. E., *Personality, Culture, and Subjective Well-Being: Emotional and Cognitive Evaluations of Life*, "Annual Review of Psychology", Vol. 54, pp. 403-425, 2003.
[12] Schimmack, U., Shigehiro, O., Furr R. M., David C. Funder, *Personality and Life Satisfaction: A Facet-Level Analysis*, Personality and Social Psychology Bulletin, Vol 30, Issue 8, 2004.
[13] Kotov, R., Gamez, W., Schmidt, F., & Watson, D. *Linking "big" personality traits to anxiety, depressive, and substance use disorders: A meta-analysis*. (2010).
[14] Mellor, D., Stokes, M., Firth, L., Hayashi, Y., & Cummins, R. (2008). *Need for belonging, relationship satisfaction, loneliness, and life satisfaction*. „Personality and individual differences", 45(3), pp. 213-218, 2008.
[15] Huebner, E. Scott, *Correlates of life satisfaction in children*, „School Psychology Quarterly", Vol 6(2), pp. 103-111, 1991.
[16] Nolen-Hoeksema, S., Larson, J., & Grayson, C. (1999). *Explaining the gender difference in depressive symptoms*. „Journal of personality and social psychology", 77(5), 1061.
[17] Lucas, R. E., & Donnellan, M. B. (2012). *Estimating the reliability of single-item life satisfaction measures: Results from four national panel studies*. „Social Indicators Research", 105(3), 323-331.
[18] Lyubomirsky, S., & Lepper, H. S. (1999). *A measure of subjective happiness: Preliminary reliability and construct validation*. „Social indicators research", 46(2), 137-155.
[19] Diener, E. D., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). *The satisfaction with life scale*. „Journal of personality assessment", 49(1), 71-75.
[20] Pavot, W., & Diener, E. *Review of the satisfaction with life scale*. „Psychological assessment", 5(2), p. 164, 1993.
[21] Atroszko P., Krzyżaniak P., Sendal L., Atroszko B., *Validity and reliability of single-item self-report measures of meaning in life and satisfaction with life*. [in:] "Proceedings/Research Track of the 4th Biannual CER Comparative European Research Conference International Scientific Conference for Ph.D. students of EU countries, October 26-30, 2015", London: Sciemcee Publishing London. pp. 212-215.
[22] Atroszko P., Bagińska P., Mokosińska M., Atroszko B., *Validity and reliability of single-item self-report measures of general quality of life, general health and sleep quality*. [in:] "Proceedings/Research Track of the 4th Biannual CER Comparative European Research Conference International Scientific Conference for Ph.D. students of EU countries, October 26-30, 2015", London: Sciemcee Publishing London. pp. 207-211.
[23] Atroszko P., Pianka L., Raczyńska A., Atroszko B., *Validity and reliability of single-item self-report measures of social support*. [in] "Proceedings/Research Track of the 4th Biannual CER Comparative European Research Conference International Scientific Conference for Ph.D. students of EU countries, October 26-30, 2015" London: Sciemcee Publishing London. pp. 216-219.
[24] Gardner, D. G., Cummings, L. L., Dunham, R. B., & Pierce, J. L. (1998). *Single-item versus multiple-item measurement scales: An empirical comparison*. „Educational and Psychological Measurement", 58(6), 898-915.
[25] Cheung, F., & Lucas, R. E. (2014). *Assessing the validity of single-item life satisfaction measures: Results from three large samples*. „Quality of Life research", 23(10), 2809-2818.
[26] Carifio, J., and Perla, R. J., *Ten common misunderstandings, misconceptions, persistent myths and urban legends about Likert scales and Likert response formats and their antidotes*, „Journal of the Social Sciences", Vol. 3, No. 3, pp. 106–116, 2007.
[27] Skevington, S. M., Lotfy, M., O'Connell, K. A, The World Health Organization's WHO QUALITY OF LIFE-BREF quality of life assessment: psychometric properties and results of the international field trial. A report from the WHOQOL group, „Quality of Life Research", Vol. 13, No. 2, pp. 299-310, 2004.
[28] Cohen, S., Kamarck T., Mermelstein R., *A global measure of perceived stress*, „Journal of Health and Social Behavior", Vol. 24, No. 4, pp. 385–396, 1983.
[29] Zigmond, A. S., Snaith, R. P., *The Hospital Anxiety and Depression Scale*. „Acta Psychiatrica Scandinavica", Vol. 67, No. 6, pp. 361-370, 1983.
[30] Hughes, M. E., Waite, L. J., Hawkley, L. C., Cacioppo, J. T., *A Short Scale for Measuring Loneliness in Large Surveys: Results From Two Population-Based Studies*, „Research On Aging", Vol. 26, No. 6, 655-672, 2004.
[31] Gosling, S. D., Rentfrow, P. J., Swann, W. B. *A very brief measure of the Big-Five personality domains*. „Journal of Research in Personality", 37(6), pp. 504-528, 2003.
[32] Carlson, K., & Herdman, A., *Understanding the impact of convergent validity on research results*, „Organizational Research Methods", Vol.15, No. 1, pp. 17-32, 2012.

THE MOST IMPORTANT VALUES FOR PEDAGOGY AND SPECIAL EDUCATION STUDENTS

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Abstract: *There were two aims of this study. The first was to investigate what are the most important values for general education (pedagogy) students and special education students in terms of S. H. Schwartz Theory of Basic Human Values. The second aim of this study was to compare general education students and special education students in terms of their values. Two hypotheses were put forward: H1: Special education students are less often guided by the self-enhancement values than general education students. H2: Special education students are more often guided by self-transcendence values than general education students. Hypothesis 1 was partially confirmed. Special education students are less often guided by hedonism value. Although not significant (p = .103), the difference in power value is noticeable. Hypothesis 2 was not confirmed. There were no differences between studied groups in self-transcendence values. In both groups benevolence was the one valued the most, and power was valued the least.*

Keywords: *values, pedagogy students, vocational interests*

1. Introduction

The teaching profession, especially the special education teaching profession, is very demanding. People who work in this area take responsibility for the health and life of children, including their proper mental and social development. In Poland, the profession of teacher is a profession of public trust [1]. On the one hand, teachers spend a lot of time with their pupils (sometimes even more than the busy parents), but on the other, teachers' work (due to their specificity) is not and cannot be fully controlled by certain procedures. Parents must believe that they leave their children under the care of responsible people. The issue of trust is particularly important in the case of parents of children with disabilities who are helpless without the help of adults. It is important to emphasise that teachers should become people who not only have the formal qualifications to practice, but must also be trustworthy, ethical, and guided in life by appropriate values.

The current sociopolitical state of the Western world gives numberless opportunities for young people regarding their career choices. On the one hand it leads to new, broader life perspectives and growth, on the other can cause a sense of living in a very dynamic and unstable environment that is difficult to gain control over. One's life experience and inner representation of the world are a foundation for values they form [2].

Most people are not aware of the impact of their self-identity until they are about to make choices regarding self-development, family or career [3]. In order to make thoughtful decisions it is important to take that influence into account. Investigating the relation between people's values and their career choices leads to better understanding of fulfilling one's various needs.

Schein's theory of career anchors highlights the relation between a person's value system, needs, competence and the career of their choice. According to that theory, a career anchor is one's self-concept that consists of self-perceived talents and abilities, basic values and the evolved sense of motives and needs referring to the career. The concept evolves along with work and life experience, however, after it has been formed, it works as an anchor stabilizing the values and motives one will not give up to take a decision. E. H. Schein identified 8 categories of anchors: autonomy/independence, security/stability, technical-functional competence, general managerial competence, entrepreneurial creativity, service or dedication to a cause, pure challenge and lifestyle [3].

The Schwartz Value Theory describes values as trans-situational goals that vary in importance and function as a motivational guide in one's life. The ten distinguished values are culturally universal core principles: self-direction, stimulation, hedonism, achievement, power, security, conformity, tradition, benevolence and universalism. Moreover, the theory underlines the dynamic relations between them, e. g. some of the values oppose one another and cannot be retained by one person at the same time, whereas other are congruent [2].

L. Wils, T. Wils, and M. Tremblay [4] proposed a Circular Model of Career Anchor Structure that is a link between Schwartz's value concept and Schein's theory. Research shows that some motivational domains (self-transcendence, conservation, self-enhancement and openness to change) correspond directly to career anchors. Accordingly, they can be construed as values that guide career decisions. Moreover, in contrast to E. H. Schein, the authors state that, as some values are complimentary and other are conflictual, individuals can possess multiple dominant career anchors.

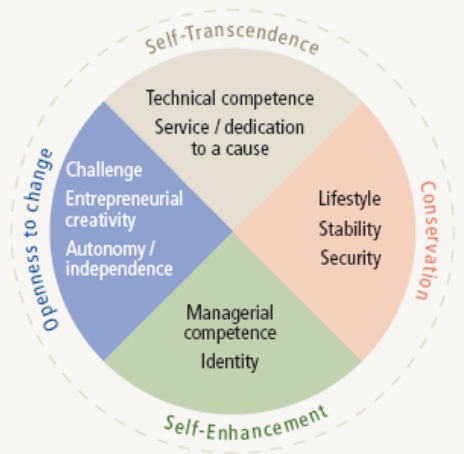

Figure 1. Circular model of Career Anchor Structure. Wils et al. 2010.

The main purpose of this research was to examine the differences pedagogy students' and special education students' values. In the context of values as career guides [5] it is important to analyse differences between regular teachers and special education teachers. In Poland, special education teacher is the least prestigious occupation associated with education [6]. Also, a risk of burnout is higher among special education teachers [7][8]. Existential hardness is one of the main problems associated with it. The engagement and effort put into the work does not always give satisfying results and the employees receive less gratification. Special education teachers are working in much less controllable conditions with less instruments of influence. Also, it is important to notice that they know and implement a variety of methods to meet the needs of students with disabilities. Giving the fact that it is a more resource-intensive occupation, with slightly higher earnings (in Poland maximum benefit is 20% [9]) it is crucial to identify the factors affecting students' decisions to choose special education instead of pedagogy.

2 Hypotheses

On the basis of previous theoretical framework and empirical research concerning special education teachers' difficulties it can be concluded that students are more prone to anticipate hardship related to that profession. Therefore, values and career anchors are different among pedagogy and special education students. Special education may not be interesting for students aiming for power, achievements, and hedonism. It is an occupation associated with emotional distress and less predictable outcomes than pedagogy. Thus, it is hypothesized that special education students are less often guided by the self-enhancement values than pedagogy students (H1). On the other hand, special education requires various competences and dedication to a cause that may not have any tangible outcomes. It is assumed that these anchors, related to values of universalism and benevolence, are important factors in choosing a special teacher occupation. Therefore, it is hypothesized, that special education students are more often guided by self-transcendence values than pedagogy students (H2). Another premise for these hypotheses is the sinusoidal nature of values described by Schwartz [10][11], and incongruence of self-transcendence values and self-enhancement values.

3. Methods

Participants. A total of 355 students took part in the study, 332 women (93.0%) and 17 men (4.8%), 8 persons (2.2%) did not report gender, with mean age of 22.17 years (*SD* = 4.63). Students were studying at the University of Gdańsk, at the Faculty of Social Sciences. 186 participants (52.4%) were pedagogy students and 169 (47.6%) were special education students. They were from different years and modes of study.

Measures. 10-item, self-report measures were developed on the basis of items from the *Short Schwartz's Value Survey* (*SSVS*). The scale of value consisted of the question: "Please, rate the importance of the following values as a life-guiding principle for you. Use the 8-point scale in which 0 indicates that the value is opposed to your principles, 1 indicates that the value is not important for you, 4 indicates that the value is important, and 8 indicates that the value is of supreme importance for you."

There were 10 values, divided into two dimensions:

A. Self-enhancement vs. self-transcendence
   1. Power (social power, authority, wealth)
   2. Achievement (success, capability, ambition, influence on people and events)
   3. Hedonism (gratification of desires, enjoyment in life, self-indulgence)
   4. Universalism (broad-mindedness, beauty of nature and arts, social justice, a world at peace, equality, wisdom, unity with nature, environmental protection)
   5. Benevolence (helpfulness, honesty, forgiveness, loyalty, responsibility)

B. Conservation vs. openness to change
   6. Tradition (respect for tradition, humbleness, accepting one's portion in life, devotion, modesty)
   7. Conformity (obedience, honoring parents and elders, self-discipline, politeness)
   8. Security (national security, family security, social order, cleanliness, reciprocation of favors).
   9. Stimulation (daring, a varied and challenging life, an exciting life)
   10. Self-Direction (creativity, freedom, curiosity, independence, choosing one's own goals)

Procedure. Data collection used opportunistic sampling. Students were invited to participate anonymously in the study during classes or lectures. More than 90% of all present students agreed to do so. All participants filled in 'paper and pencil' questionnaires. The study endured from December 2016 to January 2017.

Statistical analyses. Value scores have been centered in order to correct for individual differences in use of the response scale [12]. Each person's mean rating score was subtracted from his/her rating scores. Deviation scores are treated as corrected data. Student's *t* test was used to

compare two groups. All statistical analyses were conducted in IBM SPSS Statistics 24.0.

4. Results

4.1 Descriptive statistics

The most important value both for pedagogy students and special education students is benevolence (mean for all students M = 6,64). The second most important value is self-direction (M = 6,24). In third place were security (M = 6,04). On the following items were conformity (M = 5,65), achievement (M = 5,31), universalism (M = 5,23) and stimulation (M = 4,87). The least important values for students were hedonism (M = 4,81), tradition (M = 4,64) and power (M = 2,78) (Figure 1).

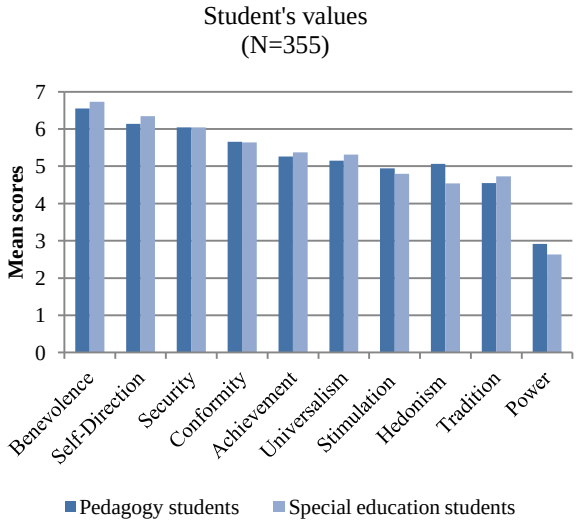

Figure 1. Student's values on Schwartz Value Survey. Arithmetic mean of the raw scores.

Value scores have been centered in order to correct for individual differences in use of the response scale are presented in Figure 2.

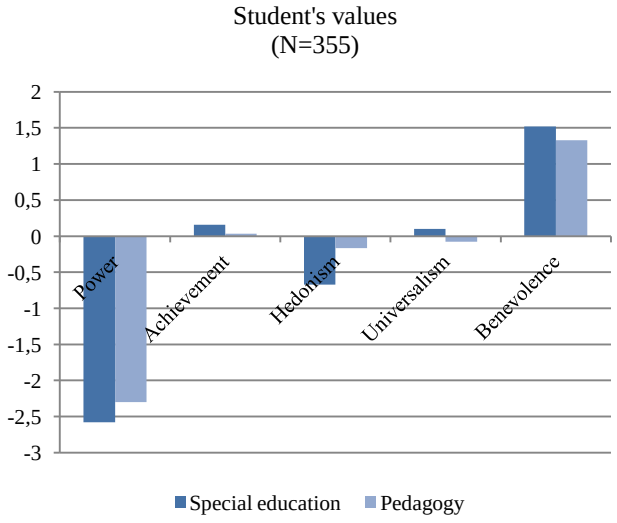

Figure 2. Students' values on Short Schwartz' Value Survey. The table shows the individual values relative to the mean of all values.

Power was positively related to achievement and hedonism. Universalism was positively related to benevolence. Power was negatively related to universalism and benevolence. Achievement was negatively related to universalism and benevolence. Hedonism was negatively related to universalism and benevolence. Pearson correlation coefficients, means and standard deviations are presented in Table 1.

Table 1: Means, standard deviations, and correlations (Pearson's r) of studied variables

	M (SD)	*2.*	*3*	*4*	*5*
Power	–2.43 (1.60)	.25**	.14**	–.32**	–.37**
Achievement	0.09 (1.37)		.01	–.29**	–.18**
Hedonism	–0.41 (1.58)			–.32**	–.36**
Universalism	0.01 (1.61)				.30**
Benevolence	1.42 (1.79)				

*p < .05, **p < .01

4.2 Group comparisons

There was no significant difference in power value between pedagogy students (M = –2.30; SD = 1.73) and students of special education (M = –2.58; SD = 1.42), t_{350} = 1.61, p = .103, d = 0.17. There was no significant difference in achievement value between pedagogy students (M = 0.04; SD = 1.31) and students of special education (M = 0.16; SD = 1.44), t_{349} = –0.85, p = .399, d = –0.09. There was a significant difference in hedonism value between pedagogy students (M = –0.17; SD = 1.48) and students of special education (M = –0.67; SD = 1.64), t_{351} = 3.04, p = .003, d = 0.32. There was no significant difference in the scores of universalism between pedagogy students (M = –0.08; SD = 1.63) and students of special education (M = 0.10; SD = 1.59), t_{350} = –1.03, p = .306, d = –0.11. There was no significant difference in the scores of benevolence between pedagogy students (M = 1.33; SD = 1.10) and students of special education (M = 1.52; SD = 1.26), t_{351} = –1.53, p = .128, d = –0.16 (Table 2).

Table 2: A comparison using the Student t-test group of students of general education and special education students in terms of their values

	Pedagogy students (n=186)		*Special education students (n=169)*		*t*	*p*	*d*
Variable	*M*	*SD*	*M*	*SD*			
Power	–2.30	1.73	–2.58	1.42	1.61	.103	0.17
Achievement	0.04	1.31	0.16	1.44	–0.85	.399	–0.09
Hedonism	–0.17	1.48	–0.67	1.64	3.04	.003	0.32
Universalism	–0.08	1.63	0.10	1.59	–1.03	.306	–0.11
Benevolence	1.33	1.10	1.52	1.26	–1.53	.128	–0.16

5. Conclusions

Hypothesis 1 was partially confirmed. Special education students are less often guided by hedonism value. Although not significant (p = .103), the difference in power value is noticeable. Hypothesis 2 was not confirmed. There were no differences between studied groups in self transcendence values. In both groups benevolence was the one valued the most, and power was

valued the least. This study shows that people who want to practice special education teaching profession have different values than people who want to be a teacher. On the basis of the study, it may be assumed that the profession of a special education teacher selects specific persons who are less concerned about their own sense of comfort and pleasure. This seems to be consistent with (postulated in pedagogy) ideal special education teacher as a supporter of others, with a sense of mission.

6. Discussion

Biggest strengths of this research are large sample and use of one of the most popular value theories, which make interpretation more efficient. Main limitations of this study are no direct measurement of career anchors, and cross-sectional data on non-representative sample. Future studies should include different measurement tools, providing quality data (such as interviews). Study was conducted among students, and many of them were at the beginning of their courses. Longitudinal data is important to examine how many of them is really going to work as special education teachers. Nevertheless, this study provided some evidence concerning differences between people educating themselves at these two courses. Two groups were mostly similar in value structure. Lower hedonism among special education students may be an effect of their different view on happiness. Differentiation of hedonic and eudaimonic well-being [13] may be useful in interpretation of these results. Subsequent studies should compare the group of students of special education and pedagogy with students from other fields. That comparison may show significant differences in terms of values.

Acknowledgements

The publication was funded by a grant of the Faculty of Social Sciences of the University of Gdansk on the projects of young scientists and doctoral students in 2016. Grant No: 538-7300-B273-16.

References

[1] Torczyńska, M., *Współczesny wizerunek zawodu nauczyciela w świetle badań opinii publicznej*. „Rozprawy Społeczne", 3 (VIII), pp. 41-47, 2014.

[2] Schwartz, S. H., *An overview of the Schwartz theory of basic values. Online readings in Psychology and Culture*, 2(1), 11, 2012.

[3] Schein, E. H., *Career anchors revisited: Implications for career development in the 21st century*, "The Academy of Management Executive", 10(4), pp. 80-88, 1996.

[4] Wils, L., Wils, T., & Tremblay, M., *Toward a career anchor structure: An empirical investigation of engineers*. "Relations industrielles/Industrial relations", pp. 236-256, 2010.

[5] Sagiv, L., *Vocational interests and basic values*. "Journal of Career Assessment", 10(2), pp. 233-257, 2002.

[6] Olszak, A., *Psychopedagogiczne kompetencje nauczycieli szkół specjalnych*. Wydawnictwo UMCS, Lublin 2001, p. 14.

[7] Platsidou, M., *Trait emotional intelligence of Greek special education teachers in relation to burnout and job satisfaction*, "School Psychology International", 31(1), pp. 60-76, 2010.

[8] Wisniewski, L., & Gargiulo, R. M., *Occupational stress and burnout among special educators: A review of the literature*, "The Journal of Special Education", 31(3), pp. 325-346, 1997.

[9] *Rozporządzenie Ministra Edukacji Narodowej i Sportu z dnia 31 stycznia 2005 r. w sprawie wysokości minimalnych stawek wynagrodzenia zasadniczego nauczycieli, ogólnych warunków przyznawania dodatków do wynagrodzenia zasadniczego oraz wynagradzania za pracę w dniu wolnym od pracy*, Dziennik Ustaw 2005, nr 22, pozycja 181, Internetowy System Aktów Prawnych, http://isap.sejm.gov.pl/DetailsServlet?id=WDU20050220181.

[10] Cieciuch, J., *Nadzieja jako moderator związku poczucia koherencji z preferencjami wartości*. „Sociologie", 47(4), pp. 929-968, 2006.

[11] Schwartz, S. H., *Basis Human Values: Theory, Measurement, and Applications*, "Revue française de sociologie", 47/4, 2006.

[12] Sagiv, L., & Schwartz, S. H. *Value priorities and subjective well-being: Direct relations and congruity effects*, "European Journal of Social Psychology", 30(2), pp. 177-198, 2000.

[13] Ryan, R. M., & Deci, E. L., *On happiness and human potentials: A review of research on hedonic and eudaimonic well-being*, "Annual review of psychology", 52(1), pp. 141-166, 2001.

PEDAGOGY STUDENTS' OPINIONS ON EDUCATION IN POLAND

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Abstract: *The aim of this article is to present the results of a survey on students' opinions about the Polish education system. The survey was conducted in December 2016 and January 2017. The questionnaire was filled by 443 students. The survey results indicate that have mostly negative opinions on Polish education. More than 80% of students agreed with the statements "Polish education system needs reform", "The way of teaching at school means that students often get bored during the classes" and "School is too often a source of excessive stress for students". More than 50% of students agreed with the following statements: "Knowledge which is taught at school is not very useful in adult life", "School is an institution which does not fit the modern world", "Students cannot express their point of view in class" and "Teachers do not develop their competences in a sufficient way". More than 50% of students disagreed with the statements "Polish education works well", "In Poland, the teaching profession enjoys social prestige" and "In a typical Polish school, young people receive a decent education". Less than 30% of students agreed with the statements "Students in Polish schools feel safe", "In a typical Polish school there is a good atmosphere", "Polish education is changing for the better, the changes are going in the right direction" and "School thoroughly prepares young people for life in adulthood".*

Keywords: *opinions about education, student's opinions*

1. Introduction

The study of human attitudes is important in terms of explaining and predicting the actions of individuals or social groups. They can be both dependent variables, when we try to explain their cause, and independent variables when they influence human behavior [1]. In the literature we can find different definitions of attitudes. The most popular and the most accurate from a psychological perspective seems to be the three-dimensional definition. It presents attitude toward the object as relatively stable beliefs and opinions (cognitive element), emotions and feelings (affective component) and the behavior and actions (behavioral component). It targets a particular object or phenomenon and is subjective. In this article we focus on beliefs, that are a part of the cognitive element of students' attitudes towards education system" [1].

Education is undergoing both top-down and bottom-up changes. An example of the first one may be the latest education reform which eliminated the existing middle schools and restored the eight-year elementary school, which caused various opinions of education representatives. Experience shows that such rapid changes made in such a short time are often badly socially perceived [2] [3] or withdrawn very quickly. Sudden decision about compulsory education for six-year-old children met with great parents' reluctance and was withdrawn a year later [4]. Not only primary schools are faced with such problems. The obligation to pay for the second course of study introduced in 2011 together with the amendment of the Law on Higher Education was abolished along with another amendment in 2015. These types of changes are stressful for people and undermine their trust in the constancy of the applicable law. In extreme situations, these conditions might even lead to protests, such as the action "Visible Hand", where hundreds of parents expressed their objection against six-year-old children's compulsory schooling. This moves responsibility for education from the Ministry of Education experts to ordinary people. This trend can be seen in a growing number of schools implementing programs of alternative education.

From the foregoing, we can see a picture of destabilization and high social anxiety in the subject of Polish education. We have attempt to investigate general education students who take a special place here because of the close relationship between their planned career and Polish education system. Many of them can become not only teachers but also specialized advisors for legislative authorities in our country. The need for change within Polish education system has been previously discussed [5]. Such problem as dissatisfaction with education system was identified. The aim of this paper is to present the results of a survey on students' opinions about the Polish education system.

2. Methods

Participants. A total of 443 students from University of Gdańsk took part in the study, 420 women (94.8%) and 17 men (3.8%), 6 persons (1.4%) did not report gender, with mean age of 21.63 years (*SD* = 4.40). All participants were from Faculty of Social Sciences. Students were from different courses of study: 184 persons (41.53%) from general education (pedagogy), 87 persons (19.64%) from pedagogy of early childhood education and 171 persons (38.60%) from special education. 1 person was a student of both Pedagogy of early childhood education and special education (0.23%). 393 persons (90.14%) were full-time students and 43 persons (9.86%) were extramural students. 176 individuals (40.37%) were first-year students 85 individuals (19.50%) were sophomores, 22 individuals

(5.05%) were third-year students, 119 individuals (27.29%) were fourth-year students, 34 individuals (7.80%) were fifth-year students.

Measures. A self-report, 14-item original measure of opinions about Polish education: *Questionnaire opinion on Polish education (primary, secondary and upper secondary education)*. Questionnaire was written in Polish and was called *Kwestionariusz opinii o polskim szkolnictwie (podstawowym, gimnazjalnym i ponadgimnazjalnym)*. Opinions about Polish education were measured by question: "Please, check how much you agree or disagree with the following statements about Polish education." With 7-point response scale, from 1 – "Strongly disagree", 2 – "Disagree", 3 – "Rather disagree", 4 – "Neither agree nor disagree", 5 – "Rather agree", 6 – "Agree", to 7 - "Strongly agree".

Within the questionnaire respondents were asked to assume an attitude to 14 various statements about Polish education: 1. "Polish education system works well", 2. "Polish education system needs reform", 3. "In a typical Polish school young people receive a decent education", 4. "Knowledge which is taught at school is not very useful in adult life", 5. "In Poland, the teaching profession enjoys social prestige", 6. "Polish education is changing for the better, the changes are going in the right direction", 7. "The way of teaching at school means that students often get bored during the classes", 8. "School is too often a source of excessive stress for students", 9. "School is an institution which does not fit the modern world", 10. "School thoroughly prepares young people for life in adulthood", 11. "In a typical Polish school there is a good atmosphere", 12. "Students cannot express their point of view in class", 13. "Students in Polish schools feel safe", 14. "Teachers do not develop their competences in a sufficient way".

Procedure. Data collection used opportunistic sampling. Students were invited to participate anonymously in the study during lectures or classes. More than 90% of all present students agreed to do so. All participants filled in 'paper and pencil' questionnaires.

Statisitcal analysis. Frequencies calculated with SPSS Statistics 24.0.

3. Results

29 people (6.61%) agreed with the statement "Polish education system works well". 3 people marked "Strongly agree", 5 people "Agree" and 21 "Rather agree". 321 people (73.12%) disagreed with the statement. 83 people marked "Strongly disagree", 149 "Disagree" and 89 "Rather disagree". 89 people marked the answer "Neither agree nor disagree" (Fig. 1).

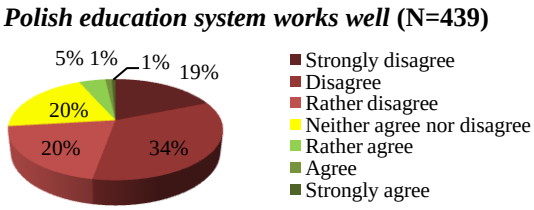

Figure 1: Polish education system works well (N=439).

386 people (88,13%) agreed with the statement "Polish education system needs reform". 128 people marked "Strongly agree", 146 marked "Agree" and 112 marked "Rather agree". 22 people disagreed with the statement. 5 people marked "Strongly disagree", 5 people "Disagree" and 12 people "Rather disagree". 30 people marked the answer "Neither agree nor disagree" (Fig. 2).

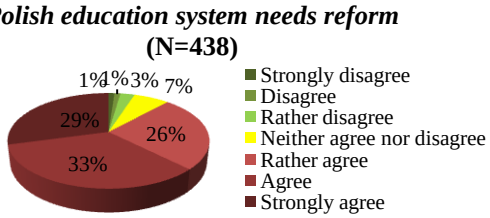

Figure 2: Polish education system needs reform (N=438).

80 people (18.26%) agreed with the statement "In a typical Polish school young people receive a decent education". 1 person marked "Strongly agree", 14 people "Agree" and 65 "Rather agree". 234 people (53.42%) disagreed with the statement. 41 people marked "Strongly disagree", 96 people "Disagree" and 97 people ""Rather disagree". 124 people marked the answer "Neither agree nor disagree" (Fig. 3).

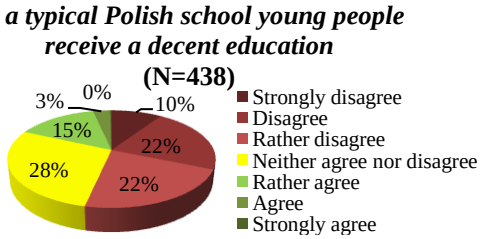

Figure 3: In a typical Polish school young people receive a decent education (N=438).

322 people (73.68%) agreed with the statement "Knowledge which is taught at school is not very useful in adult life". 91 people marked "Strongly agree", 145 "Agree" and 86 "Rather agree". 50 people disagreed with the statement. 11 people marked "Strongly disagree", 10 people "Disagree" and 29 people "Rather disagree". 65 people marked the answer "Neither agree nor disagree" (Fig. 4).

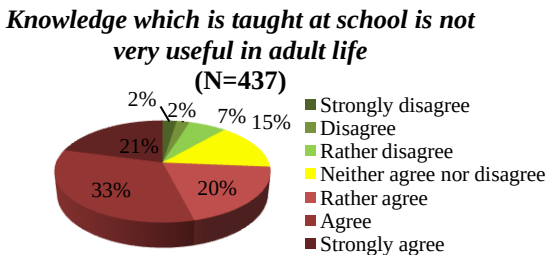

Figure 4: Knowledge which is taught at school is not very useful in adult life (N=437).

63 people (14.38%) agreed with the statement "In Poland, the teaching profession enjoys social prestige". 1 person marked "Strongly agree", 12 people marked "Agree" and 50 "Rather agree". 277 disagreed (63.24%) with the statement. 56 people marked "Strongly disagree", 128 people "Disagree" and 93 people "Rather disagree". 98 people marked the answer "Neither agree nor disagree" (Fig. 5).

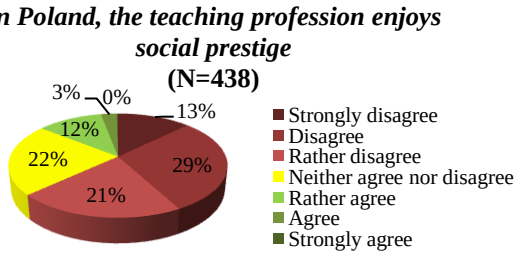

Figure 5: In Poland, the teaching profession enjoys social prestige (N=438).

47 people (10.73%) agreed with the statement "Polish education is changing for the better, the changes are going in the right direction". 1 person marked "Strongly agree", 8 people "Agree" and 38 people "Rather agree". 264 people (60.27%) disagreed with the statement. 76 people marked "Strongly disagree", 109 "Disagree" and 79 "Rather disagree". 127 people (29.00%) marked the answer "Neither agree nor disagree" (Fig. 6).

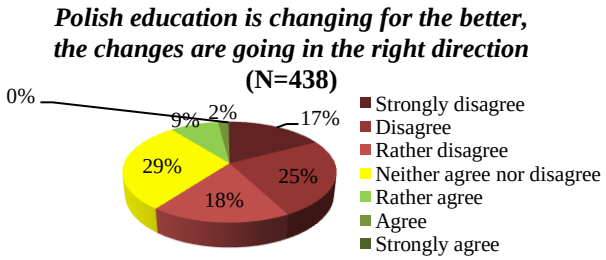

Figure 6: Polish education is changing for the better, the changes are going in the right direction (N=438).

391 people (89.47%) agreed with the statement "The way of teaching at school means that students often get bored in class". 158 people marked "Strongly agree", 146 people "Agree" and 87 people "Rather agree". 16 people (3.66%) disagreed with the statement. 6 people marked "Strongly disagree", 4 people "Disagree" and 6 people "Rather disagree". 30 people marked the answer "Neither agree nor disagree" (Fig. 7).

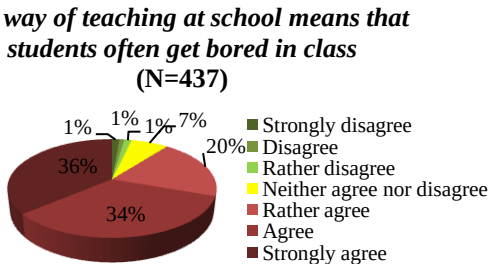

Figure 7: The way of teaching at school means that students often get bored in class (N=437).

375 people (85.62%) agreed with the statement "School is too often a source of excessive stress for students". 124 people marked "Strongly agree", 157 "Agree" and 94 "Rather agree". 30 people (6.85%) disagreed with the statement. 3 people marked "Strongly disagree", 12 people "Disagree" and 15 people "Rather disagree". 33 people marked the answer "Neither agree nor disagree" (Fig. 8).

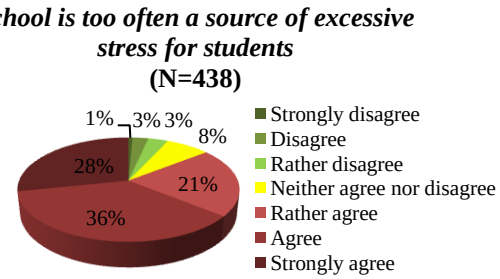

Figure 8: School is too often a source of ecessive stress for students (N=438).

258 people (59.04%) agreed with the statement "School is an institution which does not fit the modern world". 69 people marked "Strongly agree", 100 people "Agree" and 89 people "Rather agree". 64 people (14.65%) disagreed with the statement. 9 people marked "Strongly disagree", 16 people "Disagree" and 39 people "Rather disagree". 115 people marked the answer "Neither agree nor disagree" (Fig. 9).

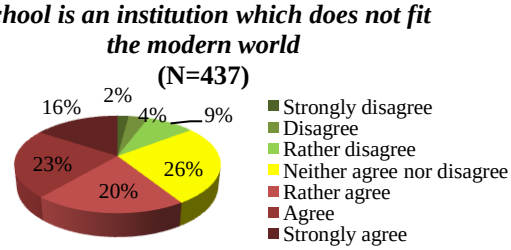

Figure 9: School is an institution misfit to the modern world (N=437).

31 people (7.11%) agreed with the statement "School prepares well young people for life in adulthood". 3 people marked "Strongly agree", 4 people "Agree" and 24 people "Rather agree". 322 people (73.85%) disagreed with the statement. 82 people marked "Strongly disagree", 117 people "Disagree" and 123 people "Rather disagree". 83 people (19.04%) marked the answer "Neither agree nor disagree" (Fig. 10).

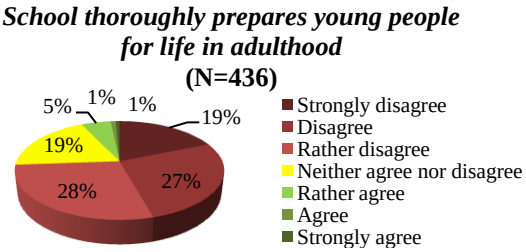

Figure 10: School thoroughly prepares young people for life in adulthood (N=436).

82 people (18.81%) agreed with the statement "In a typical Polish school there is a good atmosphere". 5 people marked "Strongly agree", 12 "Agree" and 65 "Rather agree". 197 people (45.18%) disagreed with the statement. 31 people marked "Strongly disagree", 74 people "Disagree" and 92 people "Rather disagree". 157 people marked the answer "Neither agree nor disagree" (Fig. 11).

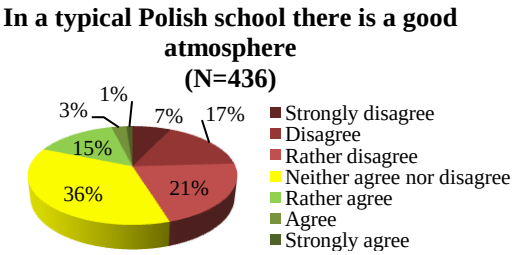

Figure 11: In a typical Polish school there is a good atmosphere (N=436).

244 people (56.35%) agreed with the statement "Students cannot express their point of view in class". 63 people marked "Strongly agree", 86 "Agree" and 95 "Rather agree". 95 people (21.94%) disagreed with the statement. 11 people marked "Strongly disagree", 35 people "Disagree" and 49 people "Rather disagree". 94 people marked the answer "Neither agree nor disagree" (Fig. 12).

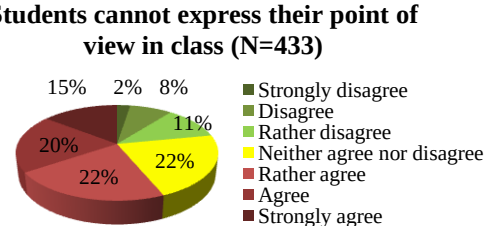

Figure 12: Students cannot express their point of view in class (N=433).

127 people (29.13%) agreed with the statement "Students in Polish school feel safe". 4 people marked "Strongly agree", 22 "Agree" and 101 "Rather agree". 135 people (30.96%) disagreed with the statement. 22 people marked "Strongly disagree", 37 people "Disagree" and 76 people "Rather disagree". 174 people marked the answer "Neither agree nor disagree" (Fig. 13).

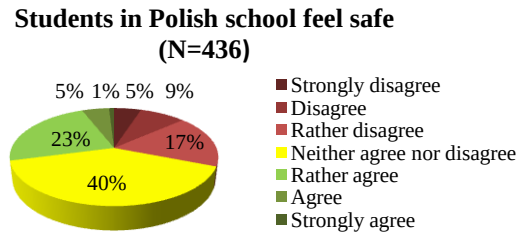

Figure 13: Students in Polish school feel safe (N=436).

244 people (55.96%) agreed with the statement "Teachers do not develop their competences in a sufficient way". 34 people marked "Strongly agree", 94 "Agree" and 116 "Rather agree". 72 people (16.51%) disagreed with the statement. 7 people marked "Strongly disagree", 25 people "Disagree" and 40 people "Rather disagree". 120 people marked the answer "Neither agree nor disagree" (Fig. 14).

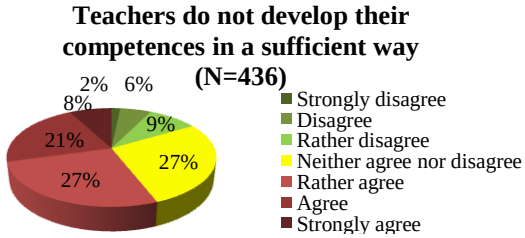

Figure 14: Teachers do not develop their competences in a sufficient way (N=436).

4. Discussion

The results of the study showed that the general education students, special education students and early childhood education students have mostly negative opinions on Polish education. The majority of students believe that the Polish education system needs reform. On the other hand, most people do not believe that the changes taking place in Polish education are going in the right direction. Particularly large percentage of students pointed out that school is a source of excessive stress for students, and that students are bored in school. Both of these problems indicate that Polish students often experience negative emotions in school, and so they feel bad. Students expect changes in education, but we do not know what changes they would like. It is necessary to examine what kind of changes in education are expected and required in students' opinions.

It is debatable why general education students have such negative opinions about education. Perhaps students have very high expectations of education. Possibly students expect profound changes in education including model of

teaching in school. This issue should be examined in subsequent studies.

Acknowledgements
The publication was funded by a grant of the Faculty of Social Sciences of the University of Gdansk on the projects of young scientists and doctoral students in 2016. Grant No: 538-7300-B273-16.

References
[1] Nowak S., *Pojęcie postawy w teoriach i stosowanych badaniach społecznych*. [in:] „Teorie postaw“, S. Nowak (Ed.), Warszawa 1973.
[2] Mądrzycki T., *Psychologiczne prawidłowości kształtowania się postaw*, Warszawa 1971.
[2] Putkiewicz E., Siellawa-Kolbowska K. E., Wiłkomirska A., Zahorska M., *Nauczyciele wobec reformy edukacji*, Raport Intytutu Spraw Publicznych, Warszawa 1999.
[3] Osiecka J., *Społeczne opinie o reformach służby zdrowia i edukacji*, 2000.
[4] http://www.cbos.pl/SPISKOM.POL/2013/K_090_13.PDF
[5] Atroszko B., Atroszko P., *Innowacje edukacyjne jako element rozwoju gospodarki opartej na wiedzy w Polsce*. [in:] "MMK 2013. International Masaryk Conference for Ph.D. Students and Young Researchers ", Magnanimitas: Hradec Králové (The Czech Republic) 2013.

VALIDITY AND RELIABILITY OF SINGLE-ITEM SELF-REPORT MEASURE OF GLOBAL SELF-ESTEEM

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Abstract: *Self-esteem, is one of the most important predictors of psychological well-being, therefore valid, reliable and convenient measures of this construct are necessary. Well-being is often measured in large scale surveys, and to overcome some difficulties associated with measurement of many variables with multi-item scales, ultra-brief measures are being developed. Validity and reliability of single-item self-report measure of self-esteem focused on the degree of satisfaction with the self was examined in a sample of 1451 university students in Poland. Subsample of 135 students was used to assess intraclass correlation coefficient (ICC) for test-retest reliability of that measure. ICC was .79, which can be interpreted as adequate reliability. Self-esteem was related in predictable ways to different measures related to well-being, including perceived stress, depressiveness, anxiety, and various facets of quality of life, as well as self-blame as ineffective stress coping This study provides initial evidence for good psychometric properties of a single-item self-report measure of self-esteem.*

Keywords: *global self-esteem, quality of life, single-item measures,, stress, well-being*

1. Introduction

Global self-esteem is defined as individual's positive or negative attitude toward the self as a totality. A number of studies have stressed the importance of studying specific self-esteem (e.g. academic self-esteem), but global self-esteem remains essentially relevant to psychological well-being [1], and therefore, is the subject of this research.

Self-esteem is one of the most often studied psychological constructs. Literature provides evidence of its relationship with a number of phenomena, from academic [2] and professional success [3] to social relations and personal growth [4]. Self-esteem is studied as one of the internal factors protecting one from perceived stress [5]. People with high self-esteem more often use constructive coping strategies, whereas people with low self-esteem have a poor perception of their abilities to cope with stressing environment [6] and tend to use emotional-focused strategies [7]. This phenomenon is showed in research conducted among adolescents as well as adults [5]. Prospective analyses provided evidence for a relation between low self-esteem in adolescence and negative consequences for mental and physical health during adulthood [8]. It is also strongly related to psychological problems, such as depression, suicidal tendencies, eating disorders, anxiety, and aggressive tendencies [9]. Self-esteem also affects quality and quantity of sleep, which are considered to be good predictors of health and quality of life [10]. It is also important as a predictor of people's social behaviour. People high on self-esteem tend to have higher social capital [11], they tend to strengthen relationships in the face of difficulties [12]. Low self-esteem is related to avoidance [13] and experiencing rejection (even where none exist) [14], which can lead to loneliness and narrow social network. It is related to lower satisfaction with romantic relationships as well [15]. Generally, self-esteem is one of the basic predictors of life satisfaction and happiness (directly [16], and indirectly[17]), is related to meaning in life [18], and self-reported quality of life [19]. Relations of self-esteem with mentioned psychological phenomena are well established and studied in numerous research. Therefore, most of them were used as criterion variables for investigating concurrent validity.

Single-item measure of self-esteem, (SISE) was developed and shown to be valid and reliable [20]. However, this measure asks directly about high self-esteem, and this anchoring may have effect on its validity in certain contexts. What is more, it seems to be more cognitive rather than emotional evaluation of oneself. This measure may also show some tendency to be related to some extent to a narcissistic self-evaluation understood as overly inflated declarative high self-esteem [21]. It is suggested that a more indirect measure of one's attitude towards the self could provide more useful information in the context of psychosocial functioning. Therefore, on the basis of WHOQOL Bref a single item measure of self-esteem was developed and it asks the question "How satisfied are you with yourself?".

2. Single-item scales

Single-item measures are increasingly more often used, especially in large surveys in which there is necessity for controlling multitude of different variables. Repeatedly they prove to be valid and reliable tools. Gradually recommendations and guidelines on the usage of single-item scales are being developed [22]. The use of ultra-brief scales becomes more common practice in educational research, marketing research and health research [23]. Although, it has to be emphasized that not always single-item scales are best solution. In some situations or contexts their performance is significantly inferior to multi-item questionnaires, for example in studies on sexual satisfaction [24]. Therefore, it is highly recommended to think through advantages and disadvantages of the use of ultra-brief scales in a specific research setting, following current data available on the subject.

One of the reasons which make ultra-brief scales useful tools is the fact that analysis of Likert response format data

at the item level is statistically robust [25]. Nonetheless, in cases in which single-item scales are used, it is recommended to use more stringent alpha level in order to make prudent statistical decisions.

On the basis of previous theoretical frameworks and empirical research into self-esteem, the aims of the current study were to: (1) assess concurrent validity of single-item measure of self-esteem through relationships with perceived stress, depressiveness, anxiety, loneliness, facets of quality of life and self-blame as ineffective coping mechanism – it is expected that self-esteem will be positively related to the indicators of well-being and negatively related to indicators of stress and diminished well-being as well as using self-blame as coping mechanism, (2) the currently investigated single-item measure will show stronger relationships with indicators of well-being (stress, depressiveness, satisfaction with life) than SISE; (3) assess the reliability of single-item measure of self-esteem with test-retest method.

3. Methods

Participants. A total of 1451 students from different universities in Pomerania Region in Poland took part in the study, 675 men (43.6%) and 751 women (50.3%), 25 (6.2%) persons did not report gender, with mean age of 21.13 years (*SD* = 1.82). Students were from different faculties, courses of study, years and modes of study. One hundred thirty five participants took part in test-retest procedure, 87 females and 77 males, 5 persons did not report gender, with mean age years *M* = 21.17, *SD* = 1.86.

Measures. A self-report, single-item measure of self-esteem was developed on the basis of item from WHOQOL Bref Scale [26]. Originally used 5-point response scale has been modified to 9-point response scale, in compliance with recommendations to use at least 7-point Likert format response data when conducting statistical analyses on single item measures [25]. Self-esteem was measured by question "How satisfied are you with yourself?" with 9-point response scale, from 1 - "very dissatisfied" to 9 – "very satisfied". Other measures were widely used valid and reliable scales adapted in Poland. Perceived stress was measured with Perceived Stress Scale (PSS-4), a 4-item, 5-point Likert response format scale [27]. Depressiveness and anxiety were measured by Hospital Anxiety and Depression Scale, which includes 14 items with 4-point response format, seven items for anxiety and seven for depression [28]. Loneliness was measured by Short Loneliness Scale, which includes three items with 3-point response format [29]. Self-blame was measured as one of the dimensions from Mini-COPE scale, this dimension includes two items with 4-point Likert response format scale [30]. General health, Sleep quality, General quality of life, Satisfaction with support from friends, Satisfaction with personal relationship, Meaning in life, and Satisfaction with life were measured with single-item scales, developed on the basis of WHOQOL Bref Scale [31,32,33].

Procedure. Data collection used convenience sampling. Students were invited to participate anonymously in the study during lectures or classes. More than 90% of all present students agreed to do so. Ninety one percent of participants filled in 'paper and pencil' questionnaires and nine percent of students completed online versions of the questionnaires. Self-esteem was measured on two occasions with three week interval between them. Anonymous way of coding participants was applied in order to match responses from both measurement occasions. Participation in the study was anonymous and no monetary or other material rewards were offered to the participants.

Statistical analyses. Intraclass correlation coefficient (ICC) along with the 95% confidence interval (CI) was used as a measure of test-retest reliability [34]. Means, standard deviations, percentages and correlation coefficients were calculated. Comparison of two correlation coefficients was performed with z statistic. All statistical analyses were conducted in IBM SPSS 24.

4. Results

Means, standard deviations and correlations between self-esteem and other measured variables are presented in table 1. An intraclass correlation coefficient (ICC) of .79 (95% CI = .71-.85, $p < .001$) was obtained for self-esteem. The correlation between self-esteem (*M* = 6.09, SD = 1.80) and satisfaction with life (M = 6.00, *SD* =1.86) was strong, $r = .60$, $p < .001$.

Table 1. Means, standard deviations and correlations of single-item self-esteem measure with perceived stress, depressiveness, anxiety, loneliness self-blame, general health, sleep quality, general quality of life, satisfaction with support from friends, satisfaction with personal relationships, meaning in life, and satisfaction with life

Scale	*M* (*SD*)	Self-esteem
Perceived stress	10.53 (3.05)	–.49**
Depressiveness[a]	13.88 (4.13)	–.48**
Anxiety[a]	12.00 (3.88)	–.49**
Loneliness	4.59 (1.71)	–.39**
Self-blame[a]	2,86 (1.64)	–.40**
General health	5.88 (2.09)	.41**
Sleep quality	5.55 92.11)	.42**
General quality of life	6.72 (1.39)	.54**
Satisfaction with support from friends	6.76 (1.83)	.37**
Satisfaction with personal relationships	6.03 (2.34)	.43**
Meaning in life	6.05 (2.01)	.55**
Satisfaction with life	6.00 (1.86)	.60**

*$p < .05$; **$p < .01$

[a] Subsample of 1074 students, 481 men (44.8%) and 572 women (53.3%), 21 (2.0%) persons did not report gender, with mean age of 21.77 years (*SD* = 3.24)

Comparison of correlation coefficients between self-esteem and well-being indicators in the present study (r_1) and in the study where SISE (r_2) was used [20] showed that: (1) these correlations with stress were significantly different $r_1 (1451) = –.49$, $r_2 (496) = –.36$, $Z = –3.05$, $p =$

.001; (2) these correlations with depressiveness were significantly different r_1 (1451) = –.48, r_2 (496) = –.25, Z = –5.13, p < .001; (3) these correlations with satisfaction with life were significantly different r_1 (1451) = .60, r_2 (496) = .45, Z = 3.83, p < .001.

5. Discussion

The results provided evidence of good test-retest reliability of single-item measure of self-esteem. Study provides sufficient level of concurrent validity. The results were congruent with expectations, and as predicted, self-esteem was negatively associated with perceived stress, depressiveness, anxiety, loneliness, and self-blame coping style. Positive relations of self-esteem were obtained for general health, sleep quality, general quality of life, satisfaction with support from friends, satisfaction with personal relationships, meaning in life, and satisfaction with life. The strength of relationship of self-esteem with meaning in life and satisfaction with life is higher than in the previous studies with multi-item scales (e.g. r = .47 for satisfaction with life [16], r = .37 for meaning in life [18]). It may be an effect of common method bias, caused by similar response format in all of the quality of life measures.

This measure is very quick to fill and therefore it offers low cost and minimalized burden option for both respondents and researchers. It can be easily applied in large scale researches in which self-esteem have to be measured along with many other variables. As predicted, this measure also showed stronger relationships with indicators of well-being such as perceived stress, depressiveness, and satisfaction with life than the SISE. It suggests that this measure more adequately captures the emotional aspect of ones attitude to the self than SISE. A significant advantage of the examined comparison is similarity of some measures used in both studies. In both studies PSS scales (PSS-6 in SISE study, PSS-4 in this study [27]) were used to assess perceived stress. Also, in both studies single-item measures of satisfaction with life were used ("How satisfied are you with your life as a whole these days?" [35] in SISE study, and "How much do you enjoy your life?" in this study).

Weakness of this tool is its brevity, therefore it is not useful in precise individual evaluation of self-esteem for the purposes of diagnosis or direct comparison between individuals.

The biggest strengths of the study are a large and heterogeneous sample of university students and the use of widely applied valid and reliable measures of criterion variables. The main limitation of the study is that it has not been performed on a representative sample of students nor representative sample of general population. Research on more representative samples is warranted. The future studies should investigate convergent validity of this measure. Also, different methods of measurement, such as observation or experience sampling methodology are recommended. Potential common method bias has to be taken into account whenever several single-item scales with similar response format are used in surveys. More data on common method bias for these measures is required.

The aim of this study was to provide empirical evidence of the psychometric properties of single-item measure of self-esteem. Reliability and criterion validity were tested. The study shows that single-item self-report measure of global self-esteem is a potentially useful research tool.

Acknowledgements

Grant: Grant badawczy w ramach projektu młodych naukowców i uczestników studiów doktoranckich Uniwersytetu Gdańskiego. Number of grant: 538-7422-B121-13 in 2013 and 538-7422-B450-14 in 2014. On the basis of decision number DEC-2013/08/T/HS6/00403 the author (Paweł Andrzej Atroszko) received funds from National Science Centre Poland within doctoral scholarship for preparing PhD dissertation.

Grant: The publication was funded by a grant of the Faculty of Social Sciences of the University of Gdansk on the projects of young scientists and doctoral students in 2016 (Bartosz Atroszko). Grant No: 538-7300-B273-16.

References

[1] Rosenberg, M., Schooler, C., Schoenbach, C., & Rosenberg, F., *Global self-esteem and specific self-esteem: Different concepts, different outcomes*, "American Sociological Review", pp. 141-156, 1995.

[2] Hansford, B. C., & Hattie, J. A., *The relationship between self and achievement/performance measures*. "Health Review of Educational Research", 52, pp. 123–142, 1982.

[3] Frone, M. R., *Interpersonal conflict at work and psychological out-comes: Testing a model among young workers*, "Journal of Occupational Health Psychology", 5, pp. 246–255, 2000.

[4] Judge, T. A., & Bono, J. E., *Relationship of core self-evaluations traits—self-esteem, generalized self-efficacy, locus of control, and emotional stability—with job satisfaction and job performance: A meta-analysis*, "Journal of Applied Psychology", 86(1), 80, 2001.

[5] Dumont, M., & Provost, M. A., *Resilience in adolescents: Protective role of social support, coping strategies, self-esteem, and social activities on experience of stress and depression*, „Journal of Youth and Adolescence", 28(3), pp. 343-363, 1999.

[6] Plancherel, B., Bettschart, W., Bolognini, M., Dumont, M., & Halfon, O., *Influence comparée des événements existentiels et des tracas quotidiens sur la santé psychique à la préadolescence*, „Neuropsychiatrie de l'Enfance et de l'Adolescence", 45(3), pp. 126-138, 1997.

[7] Thoits, P. A., *Stress, coping, and social support processes: Where are we? What next?*, "Journal of Health and Social Behavior", pp. 53-79, 1995.

[8] Trzesniewski, K. H., Donnellan, M. B., Moffitt, T. E., Robins, R. W., Poulton, R., & Caspi, A., *Low self-esteem during adolescence predicts poor health, criminal behavior, and limited economic prospects during adulthood*, "Developmental psychology", 42(2), p. 381, 2006.

[9] Olweus, D. *Bullying among school children*. In K. Hurrelmann & F. Loesel (Eds.), "Health hazards in adolescence", Berlin, Germany: Walter De Gruyter, pp. 259–297, 1990.
[10] Lemola, S., Räikkönen, K., Gomez, V., & Allemand, M., *Optimism and self-esteem are related to sleep. Results from a large community-based sample*, "International journal of behavioral medicine", 20(4), pp. 567-571, 2013.
[11] Steinfield, C., Ellison, N. B., & Lampe, C., *Social capital, self-esteem, and use of online social network sites: A longitudinal analysis*, "Journal of Applied Developmental Psychology", 29(6), pp. 434-445, 2008.
[12] Murray, S. L., Rose, P., Bellavia, G. M., Holmes, J. G., & Kusche, A. G. *When rejection stings: How self-esteem constrains relationship enhancing processes*. "Journal of Personality and Social Psychology", 83, pp. 556–573, 2002.
[13] Ottenbreit, N. D., & Dobson, K. S., *Avoidance and depression: The construction of the Cognitive-Behavioral Avoidance Scale*, "Behaviour Research and Therapy", 42, pp. 293–313, 2004.
[14] Murray, S. L., Rose, P., Bellavia, G. M., Holmes, J. G., & Kusche, A. G., *When rejection stings: How self-esteem constrains relationship enhancing processes*, "Journal of Personality and Social Psychology", 83, pp. 556–573, 2002.
[15] Hendrick, S. S., Hendrick, C., Adler, N. L., *Romantic relationships: Love, satisfaction, and staying together*, "Journal of Personality and Social Psychology", 54, pp. 980–988, 1988.
[16] Diener, E., & Diener, M., *Cross-cultural correlates of life satisfaction and self-esteem*. In *Culture and well-being*, Springer Netherlands, pp. 71-91, 2009.
[17] Kang, S. M., Shaver, P. R., Sue, S., Min, K. H., & Jing, H., *Culture-specific patterns in the prediction of life satisfaction: Roles of emotion, relationship quality, and self-esteem*, "Personality and Social Psychology Bulletin", 29 (12), pp. 1596-1608, 2003.
[18] Steger, M.F., P. Frazier, S. Oishi and M. Kaler: *The Meaning in Life Questionnaire: Assessing the presence of and search for meaning in life*, "Journal of Counseling Psychology", 53, pp. 80–93, 2006a.
[19] Kuehner, C., & Buerger, C., *Determinants of subjective quality of life in depressed patients: the role of self-esteem, response styles, and social support*, "Journal of Affective Disorders", 86(2), pp. 205-213, 2005.
[20] Robins, R. W., Hendin, H. M., & Trzesniewski, K. H., *Measuring global self-esteem: Construct validation of a single-item measure and the Rosenberg Self-Esteem Scale*, „Personality and Social Psychology Bulletin", 27(2), pp. 151-161, 2001.
[21] John, O. P., & Robins, R. W., *Accuracy and bias in self-perception: individual differences in self-enhancement and the role of narcissism*, „Journal of Personality and Social Psychology", 66(1), p. 206, 1994.
[22] Diamantopoulos, A., Sarstedt, M., Fuchs, C., Wilczynski, P., and Kaiser, S., *Guidelines for choosing between multi-item and single-item scales for construct measurement: a predictive validity perspective*, "Journal of the Academy of Marketing Science", Vol. 40, No. 3, pp. 434-449, 2012.
[23] Mannion, A. F., Mutter, U. M., Fekete, T. F., Porchet, F., Jeszenszky, D., & Kleinstuck, F. S., *Validity of a single-item measure to assess leg or back pain as the predominant symptom in patients with degenerative disorders of the lumbar spine*, "European Spine Journal", Vol. 23, No. 4, pp. 882-887, April 2014.
[24] Shaughnessy, K., and Byers, E. S., *Seeing the forest with the trees: Cybersex as a case study of single-item versus multi-item measures of sexual behavior*, "Canadian Journal of Behavioural Science", Vol. 45, No. 3, pp. 220-229, 2013.
[25] Carifio, J., and Perla, R. J., *Ten common misunderstandings, misconceptions, persistent myths and urban legends about Likert scales and Likert response formats and their antidotes*, "Journal of the Social Sciences", Vol. 3, No. 3, pp. 106–116, 2007
[26] Skevington, S. M., Lotfy, M., O'Connell, K. A, *The World Health Organization's WHO QUALITY OF LIFE-BREF quality of life assessment*, "Quality of Life Research", Vol. 13, No. 2, pp. 299-310, 2004.
[27] Cohen, S., Kamarck T., Mermelstein R., *A global measure of perceived stress*, "Journal of Health and Social Behavior", Vol. 24, No. 4, pp. 385–396, 1983
[28] Zigmond, A. S., Snaith, R. P., *The Hospital Anxiety and Depression Scale*, "Acta Psychiatrica Scandinavica", Vol. 67, No. 6, pp. 361-370, 1983.
[29] Hughes, M. E., Waite, L. J., Hawkley, L. C., Cacioppo, J. T., *A Short Scale for Measuring Loneliness in Large Surveys: Results From Two Population-Based Studies*, "Research On Aging", Vol. 26, No. 6, pp. 655-672, 2004.
[30] Carver, C. S., *You want to measure coping but your protocol'too long: Consider the brief cope*, "International journal of behavioral medicine", Vol 4, No. 1, pp. 92,1997.
[31] Atroszko P., Krzyżaniak P., Sendal L., Atroszko B., *Validity and reliability of single-item self-report measures of meaning in life and satisfaction with life*, CER Comparative European Research 2015, 1st ed.; McGreevy, M., Rita, R., Eds.; Sciemcee: London, UK, 2015; pp. 212–215.
[32] Atroszko P., Bagińska P., Mokosińska M., Atroszko B., *Validity and reliability of single-item self-report measures of general quality of life, general health and sleep quality*, CER Comparative European Research 2015, 1st ed.; McGreevy, M., Rita, R., Eds.; Sciemcee: London, UK, 2015; pp. 207–211.
[33] Atroszko P., Pianka L., Raczyńska A., Atroszko B., *Validity and reliability of single-item self-report measures of social support*, CER Comparative European Research 2015, 1st ed.; McGreevy, M., Rita, R., Eds.; Sciemcee: London, UK, 2015; pp. 216–219.
[34] McGraw, K.. and Wong, S. P., *Forming inferences about some intraclass correlation coefficients*, "Psychological Methods", Vol. 1, No. 1, pp. 30-46, 1996.
[35] Campbell, A., Converse, P. E., & Rodgers, W. L., *The quality of American life: Perceptions, evaluations, and satisfactions*, Russell Sage Foundation, 1976.

A COMPARISON OF GENERAL EDUCATION STUDENTS AND SPECIAL EDUCATION STUDENTS IN TERMS OF SELF-EFFICACY AND HOPELESSNESS

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Abstract: *The aim of this study was to compare general education students and special education students in terms of self-efficacy and sense of hopelessness. Two hypotheses were put forward. Hypothesis 1: Special education students have higher levels of self-efficacy than general education students. Hypothesis 2: Special education students have lower levels of hopelessness than general education students. None of the hypotheses was confirmed. Study showed that there were no differences between general education students and special education students. The survey was conducted in December 2016 and January 2017. The questionnaires were filled by 355 students. Self-efficacy was measured on a self-report, 2-item scale. Hopelessness was measured on 4-item, self-report Short Hopelessness Scale* (*Beck, A. T., Weissman, A., Lester, D., Trexler, L.).*

Keywords: *hopelessness, general education students, self-efficacy*

1. Introduction

Matching personality to a suitable profession is crucial from the perspective of a good job and career opportunities. Incongruity to one's profession can cause less satisfaction and in consequence, worse relationships with colleagues, slower development and perception of negative emotions [1].

For teachers, the profession matching factor can be crucial not only for the functioning of a person as an employee but also in the functioning of his pupils. In this article, we would like to present a study about the differences between general education students and special education students in terms of self-efficacy and sense of hopelessness.

Features such as hopelessness and self-efficacy seem to be particularly important while working with children with developmental disabilities, mental disorders and special learning needs. Such children need a teacher who will be able to give them support and the sense of stability. As pupils with difficulties face various problems with building relationships, the teacher's self-efficacy and low level of hopelessness might help students overcome these barriers. A person who exhibits low self-efficacy and high hopelessness may have a problem with persistence in difficult conditions, which will undoubtedly accompany working with children with special needs. It is less relevant in the case of a general educator who is responsible to a greater extent for substantive activities, but social component and building lasting and deep relationships with students is not so demanding for him.

Being a teacher requires not only certain formal qualifications, but also interpersonal skills and relevant personality traits. In particular, it applies to the teachers working with disabled children. It is assumed that for the role of the teacher predetermines characteristics such as self-control, patience, and emotional balance [2]. Frequently, the expected features of a good teacher are: relating to others, a friendly manner, well-rounded education, extensive knowledge, justice, self-control, honesty and pleasant disposition [3]. Mostly, these are typical social skills. Students claim that qualities of teachers such as kindness, honesty and ability to establish contacts have a decisive impact on their sense of security and are the basis of building contacts with both the teachers and other members of the class and the school community [3].

Moreover, teachers should possess certain diagnostic skills in order to recognize students' potential, abilities, interests, and limitations [4]. Diagnosis is an essential part of the education process, so the ability to diagnose seems to be one of the core competences of the teacher [5]. In addition, pursuing the profession of teacher requires continuous professional development [6].

In the literature, there are several pedagogical paradigms about features of an ideal special educator. K. Plutecka has divided the paradigms into the following groups: the paradigm of a human nature, the paradigm of motivating authority, the paradigm of self-education, the paradigm of responsibility, the paradigm of support for a person who helps children, and also the paradigm of self-awareness [7]. According to the paradigm of humanity, special education teachers are more likely to use the individual teaching skills in their profession if they act in accordance with their inner nature. What is more, a special educator should be an ethical person [7]. According to another paradigm, a special education teacher should be a motivating authority for both his pupils and their parents. The success of a special educator depends on the respect that he or she manages to get in his or her environment. Special educator should have the moral and intellectual authority and must be a person of trust [7]. The paradigm of self-education mainly covers the continuous development of special education teachers' competence. Special educator - in line with this point of view - should be a person focused on continuous improvement of himself and preparing his or her students for self-education [7]. Development of professional skills should also be linked to the improvement of ethics. In the paradigm of sense of

responsibility, the main emphasis is put on responsibility for educating and upbringing of disabled people. Therefore, a special education teacher must know his students and must have some interpersonal skills, including empathy and respect for the student [7]. Special educator must have a mature personality, because this is a prerequisite for the development of pupils. The paradigm of support for a person who helps children pays special attention to the problems and ethical dilemmas which a special educator must deal with. Being a teacher requires struggling with one's own weaknesses and understanding oneself [7]. In the paradigm of self-actualization, the emphasis is put on breaking the routine at work of a special education teacher [7].

1.2 Self-efficacy

One of the most important agents which makes teachers' work more effective is educators' sense of self-efficacy which, according to A. Bandura, means "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" [8]. In other words, self-efficacy changes individuals' motivation, affecting aims they want to achieve, determines the period of time in which people endure all the obstacles, how hard they endeavor to succeed and how persistent they are while struggling with the lack of success, which contributes to high level of performance [9]. This conclusion has been proved by the positive association between beneficial self-efficacy beliefs and academic performance which has been found among students [10][11]. In educational contexts, teacher's self-efficacy means the educator's conviction about his skills concerning teaching the students in a successful way. This is a concept which makes teachers use their capabilities to increase students' acquisition of knowledge as educators who feel self-efficient experience more perseverance which result in better schooling abilities [12]. This factor mediates between teachers' aims and efforts turned to fulfilling various tasks [13]. The teacher's self-efficacy plays an important role as it influences students' performance in a positive way [14][15][16].

A distinctive group of educators are special education teachers whose work is inseparably connected with great emotional and physical burden as they have to use specialized skills in their everyday work with children who are affected by numerous disabilities and who have many different needs. Moreover, these educators are supposed to put greater effort into achieving learning goals of pupils with disabilities and spend more time on it as well [17]. It has been found that special education teachers show more self-efficacy than general education teachers in educating children with disabilities such as autism [18].

1.3 The sense of hopelessness

Another factor which has influence on teachers' everyday work is the sense of hopelessness which causes that individuals perceive themselves as incapable of achieving anything valuable [19] and regard their future as pessimistic and impossible to control. When the level of stress begins to overwhelm a person's life, the sense of hopelessness might develop [20]. Being one of the major components of depression [21] or other mental difficulties such as alcoholism [22], hopelessness is a considerable problem nowadays. What is more, people experiencing the sense of hopelessness tend to have higher blood pressure three times more often than average [23].

In educational contexts, the concept of hopelessness is particularly significant as it is claimed that teacher trainees' positive or negative expectations toward their future have a severe impact on their pupils' lives as well as the quality of the whole education system [24]. The issues teacher trainees usually worry about are economic conditions, unemployment and not being able to predict their future. It has been found that attitude towards one's occupation can change the person's future perspectives. According to recent research, teacher trainees who regard their job as valuable and rewarding show beneficial beliefs about the future whereas ones who do not appreciate their profession are more worried about the future [25]. Consequently, individuals who chose their future career owing to their families' suggestions or due to examination results, showed more hopelessness than those who decided to be teachers willingly and due to the internal sense of mission [26].

2. Hypothesis

H1: Special education students have higher levels of self-efficacy than general education students.

H2: Special education students have lower level of hopelessness than general education students.

3. Methods

Participants. A total of 355 students took part in the study, 332 women (93.0%) and 17 men (4.8%), 8 persons (2.2%) did not report gender, with mean age of 22.17 years (*SD* = 4.63). Students were from the University of Gdańsk, from the Faculty of Social Sciences. 186 individuals (52.4%) studied general education and 169 (47.6%) persons studied special education. Participants were from different years and modes of study.

Measures. A self-report, 2-item measure of self-efficacy was used. Within the questionnaire respondents were asked to assume an attitude to 2 various statements: „Usually, I am able to cope with what happens to me" and „I am able to solve most of problems if I put enough effort in it". Sense of hopelessness was measured by self-report, 4-item *Short Hopelessness Scale* (Beck, A. T., Weissman, A., Lester, D., Trexler, L.).

Procedure. Data collection used opportunistic sampling. Students were invited to participate anonymously in the study during classes or lectures. More than 90% of all present students agreed to do so. All participants filled in 'paper and pencil' questionnaires. The study took place from December 2016 to January 2017.

Statistical analyses. Student *t* test for independent groups was used to compare two groups of students. All statistical analyses were conducted in IBM SPSS Statistics 24.0.

4. Results

4.2 Comparing the values of the students using the *t* test

There was no significant difference in the scores of self-efficacy between general education students (M = 13.75; SD = 2.56) and students of special education (M = 13.81; SD = 2.18), $t(355)$ = -0,22, p = .823. There was no significant difference in the scores of hopelessness between general education students (M = 9.26; SD = 4.04) and students of special education (M = 9.15; SD = 3.87), $t(355)$ = 0.25, p = .803 (Table 1).

Table 1: A comparison using the Student t-test group of students of general education and special education students in terms of their personality traits

	General education students (n = 186)		*Special education students (n = 169)*		*t (355)*	*p*
Variable	*M*	*SD*	*M*	*SD*		
Self-Efficacy	13.75	2.56	13.81	2.18	-0.22	.823
Hopelessness	9.26	4.04	9.15	3.87	0.25	.803

5. Conclusions

None of the hypotheses was confirmed. Hypothesis 1 was not confirmed. Special education students do not have higher levels of self-efficacy than general education students. Hypothesis 2 was not confirmed. Special education students do not present lower levels of hopelessness than general education students.

6. Discussion

The results that indicate no differences in terms of self-efficacy and the sense of hopelessness between general education students of both specializations can be caused by a number of reasons. People can manifest these qualities in the same degree in the general measurement, but this does not exclude differences in the intensity of their expression in other areas of life. Self-efficacy of general education students may relate to feeling confident in developing a career path, promotion or fighting for higher wages. Students of special education can manifest self-efficacy in a greater commitment to work with the student or the better effects of their pedagogical therapy they plan to carry out. Moreover, the sense of hopelessness can be developed by them in the following directions: success as an employee and success as a therapist. We should test this hypothesis in further studies

We may also consider a conscious choice of the young candidates. High school graduates with only a basic knowledge of the conditions of education and work after completing the specialization can see the general and special education as almost equivalent fields of study. Not noticing the differences between them can affect the randomness of their choice caused by poor reflection. The question is whether the hypothesis differentiate students first and last years of special education. It is possible that people who randomly decided to choose this path give up their studies or change specialization to more suited to their personality.

On the other hand, if our results do not come from these possibilities, it indicates a worrying trend in higher education. Students are admitted to the directions that require not only hard skills, but also social skills in a completely uncontrolled way. This indicates special educator to have no predisposition to perform such a difficult and demanding profession, which is to work with children with special educational needs in spite of their knowledge after graduation. Potentially, in a group of graduates we can find units that should not practice this area of education. We may therefore have to make some kind of selection of candidates for the specializations or think about a way of counseling and selection for specific jobs. Person after graduation can perform a number of tasks not directly related to the work with another person as the creation of teaching materials and academic work. Far-reaching idea to solve this problem could be the subspecialty, which will naturally separate persons having adequate social skills and conditions of personality to activities related to work in an institution dealing with children with special needs from people who want work in this field of science, although do not have qualifications mentioned above. Nevertheless, this could be the area to further deliberations.

Acknowledgements

The publication was funded by a grant of the Faculty of Social Sciences of the University of Gdansk on the projects of young scientists and doctoral students in 2016. Grant No: 538-7300-B273-16.

References

[1] Lipińska-Grobelny, A., Głowacka, K., *Zadowolenie z pracy a stopień dopasowania do zawodu*, „Przegląd psychologiczny", 52(2), pp. 181-194, 2009.

[2] Kawka, Z., *Między misją a frustracją. Społeczna rola nauczyciela*, Wydawnictwo Uniwersytetu Łódzkiego, p. 85, Łódź 1998.

[3] Kordziński, J., *Nauczyciel, trener, coach*, Wolters Kluwer Polska, p. 99, Warszawa 2013.

[4] Wosik-Kawala, D., Zubrzycka-Maciąg, T., *Wstęp.* [in:] „Kompetencje diagnostyczne i terapeutyczne nauczyciela", D. Wosik-Kawala, T. Zubrzycka-Maciąg (Eds.), Impuls, pp. 7-9, Kraków 2011.

[5] Rudek, I., *Poznawanie ucznia i diagnozowanie wychowawcze jako konieczne umiejętności nauczyciela.* [in:] „Kompetencje nauczyciela wychowawcy", Ferenz, E. Kozioł (Eds.), Redakcja Wydawnictw Humanistyczno-Społecznych Uniwersytetu Zielonogórskiego, p. 125. Zielona Góra 2002.

[6] Day, Ch., *Rozwój zawodowy nauczyciela. Uczenie się przez całe życie*, Gdańskie Wydawnictwo Psychologiczne, p. 17, Gdańsk 2004.

[7] Plutecka, K., *Obraz pedagoga specjalnego w aspekcie nowoczesnych paradygmatów pedeutologicznych*, „Szkoła Specjalna" 1/2005, pp. 113-115.

[8] Bandura, A., *Social foundations of thought and action: A social cognitive theory*, Englewood Cliffs, NJ: Prentice-Hall, 1986.
[9] Bandura, A., *Self-efficacy: the exercise of control*, W. H. Freeman and Company, New York 1997.
[10] Multon, K. D, Brown S. D, Lent R. W., *Relation of self-efficacy beliefs to academic outcomes: a meta-analytic investigation*, "Journal of Counseling Psychology" (38) 1991, pp. 30–38.
[11] Johnson I., *Female Faculty Role Models, Self-Efficacy and Student Achievement*, "College Student Journal", Spring 2017, Vol. 51 Issue 1, pp. 151-172.
[12] Gavora, P., *Slovak pre-service teacher self-efficacy: theoretical and research considerations*, "The New Educational Review", Vol. 21, No. 2 (2010), pp. 17-30.
[13] Pervin L. A., John O. P., *Osobowość. Teoria i badania*, Wydawnictwo Uniwersytetu Jagiellońskiego, Kraków, p. 481, 2002.
[14] Ross J. A., *Teacher efficacy and the effects of coaching on student achievement*, "Canadian Journal of Education", Vol. 17, No. 1, Winter, 1992, pp. 51-65.
[15] Soto, G., & Goetz, L., *Self-efficacy beliefs and the education of students with severe disabilities*, "Journal of the Association for Persons with Severe Handicaps", 23(2), 1998, pp. 134-143.
[16] Caprara, G.V., Barbaranelli, C., Steca, P., Malone, P. S., *Teachers' self-efficacy beliefs as determinants of job satisfaction and students' academic achievement: a study at the school level*, "Journal of School Psychology", Volume 44, Issue 6, December 2006, Pages 473–490.
[17] Jennett, H. K., Harris, S. L., and G. B. Mesibov, *Commitment to Philosophy, Teacher Efficacy, and Burnout among Teachers of Children with Autism*, "Journal of Autism and Developmental Disorders", 33, 2003, pp. 583–593.
[18] Schwarber, L. A., *A Comparison of General Education and Special Education Teachers' Knowledge, Self-Efficacy, and Concerns in Teaching Children with Autism*, Doctoral dissertation, Miami University, 2006.
[19] Avci, I. A., Okanli, A., Karabulutlu E., Bilgili N., *Women's marital adjustment and hopelessness levels after mastectomy*, "European Journal of Oncology Nursing", no. 13(4), 2009, pp. 299-303.
[20] Beck, A. T., Weissman, A., Lester, D., & Trexler, L., *The measurement of pessimism: the hopelessness scale*, "Journal of Consulting and Clinical Psychology", 42(6), 1974, p. 861.
[21] Melges, F. T., Bowlby, J., *Types of hopelessness in psychopathological process*, "Archives of General Psychiatry", no 20(6), 1969, pp. 690-699.
[22] Smart R. G., *Future time perspective in alcoholic and social drinkers*, "Journal of Abnormal Psychology", no 73, 1968, pp. 81–83.
[23] Everson, S. A., Kaplan, G. A., Goldberg, D. E., Salonen, J. T., *Hypertension Incidence Is Predicted by High Levels of Hopelessness in Finnish Men*, "Hypertension", Volume 35, Issue 2, February 2000, pp. 561-567.
[24] Aydın, B., Ağır, M., *Öğretmen adaylarının mesleki beklentilerinin değerlendirilmesi*, IX. Ulusal Eğilim Bilimleri Kongresi 27-30 Eyliil 2000 Bildiri Özelleri Kitapçığı, Erzurum: Atatürk Üniversitesi, 2000.
[25] Şengül, S., Güner, P., & Altin, A., *The Hopelessness Level of 3rd Grade Elementary Mathematics Preservice Teachers' and their Perspectives about Future*, "Procedia-Social and Behavioral Sciences", 116, 2014, pp. 718-721.
[26] Ceyhan, A. A., *Öğretmen adaylarının umutsuzluk düzeylerinin incelenmesi*, "Eğitim ve Bilim", 30(137), 2005.

HOW GAMIFICATION CAN INCREASE MOTIVATION IN LANGUAGE LEARNING

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Abstract: *Gamification as a Human-Focused Design system is based on human engagement and motivation. According to Yu-kai Chou, one of the pioneers in this area, almost everything could be gamified. Gamification is present in language learning. The study is an analysis how these system can increase motivation of adult learners.*

Keywords: *gamification, Human-Focused Design, language learning, language teaching, games*

1. Introduction

In the very first days of my work as a language teacher I focused on what should be done: these words, that declination, conjugation etc. But "What?" is not the key, it does not build a bridge between me and the learner. "What?" is a question about material. First, I must know why and how to build the bridge. Then I will have the big picture of learner's motivations, needs and goals [1].

The difference between starting with "What?" and starting with "Why?" represents two types of design: Function-Focused Design and Human-Focused Design, and this second one is strictly linked with gamification [2].

1.1 Function-Focused Design vs. Human-Focused Design in language teaching

Function-Focused Design has been invented specifically to get the job done [3]. Teaching Polish as a foreign language to adults I use coursebooks which base on functions: transferring a grammar, no matter what, even if the subject is not universal or is artificial, or useless. Authors create a class where the language is located in the center, not the learner. If a teacher creates a course taking a fully function-focused approach to teaching vocabulary and grammar, then he or she shouldn't expect from the learners to do anything more.

The opposite situation takes place with Human-Focused Design which puts human in the center of every project [4]. If we think about language course that puts a learner in the center – his or her needs, potentials, expectations, goals – then from the very first moment we want to keep his or her attention, motivation, engagement and satisfaction. This is exactly that what games have done for decades – keep gamers content.

1.2 What gamification is?

Yu-kai Chou, one of the earliest pioneers in this subject, defined gamification as "the craft of deriving fun and engaging elements found typically in games and thoughtfully applying them to real-world or productive activities" [5]. Therefore, gamification doesn't involve games and it's not a game in itself [6]. So, what is it?

If we look around, we'll see that most systems are function-focused: starting from companies where employees have to get the job done because they are required to, not because they want to, ending up using every day devices which have not been designed as well as we need [7]. Also a language course is a function-focused system: a teacher must teach a student, a student must learn. How to change it into Human-Focused Design? Gamifying classes builds bigger engagement, motivation and satisfaction.

1.3 User Types / Listener Types

At the beginning, a teacher should explore temperaments of his or her students. Studying users' motivation and engagement, Marczewski, the well-known Polish gamification researcher, created the Marczewski's Gamification User Types Hexad [8].

Figure 1: Marczewski's User Type Hexad [9]

The author distinguished 6 types of users:

- Socialiser – motivated by relatedness; for him the most important are interactions with other users and social connections.
- Free Spirit – motivated by autonomy and self-expression; his goal is creating and exploring.
- Achiever – motivated by mastery; this user must learn new skills over and over, he is looking to gaing knowledge to improve their skills.

- Philanthropist – motivated by purpose and meaning; he doesn't expect a reward, because his goal is to enrich the lives of others in some way.
- Disruptor – motivated by change; he want to disrupt the system – directly or through other users; his behaviour may improve positive or negative change.
- Player – motivated by rewards; his goal is collecting rewards from the system, so he will do everything what is necessary to make it done and nothing more [10].

These six types of users are enough to plan an engaging system. Let's come back to the language course. I am quite certain that every teacher will find an example of every type of user among his or her learners. I teach people who started to learn only to meet new people, they do not want to study alone and feel bigger engagement being in a group (Socialisers). On the other hand I have students who can learn only if they have one-to-one meetings, they need to feel control and autonomy (Free Spirits). Achiever is to obvious to discuss, but an interesting user in the learning system is the Philanthropist. Once, I met a woman who started to learn Polish because she wanted to help in a Polish charity organization, and I think this is the best example. In opposition, the Player obligatorily needs all rewards from the system – for a language learner it could be diplomas, certificates, symbols of affiliation of schools, universities, language programs etc. - everything which has a logo or a title. Finally, the last type of user, the Disruptor, may be the most challenging one. If a teacher does not satisfy him or her, his or her need of change may have negative consequences.

2. How to satisfy learners?

Yu-kai Chou acknowledged that "almost every successful game appeals to certain Core Drives within us and motivates us towards a variety of decisions and activities" [11]. He designed the Octalysis Framework in octagonal shape with 8 Core Drives presenting in the Table 1.

Table 1 The 8 Core Drives of Gamification [12]

Core Drive	*Description*	*Selected Game Technique*
Epic Meaning and Calling	A user believes that he is doing something greater than himself and/or was "chosen" to take the action.	Narrative; Free Lunch
Development and Accomplishment	A user wants to make progress, develop skills, achieve mastery, and eventually overcome challenges.	Progress Bars; Achievement Symbols
Empowerment of Creativity and Feedback	A user is engaged in a creative process where he analyzes new things over and over and tries various combinations, seeing results, receiving feedback, and making changes.	Booster; Meaningful Choices
Ownership and Possession	A user is motivated because he feels like he owns or controls something, consequently, he wants to increase and improve what he owns.	The Alfred Effect
Social Influences and Relatedness	A user is engaged by all the social elements (mentorship, social acceptance, social feedback, companionship, competition, envy)	Mentorship; Water Coolers
Scarcity and Impatience	A user wants making something simply because is extremely rare, exclusive, or immediately unattainable.	Magnetic Caps
Unpredictability and Curiosity	A user is engaged because he doesn't know what is going to happen next.	Mystery Boxes
Loss and Avoidance	A user avoids something negative happening.	Countdown Timers

Everything what we do is based on one or more of the Core Drives. If none of abovementioned are present within a product or system, there is no motivation, and users will end up feeling no engagement [13].

Let's analyze selected game techniques and their utility in language classes. The Narrative gives a user context and answer to "Why?". It's an effective way to introduce a story (of a school, course, teacher) and give The Epic Meaning through interacting with us [14]. The Free Lunch sounds funny, however, it could be any free thing (that is normally not free) to make people feel special [15], for example free language class for everybody in the first day of spring.

Progress Bars [16] are present at almost every class as a book. Whole book is a 100%, and a learner fills it with every lesson. Achievements Symbols can be realized in many forms: badges, stars, belts, hats, uniforms, trophies, medals etc., but the most important thing is they must symbolize achievements [17].

Boosters are usually limited to certain conditions [18]. In a class it could be creative supplies, a game, interactive quiz, a colorful gadget. However, a teacher has to remember why he or she introduces boosters to the course. If they lose their function, they may become destructive.

When a teacher create a course, he or she can allow a learner to make the Meaningful Choices [19], like contribute to the program. It is also linked with the Alfred Effect "when users feel that a product or service is so personalized to their own needs that they cannot imagine using another service" [20] – all schools offer courses tailored to learners needs and possibilities base on this motivation.

Next game technique, the Mentorship provides directorial guidance and emotional support [21]. During a group course a teacher may use it, matching more and less advanced learners into pairs.

The Water Coolers are those places where people take a small break and talk about non-work related topics [22]. In

a language school a small break, relaxation, exercise involving people in a conversation about themselves.
Magnetic Caps designate how many times a user can complete certain action, which then stimulates more motivation to completion [23], for example how many times a learner can take a test. Mystery Boxes are unknown rewards received after completing a required action [24], e.g. less questions on a test.
What is most important about the last game technique, Countdown Timers is that they introduce the start of the opportunity, while other timers signify the end of it [25]. During a course it will be a countdown to the big trip where a learner uses the language he or she is studying.

3. Conclusions

Gamification gives a teacher tools to analyze motivation of learners and to build real engagement on this foundation. What is the most important thing that gamification is not only badges, points and leaderboards – these are only a realization of game techniques. The gamifications is not a game too, but games are at its roots. As Yu-kai Chou said, we can gamify everything, so let's gamify our language course.

Acknowledgements

This paper was supported by Łukasz Knap, my friend, an English teacher and a big fan of gamification.

References

[1] http://yukaichou.com/gamification-examples/what-is-gamification/
[2] Chou Yu-kai, Actionable Gamification: Beyond Points, Badges, and Leaderboards, Octalysis Media (Kindle Edition), 2015, p. 7.
[3] http://yukaichou.com/gamification-examples/what-is-gamification/
[4] Ibid.
[5] Chou Yu-kai, Actionable Gamification: Beyond Points, Badges, and Leaderboards, Octalysis Media (Kindle Edition), 2015, p. 7.
[6] http://yukaichou.com/gamification-examples/what-is-gamification/
[7] Chou Yu-kai, Actionable Gamification: Beyond Points, Badges, and Leaderboards, Octalysis Media (Kindle Edition), 2015, p. 7.
[8] Marczewski Andrzej, Even Ninja Monkeys Like to Play: Gamification, Game Thinking and Motivational Design, Gamified UK (Kindle Edition), 2015, p. 808-819.
[9] Ibid., p. 820.
[10] Ibid., p. 820-842.
[11] Chou Yu-kai, Actionable Gamification: Beyond Points, Badges, and Leaderboards, Octalysis Media (Kindle Edition), 2015, p. 23.
[12] Ibid., p. 23-28.
[13] Ibid., p. 33.
[14] Ibid., p. 81-82.
[15] Ibid., p. 86.
[16] Ibid., p. 111-112.
[17] Ibid., p. 115-117.
[18] Ibid., p. 146-147.
[19] Ibid., p. 153.
[20] Ibid., p. 190-192.
[21] Ibid., p. 215-216.
[22] Ibid., p. 227-229.
[23] Ibid., p. 255.
[24] Ibid., p. 299-300.
[25] Ibid., p. 333.

INCORPORATION OF PAINTING TECHNIQUES THROUGH THE METHOD OF ARTISTIC-CREATIVE COMMUNICATION IN TEACHING PRACTICE

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Abstract: *Presentation of the results of research aimed at integrating painting techniques into the art of teaching experience with the use of method artistic-creative of communication. We describe the importance of artistic-creative communication in teaching practice. We focus on familiarizing students in adolescence with a wide variety of painting techniques and extend into the contexts of communication between teacher and students.*

Keywords: *artistic-creative communication, painting techniques, research, adolescent,*

1. Introduction

The project is a research-oriented quality. It is based on mapping the process of method artistic-creative of communication such as the illustrative work with painting techniques. Artistic-creative communication is a method of teacher work with students simultaneously in one piece, leading to expressive and mostly the abstract artistic expression. It inspired the creation of Andy Warhol and Jean-Michael Basquiat in their common work. Artistic-creative communication gives us the opportunity to apply new painting techniques in teaching in an unusual way resting on the clearness and paves the way for better communication between teachers and pupils. This kind of creative communication takes place between pupils and teachers directly in the creation, turns on the establishment of a joint work as record specific dialogue in which participants alternated position with the position of the recipient creator of artwork.

2 Theoretical basis

In visual learning is the practical part of making important factor in fulfilling its objectives. "Because the only true art education: deed, creation itself." [9]. At the outset, we define painting techniques that we are able to move into the school environment. Emphasis was put on the intersections of classic and contemporary painting techniques, the overlap in playwriting and new paintings. "Technology in terms of the whole creative process is only a means of artistic expression."[3] Techniques were divided into two categories. Technology first category: Watercolor (transparent and opaque-gouache), Pastel (dry, oily, hard wax), Oil painting, Ebru, Acrylic, Encaustic and Digital painting. Techniques second category dealt with a set of techniques painting techniques under the first category, different techniques of oil painting, American, European and Cold technology of encaustic.

Selection criteria techniques were the research objectives: affordability, the possibility of incorporating into the art of teaching experience, the time required for the formation (one to two lessons), ease of procedure, the possibility of combining them, for experimentation with them, easy preparation. „An artist has a vast range of possibilities and must make decisions which depend on their knowledge, craftsmanship, judgement, opinion, vision, and many other aspects. In today's economic and technological context, painting (materials) is much more accessible than it used to be in previous centuries. The number of artists (creative people) has increased considerably just as did the variety of materials which can be used in art today.“ [10]

In addition to creating a list of painting techniques and their classification, we are focusing on their inclusion in school education, teacher´s personality as coordinator and subsequently artistic-creative communication, its objectives and the potential of the school setting.

Our work will focus mainly on the formation of young people in adolescence. Unlike pubescence, adolescence is a psychological category [6]. Adolescence usually takes place from 16 to 17 years to 21 years. [2] Turček [11] indicates end of adolescence at age 22, but Ondrejkovič [6] seen this age is seen as the end of the post adolescent period. Some authors reported adolescence up to 24 years. [1] [4]. Today we are witnessing a continuous tightening of the period. Distending the age of adolescence appears adulescencia term as first defined it in mid-1970 Tony Anatrella [1]. It constitutes a further phase transition teen to the adult world. Adulescencia takes place between 24 and 30 years of age (by Shaputis, it may take up to age 35). [7] This significant shift in the post-adolescent period is a result of stretching stages of personality development of young people and social development. Institutions aimed at educating young people should lead young people the transition from childhood to adult life. "Teacher and culture malleable human being ... rather allow, encourage, or facilitate or confirm to what exists in the bud, to become true." [5]

The above assumptions (theories) form the aims of artistic-creative communication and research to work with it. In education focus on personal development of the individual and his emotional maturation.

2.1 Research aims

Research objectives linked to the objectives of artistic-creative communication. They are aimed at further understanding the process of artistic-creative

communication as a means of learning painting techniques and getting more space for communication and knowledge of their students in the process. Painting techniques form the backbone of research.
The primary focus is to map the process of artistic-creative communication as a meaning of working with a wide variety of painting techniques in the work with students (focus on adolescence).

2.2 Methodology of the project research

The research is oriented quality. We chose integrated research (triangulation) in order to work with multiple methods on a single issue, increase the validity of the research. "The term triangulation means an attempt to obtain" real "understanding of the situation based on a combination of different points of view or other findings."[8] The process of artistic-creative communication, we decided to examine three research methods: interviews (exploratory interview, the interviews involving verbal communication during production and post-production); observation (non-verbal) and analysis of the method of creation, which includes marginally final work.
The analysis was carried out in the design of grounded theory.

Picture 1: The results of the artistic-creative communication

2.2.1 Research problems and research question

The research problem is the definition of artistic-creative process as a meaning of communication to familiarize the students in adolescence, with a variety of painting techniques through the abstract work. The communication in artistic-creative process runs between students and teachers.
Main research question: How to work with the method of artistic-creative communication within the art education in order to be used to enhance skills of adolescents to work with painting techniques?
The main research question of expanding further research questions that are directly linked to it:

- Factors supporting and making it impossible to achieve the purposes of the process of artistic-creative communication.
- The conditions of the process for acquisition of skills of painting techniques in abstract creation.
- The emerging and disappearing communication contexts in the process of artistic-creative communication.

2.2.2 Research sample and the selection of respondents

We worked with 36 respondents, 24 of them were adolescents attending the Faculty of Education and the first year, and of the 12 respondents were adulescents, who formed the control group. They were young adults up to 30 years who are not still independent. Their view was important to understand the shortcomings in work with adolescents who reflect back and adolescents compared to its own problems after graduation. We acquire the respondents based on the "snowball". They are often motivated by curiosity explore painting techniques (with that variable in the analysis, we counted). With respondents we worked individually (one teacher and one student), in pairs (one teacher and two students) and groups (one teacher and five students).

3. Results

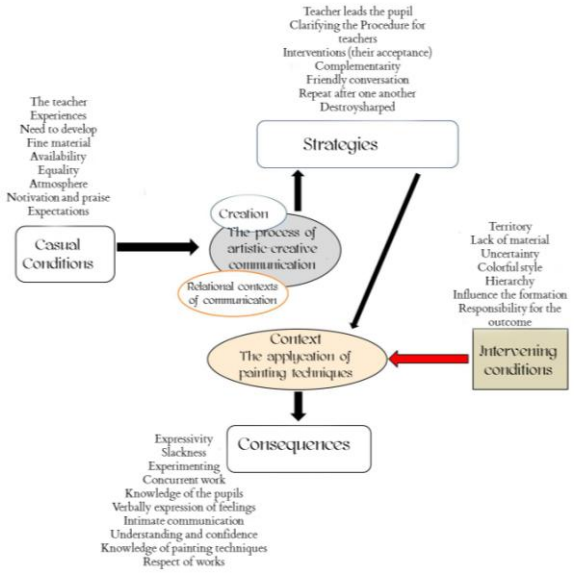
We were able to map out the process of artistic-creative communication and its various phases that are repeated during most meetings. The artistic-creative communication provides an opportunity to improve communication between students and teacher.

Transformation phenomena in artistic-creative communication	*Phase artistic-creative communication*		
	The initial phase of creation	*The high phase of creation*	*The final phase of creation*
	▪ Shower pace ▪ Building a creative atmosphere ▪ Uncertainty ▪ Preparation ▪ Discovering territories ▪ Material testing ▪ Insignificant gestures ▪ Repeating after the teacher	▪ Accelerating the pace ▪ Rapid alternation painting techniques ▪ Release ▪ Experimenting ▪ Engaging a larger area ▪ Pronounced gestures ▪ Open to nonverbal communication ▪ Concurrent work	▪ Showing the pace ▪ They are repeated painting techniques (according to personal preferences) ▪ It creates a relationship to work ▪ Smaller interventions ▪ Intimate communication ▪ The joy of creation

Table 1: Phase artistic-creative communication

The level of the communication process depends on the personality of the teacher; we could not be identified (lack of data). Process and its chronology we see in Table 2

The central category of artistic-creative communication is tied to the creation and Relational contexts of communication. The course of the process of artistic-creative communication is influenced by several variables.



Picture 2: The skeleton of the story around a central analytical category for help paradigmatic model.

From interviews it showed that most respondents perceived as a significant change, equality between all involved. And limiting factors supporting the process of artistic-creative communication (see Table 2)

	Supporting the process A-CC	*Limiting process A-CC*
Factors influencing the A-CC	▪ Teacher´s personality ▪ Experience with painting ▪ Positive experience with painting ▪ Availability of material during formation ▪ Equality of all involved in the creation and communication ▪ Creative and friendly atmosphere ▪ Motivate and praise ▪ Positive expectations ▪ Development needs ▪ The importance of the process (not final work)	▪ Insufficiently prepared teacher ▪ Lack of material ▪ Creating territories ▪ Uncertainty ▪ Fears of creation ▪ Specific picturesque style ▪ Hierarchy ▪ Fear of "spoilage" ▪ Affect ▪ Cool teacher access ▪ Lack of knowledge of painting techniques with teacher ▪ Time limits

Table 2: Factors influencing the artistic-creative communication (A-CC)

Factors that support the work of the artistic-creative in applying communication and learning painting techniques are a set of phenomena which are based on causal conditions of the paradigmatic model. Constitute a comprehensive set of defining events / factors that make it possible to work with artistic-creative communication, the conditions for the fulfillment of the objectives of this specific dialogue.

Limiting factors are partly drawn from intervening conditions and supplemented by insights from interviews. Their list has been reduced to the most important phenomena that are repeated in all meetings. As part of the research we managed to minimize the impact of limiting factors and a closer focus on the factors that support this process.

3.1 Working with variety of painting techniques in the process of artistic-creative communication granted under research results

Work with painting techniques at the various meetings we have tried to balance. Every painting techniques first category appeared in the same amount. Most individual meetings took place from 60 to 75 minutes without preparation and cleaning. Was an exception techniques of encaustic, which have been overcome in 30 minutes. When correcting the teacher they could be reduced to one lesson or stretch.

The most difficult technique in the view of the formation of large pastel works appeared. The best works created with respondents who have already had experience of painting. The biggest surprise was the work of a canvas (Adjusted for school practice), with which all the works entailed artistically very successful results. Freest it seemed to work on the pillowcase, offering completely new effects on the painted surface. Interestingly, respondents who had the least experience of painting developed interesting work in encaustic. Each respondent has a "stronger" and "weaker" technique for self-expression. Relationship to the painting technique is reflected in the level of experimentation, questions about the process, and also in the length of labor.

The method artistic-creative of communication utilized expanded diapason painting techniques other category. This process of learning painting techniques, reflected in particular by downloading painting technique modeled after the teacher (clearness), through direct communication about painting techniques, through their own trial (practical experience), to experimentation, which envisages greater courage in a separate creation. In the future, we would recommend seeing whether the experimental process of artistic-creative communication is reflected in the self-creation of the respondent, where these painting techniques worked.

3.2Teacher's personality

During data analysis showed regularly approach the teacher (causal requirement) as a considerable precondition for achieving the objectives in the process of artistic-creative communication. From the data it showed that the number of events restrictive process of artistic-creative communication approach can be minimized teacher.

The role of the teacher in the process is Ad1 create an appropriate atmosphere for the development; Ad2 work and painting techniques applied to the process of creation; Ad3 actively respond to students through verbal, nonverbal and creative aspects; Ad4 coordinate the V-; Ad5 coordinate the creative process of the student (not

including the disruption territories repaint etc.); Ad 6 pupils leave room for all kinds of expression; Ad7 for groups interested in creating a hierarchy.
Communication in this case includes all involved. Rate estimate how many students say about them is very difficult and it is assumed that the communication skills of teachers who cannot afford to be too personal, but through the prism of the circumstances should be able to communicate with the student as an equal partner in creation. Communication with students is one of the new challenges for the contemporary teacher.

4. Recommendations for practice

The method artistic-creative of communication can serve as a good resource for illustration for teaching painting techniques, or even building the image and abstract works. It also provides scope for improving communication between teacher and students and students with each other. The use of this space is the teacher and his communication skills.
The process of artistic-creative communication is quite structured and for various age groups may have different goals. We worked with him in the context of learning painting techniques. Research laid the foundation for further progress. Working with artistic-creative communication with other age groups, the non-specialist schools, more focus on the impact of personality development and teacher of painting in the style of independent creation by respondents work within the artistic-creative communication.

5. Conclusion

For acquiring skills in painting techniques in the process of artistic-creative communication it needs to teach pupils about activities to do, defined techniques, to name and to respond to their own experiments. Teacher in creating progressively implemented various painting techniques in a way that their other "forming" registered,
Artistic-creative dialogue may be an appropriate method for helping teachers to facilitate their vividly convey the students to work with painting techniques, disrupt formulaic visual learning process and establish effective communication with their pupils. It also showed that joint helps to create progress, teacher. Both sides in experimenting with the techniques in the process acquire a broader means of expression and perception of space abstract image as an internal record of the whole dialogue.
As a result of research we consider creation The Guide of painting techniques for school practice and creation, which was based on the progress and results of research. It maps the intersections of classic and contemporary painting techniques and adapting their categorization for artistic, educational practice. Painting techniques are selected on the basis of the procedures in research and the possibilities of their integration into the school setting.

References

[1] Anatrella, T., The adulescents. In Études, Volume 399, 2007/7 p. 37-47. ISSN 0014-1941 Available on: https://www.cairn.info/revue-etudes-2003-7-page-37.htm#no1
[2] Labáth, V. et al., Riziková mládež. Bratislava: SLON, 2001, 4 p. ISBN 80-85850-66-4
[3] Losos, Ľ., Techniky maľby. Bratislava: Pallas (SFVU), 1992, 8 p. ISBN 80-7095-014-5
[4] Luna, B. et al., Maturation of Cognitive Processes From Late Childhood to Adulthood. In PubMed, 2014. Volume 75, n. 5. (Sept.-Okt.) 1357-1372 p. Available on: https://www.researchgate.net/publication/8344332_Maturation_of_Cognitive_Processes_From_Late_Childhood_to_Adulthood
[5] Maslow, A. H., Ku psychológii bytia. Modra: Persona, 2000, 164 p. ISBN 80-967980-4-9
[6] Ondrejkovič, P., Socializácia mládeže ako východisková kategória sociológie výchovy a sociológia mládeže. Bratislava: Veda, 1997, 14 p. ISBN 80-224-0476-4
[7] Shaputis, K., The Crowded Nest Syndrome: Surviving the Return of Adult Children. WA?:Clutter Fairy Publishing, 2004. ISBN 978-0-9726727-0-2
[8] Silverman, D., Ako robiť kvalitatívny výskum. Bratislava: Ikar, 2005, 190 p. ISBN 80-551-0404-4
[9] Šalda, F. X., Boje o zítšek. Praha: Melantrich, 1948, 247 p.
[10] Šobáňová, P. et al., Useful symbiosis: sciene, technology, art&art education. Olomouc: Palacký University, 2016, 214 p. ISBN978-80-244-4853-4
[11] Turček, K., Psychopatologické a sociálno-patologické prejavy detí a mládeže. Bratislava: IRIS, 2003. ISBN 80-88778-99-9

STATISTICAL SURVEY OF REGISTERED DELINQUENCY TO THE POLICE, PROSECUTION AND THE COURT COMMITTED BY YOUNG PEOPLE IN THE REGION OF KYSUCE

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Abstract: *The article presents the most significant research findings out of the delinquency recorded by police, prosecution office and court of law in the region of Kysuce. Juvenile crime incidence in the district of Čadca for the years 2010 and 2015 are compared, using statistical processing. Children and juvenile delinquency is considered to be a serious problem which is necessary to be solved. The important role for solving this problem is prevention. Parents and their responsible attitude towards children' bringing up, intensive Civics and Ethics schooling, education in the field of basic law, realization of various projects focused on hobbies and leisure time activities are the ways, which help to reduce negative behavior of youth within the society.*

Keywords: *juvenile, delinquency, prevention, school, family*

1. Introduction

Through the overview of historical events we can assess that criminality is the phenomenon which has been occurring within all social systems. And it will continue to exist. This social-pathological phenomenon has always been here. As Rousseau (1753) claimed in his work "Discourse on the Origin and Basis of Inequality among Men", all the evil has its basis in private ownership, the lust for power. The consequence of above mentioned are riots, wars, crimes etc. The crime is undesirable act of human behavior which threaten life, health and property. It brings violation of both, written and unwritten rules and laws of particular society. The most dangerous form seems to be juvenile delinquency.

1.1 Juvenile Delinquency

Sejčová[2]created juvenile delinquent typical characteristics. It is characterized by single-parent family background with higher number of siblings, lack of financial means, weaker social background, absence of parental love, corporal punishments applied on children. The behaviour at school is troubled. Its typical features involve conflicts with teachers, aggression, truancy, minimal or no interest in learning, a fear from parents' reaction to poor marks, grade retention. Life satisfaction of a juvenile is low. A juvenile is not satisfied with his life and fells an urgent need to change his behaviour. He has a feeling of injustice, which he is hardly able to forgive. He is often a victim of a sexual abuse. Value orientation is focused on materialism and it is purpose-built. The need to possess dominates (preferably immediately), with purpose to avoid prison; the choice of models and ideal is in contradiction with the parents (never to be like my mother or father). He tends to take a liking to negative idols. Free time activities are spent in negative way (tobacco, alcohol, drug using). An individual chooses programmes with violent themes and identify himself with negative roles not only within the films but also in the real life. Performance - related motivation is decreased due to the fear of failure. An individual craves after people from broader surrounding who could evaluate his performance. He tries to reach his goals and outputs not for oneself, but for the others. His attitudes towards antisocial individuals and acts are more indulgent. He tends to detract serious crimes, accept and adopt asocial behaviour (drugs, alcohol using etc.); his attitudes to drugs is based on his own experience, while he lacks knowledge concerning prevention and harmful effects of drug using. The most common forms of delinquency are [1]:

- property crime
- violent crime
- crime against morality
- drug crime
- racially motivated crimes

1.2 Research aggregates and discoveries

The research topic was juvenile delinquency incidence in the district of Čadca for the year 2015. This was compared with the year 2010, analysing records of criminal offences committed by juveniles in the district of Čadca. Criminal offences (CO) were divided according to particular chapters of the criminal code (CC) which had been violated by juveniles. These are Chapter 1 of CC (Offences against Life and Limb), Chapter 2 of CC (Offences against Freedom and Human Dignity, Chapter 4 of CC (Offences against Property), Chapter 8 of CC (CO against Public Order) and Chapter 9 of CC (CO against Other Rights and Freedoms). From the total number of CO for the year 2010, the police registered 276. In the year 2015 the number of recorded CO was 258. Statistics for the year 2010 show that there were 58 CO against life and limb, 38 CO against freedom and human dignity, 142 CO against property, 6 CO against public order and 32 CO against other rights and freedom. In 2015 the police recorded 258 suspicions of committing CO. 48 of those were against health and limb, 14 against freedom and human dignity, 192 against property, none of them against public order and 4 against other rights and freedoms.

The results of juvenile delinquency comparison show that the difference in the number of CO committing is quite significant. From the long-time experience we can state that this statistical difference has not its foundation in crime reduction but as a result of pressure on police work, crime detection and public opinion as well as in legal illiteracy of our population. As specified in CC, a criminal act is considered to be a CO when a pecuniary loss exceed 266€; in the case of CO against health when the time of work incapacity (sick leave) exceeds 7 days.
The following graph indicates the summary of particular CO for the years 2010 and 2015.

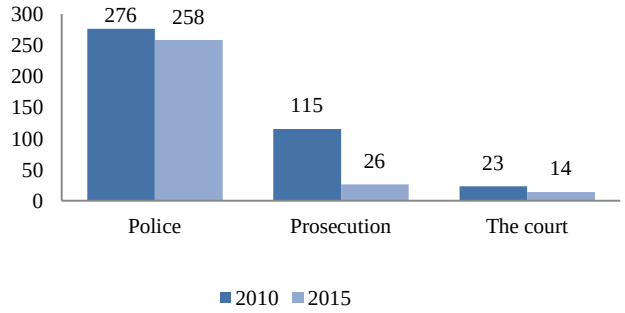

Figure 1: Total incidence of crime for 2010 and 2015

The following graph no. 2 indicates selected field of research, e.i. the number of proceeded CO exercised by the organ responsible for penal proceedings and by court of law in the year 2015.

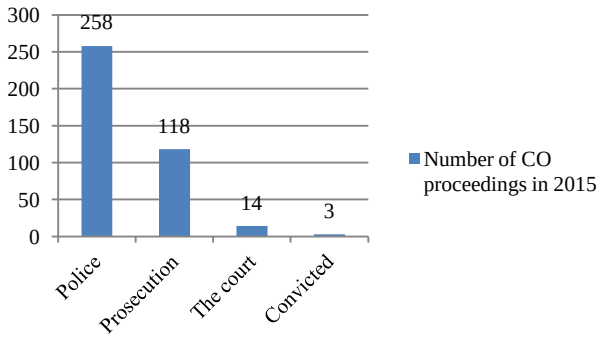

Figure 2: The number of juveniles' Co proceedings by organ responsible for penal proceedings and the court of law in the year 2015

In comparison with the year 2010, 15 juveniles were convicted in 2015. Particular institutions applied various CO procedures, e.g. plea bargain, case referral, case refusal etc. Examples and numbers are presented in the table 1.

Table 1: The number of CO proceedings by police in 2015

Police in 2015	*number*	*percentage*
crime incidence	258	100,00%
case referral	70	27,13%
case refusal	47	18,22%
case suspending	23	45,74%
accused person	118	45,74%
proposal to submit accusation	101	39,15%
proposal to conditionally terminate the criminal prosecution	13	5,04%
proposal to conciliation	4	1,55%

2. Prevention

Under this term we understand complex set of activities which are used to eliminate the risk of anti-social behaviour. It is considered to be a challenging process. On the other hand, it is necessary to be aware of the fact that education and bringing up, hobbies focused on personality developing are significant measures, which help to prevent children and juvenile delinquency. The school process is also significantly involved. It is seen especially through the school subjects of Civics and Ethics etc. Hobbies, after school leisure activities, special projects organised in cooperation with police, courts of law and other entities, education to healthy lifestyle, activity of prevention coordinator at school and cooperation of school with non-school organisations is also an important part of delinquency prevention. Prevention can be divided into three forms – primary, secondary and tertiary. School is a part of primary prevention form. Its primal function is to prevent pupils' delinquency. The function of secondary form is to reveal and deal with prevention towards juveniles. Tertiary form is focused on the work with delinquent juveniles; with the goal to prevent possible crime relapse (recidivism).

Conclusion

Particular types of juvenile delinquency are also influenced by the state of society and its technical progress. Juvenile delinquency is considered to be a serious problem. This problem must be solved, reduced, both in legal and moral respect. As the research results clearly show, the most frequent committed criminal offences are those against property (especially robberies), in combination with minor offence of forcible entry into dwelling and disorderly conduct. Early prevention, as a tool for possible reduction of children and juveniles delinquency is emphasized. This might help to strengthen family cohesion, as well.

References

[1] ONDREJKOVIČ, P. a kol. 2009. Sociálna patológia. Bratislava : VEDA. ISBN 978-80-224-1074-8.
[2] SEJČOVÁ, Ľ. Deti a mládež ako obete násilia. Bratislava : Album, 2001 pp.293-303. ISBN 80-968667-0-2.

TEACHERS´ COMPETENCIES IN CYBER BULLYING PREVENTION STRATEGIES AT PRIMARY SCHOOL

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Abstract: *The study investigates the influence of teacher competence on cyber bullying prevention strategies at primary school and achievement in skills to create training needs in order to develop teachers' vocational and pedagogical competences as well as competences relating to prevention and supporting co-operation and to the parents community. Schools should not be separated from the community where students are coming from to do better work with youth at school and eliminate different pathological manners. Second part of this study investigates the extent of pupils' experience of cyber bullying. A survey study of 152 students from primary schools and 40 teachers was conducted. In this paper, 'cyber bullying' refers to bullying via electronic communication tools. The teachers refers experiences with prevention programmes in cyber bullying at primary school. The results show that close to half of the pupils were bully victims and about one in five had been cyber-bullied. More than half of the pupils reported that they knew someone being cyber bullied and the most of them know the offender personally or have a relationship with him at school or meet him at home.*

Keywords: *cyber bullying, prevention strategies, teachers at primary school*

1. Introduction

The theoretical framework is based on perspectives in which individuals and the school environment influence, and are influenced by each other in a continuous interaction when teacher competences could here be summarized as the ability, to relate oneself both to the expectancies and demands of society, as well as to one's own attitudes and manners.

Ferguson studied teachers' results on a license test measuring pedagogical skills as well as subject knowledge. They related the result to student achievement and found these variables to be more powerful than class size and school size [1].

One common indicator of teacher competence is teaching experience. However, according to Wayne and Youngs [2], the findings regarding experience are difficult to interpret for several reasons. First, experience captures the effect of whether teachers were hired during a shortage or a surplus. Cohorts will have experienced similar competition, and selection effects are likely to confound effects of experience. Secondly, experience measures capture differences in teacher motivation resulting from time constraints on parents during years when their own children require more attention. Finally, if there are differences in effectiveness between those who leave the profession and those who stay, experience measures would capture those as well. Such differences are probably dynamic, changing with society, globalization and educational trends.

Several studies have found a positive relationship between teacher experience and student achievement as well as supporting pupils´ motivation at learning process and using active learning methods in the way suits both sides [3].

The anonymity of the Internet and knowing that they are less likely to be punished for acts taking place off school grounds makes cyber bullying a attractive as kids think they will not be held accountable for their actions. [4]

A study by Berson showed that when teachers, parents, or other caregivers have an ongoing dialogue about cyber activities and monitor adolescents´ Internet use there is a "decreased tendency to engage in cyber activities that lead to potential harm" [5].

The "Protecting Children in the 21st Century Act" of 2008 specifies that schools teach students about "appropriate online behavior, including interacting with other individuals on social networking websites and in chat rooms and cyber bullying awareness and response" [6].

Schools have used Internet safety education as strategy for reducing risky online behavior to protect students from cyber bullying and other forms of cyber harassment. Cyber bullying prevention strategies include incorporating cyber bullying prevention into anti-bullying programs at schools that should be implemented together with setting clear rules and consequences, raising awareness about cyber bullying among pupils, using Internet filters, acceptable user policies and showing students the aspects of criminalize cyber bullying and reporting of incidents for preventing cyber bullying. [7]

1.1 Methods

A mixed methods research design first using quantitative data was used in order to explore what cyber bullying policies are being employed by directors at primary school and the level of competencies to do cyber bullying prevention programmes aimed at involving active learning methods among pupils to eliminate bullying and risk behavior of the youth.

A non-standardized questionnaire, ´School prevention strategies and pupils´ experiencing cyber bullying was verified in a pre-research. Questionnaire reliability ranged from 0.58 to 0.7. The questionnaire contains scaled items and open questions focused on teachers´ competencies and prevention strategies.

The collected answers are analyzed and statistic characteristics are set (mostly median,

quadrille rate, possibly mean, modus etc.); these data are used in following rounds of evaluation (Bílek, 2008). Return rate of questionnaires was 100% due to the fact that the researchers distributed and collected them personally. The collection of data was made in 04-07/2015 including 40 teachers and 152 pupils at primary school.

The research survey was divided into two parts. In part 1 the application was evaluated from the point of pre-defined set of teacher´s competencies and preparation in objectives of cyber bullying prevention programme at primary school. Second part was focused pupil´s experience with cyber bullying and prevention strategies done at school.

Teachers expressed their opinions on four-level scale yes (1) – rather yes (2) – rather not (3) – not (4), whether the application provides support to reaching learning objectives and effectiveness of prevention programme and to having right competencies:

C1: Personal competences: Teacher is able to solve problems and manage conflicts in class, including the ability to active listening, giving constructive feedback, be aware of their own strength and weaknesses, preferences and dislikes to tackle misunderstandings, to assert one's own concerns and rights, without violating the rights of others, the ability to empathize with feelings of the pupils and understand group needs.

C2: Pedagogical competences: implies that the teacher from definite goals and frameworks, through continuous development of teaching and personal professional development, supports and facilitates the learning of the students in the best way (In Ryegård, 2010).

C3: Management competences: Teachers´ ability to do effective classroom management, and quality prevention programme implementation, make healthy teacher-student relationship, to create special learning environment for students with special needs.

C4: Vocational competences: teacher must have the ability and motivation for self-evaluation and reflection. to determine the extent the required learning outcomes, to be able to cooperate in creation learning environment and facilitate learning process in different levels.

The cyber bullying prevention programme under review takes into account the fact that successful educational activity and prevention in school calls for personal competences, as well as management and method−related skills.

In part 2 the experience of cyber bullying was evaluated on the five--level (5) – very good (4)– good (3) – sufficient (2) – low (1) – very low (1). Experience of cyber bullying were included in the view of victim and offender, level of cognition, motivation elements, activation and prevention strategies.

1.2 Results

Teacher must be competent to establish and lead good relationship with all social partners, to communicate and interact at many different levels and coproduct the learning process with all partners. Linking with colleagues to discuss the trials and challenges of teaching and share instructional strategies can result in solutions that can teachers immediately apply in the classroom, and into development projects for the school.

Table 1 presents data including the teachers´ competences needed in learning and teaching process at primary school implementing cyber bullying prevention programme.

Table 1 Correlation between teacher´s competences and personal perceptions

Competences / Teacher	*Have to teacher and learn*	*To educate and guide*	*To evaluate*	*Have to counsel*	*Have to innovate*
Personal competences	3.245	3.211	3.139	3.405	3.420
Pedagogical competences	3.521	3.195	3.083	3.922	3.901
Management competences	3.214	3.234	3.312	3.344	3.426
Vocational competences	3.218	3.547	3.426	3.320	3.714

Table 2 shows the methods used in prevention programme at primary school and it in the point of view of teachers. They find group work in class with combination of interactive workshops and preventive campaigns with active involvement of students as the best way of elimination pathological manners in school environment. On the other hand, teachers confess that lecturing, presentation and discussion are more often used at schools as the cheapest way of doing preventive programmes not bringing such a positive impact on pupils´ behavior.

Using peer to peer strategies in cyber bullying prevention programme brings positive interaction between pupils and effective way of sharing experience and exchanging opinions. Young people are more likely to listen to people like them, because young people have best knowledge of their lives, situations and contexts, they speak the same language in the same way and identify with the same cultural shorthand.

Table 2 Learning methods used by teachers in prevention programme

Methods	*Frequencies*	*Effectiveness*
Group work in the class	0.0314	0.020
Presentation about cyber bullying	0.0378	0.0415
Using active learning methods through experience	0.0294	0.0171
Peers prevention programme	0.0314	0.0163
Discussion forum	0.0411	0.0321
Interactive workshops	0.0215	0.0324
Lecturing	0.0408	0.0478
School campaigns against bullying	0.0509	0.0032

The finding is consistent with research that pupils use technology as a link to their friends and social life. No student, regardless of whether they are a pure-offender, pure-victim, or neither-offender-nor-victim, would want to be is isolated from their social network online. Parents,

schools, and social networking sites all are important stakeholders in preventing cyber bullying [8].
Hence their cooperation is needed to for that purpose. Policies need to be in place at school, and the school should involve parents when a cyber bullying issue arises. Meanwhile, parents have a responsibility to establish and enforce rules at home. Such a joint work is necessary for effectively resolving the problem of cyber bullying [9].

2. Discussion

Effective bullying prevention programs have to change the school environment and support healthy peers relationships at school and also outside of school. Cyber bullying prevention programs need to have a similar philosophy and need to empower students to stop cyber bullying themselves. Students do not perceive being told not to cyberbully as changing the school climate. They may find programs that teach them what to do if they are cyber bullied and lose control on offender.
Prior research by Harris Research for the National Crime Prevention Council revealed that 47% of teenagers thought that "cyber bullying happens because the cyberbully doesn't perceive any tangible consequences" and 45% thought it "happens because the teen think she or she won't get caught" [13]. That research also found that teens perceived the most effective strategies to be "blocking people online who bully, refusing to pass along cyber bullying messages and online groups having moderators who block offensive messages as being the most effective" (Moessner, 2007, p. 4). Strategies that were perceived as less effective were "all schools should have rules against cyber bullying; schools should educate students in small groups not to cyberbully, holding school assemblies to educate students not to cyberbully, and teaching adults to help young people not to cyberbully" [13].
Baková [14] points, that cyber bullying brings negative aspect to personś personal development and can lasts a long time to avoid offender´s attacks. Children who are targeted by cyber bullying display negative reactions that are similar to those of children who are victims of traditional bullying.
Cyber bullying has been linked to multiple maladaptive emotional, psychological, and behavioral outcomes [9]. The physical and metal effects of cyber bullying vary depending on the victim, but the consequences include low self-esteem, anxiety, feeling sad, being scared, feeling embarrassed, depression, anger, truancy, decreased academic achievement, an increased tendency to violate others, school violence, and suicide. [10]
Not all victims of cyber bullying report serious effects, but according to one study, 34% of cyber bullying victims felt frustrated, over 30% felt angry, and nearly 22% felt sad [11]. Although these behaviors don´t initially occur at school, their emotional effects often accompany students when they do come to school. Because these emotions can lead to increases in violence, increases in truancy, and decreased academic performance schools have a invested interest in dealing with issues related to cyberbullying [12].

3. Conclusion

Cyber bullying is alarm problem that should be eliminated at school environment as well as teachers should be trained to create and develop flexible and innovative prevention programme for individuals and groups based on strategies agent bullying and online harassment. Teachers are expected to be able in finding new ways in which prevention programme can be facilitated and to construct intellectually challenging, inclusive and participatory learning experiences that connect with the psychological intervention and supervision. It is important in realisation of prevention programmes at schools to eliminate risk behaviour in learning environment and to take part in parents control.
Pedagogical knowledge including knowledge of learning, teaching methods and curriculum have more often been found to influence teaching performance, and frequently these factors exert even stronger effects than subject matter knowledge. Teachers have to use specific methods based on active learning techniques to prevent cyber bullying and to form prosocial behaviour between pupils.
Research showed strong relation to teacherś quality of methods and efficiency of prevention programme. It is necessary to choose right active learning methods suits to age, mental development and large of group to achieve good results in prevention strategies among pupils. In a study involving 40 teachers and 152 pupils found that the quality of the prevention programme has a comparable impact on students' manner and elimination of risk behaviour in school environment.
Teacher must have the ability to make healthy relationship with pupils in the case to solve different serious situations and problems. Teacher is supposed to be autonomous and confident expert who is playing proactive role in school field. He is also supposed to be communicative, sensible and motivated enough to observe and lead constructive dialogue with his students in purpose to find best options for supporting their personal development and support children protection against violence and bullying.

References

[1] Ferguson, R.F. Paying for public education: New evidence on how and why money matters. Harvard Journal on Legislation, vol. 28, No. 2, pp 465-498, 1991.
[2] Wayne, A. J., & Youngs, P. Teacher Characteristics and Student Achievement Gains: A: Review. Review of Educational Research, Vol. 73, No. 1, p. 89-122, 2006.
[3] Myrberg, Rosén, M. The impact of teacher competence in public and independent schools in Sweden. 2004.online] Available at < http://www.iea.nl/fileadmin/user_upload/IRC/IRC_2004/Papers/IRC2004_Myrberg_Rosen.pdf [Accessed 04 April 2016].
[4] Shariff, S. Cyber-Bullying: Issues and Solutions for the School, the Classroom and the Home. Canada: Routledge, 2008.
[5] Berson, I. R. Emerging risk of violence in the digital age: Lessons for educators from an online study of adolescent girls in the United States. Journal of School Violence, Vol. 1, No. 2, p. 51-71, 2002.

[6] Protecting Children of the 21st Century Act. 2008. [online] Available at: http://www.theorator.com/bills110/text/s49.html [Accessed 18 November 2012].
[7] Willard, N. Educator's Guide to Cyber bullying and Cyberthreats. Center for Safe and Responsible use of the Internet. 2007. [online] Available at http://cyberbully.org/cyberbully/docs/cbcteducator.pdf[Accessed 08 December 2013].
[8] Ybarra, M., Diener-West, M., & Leaf, P. Examining the overlap in Internet harassment and school bullying: Implications for school intervention. Journal of Adolescent Health, Vol. 41, p. 42-S50, 2007.
[9] Hinduja, S., Patchin, J. Cyberbullying Research Center. 2009. Cyberbullying fact sheet [online] Available at: http://www.cyberbullying.us/cyberbullying_fact_sheet.pdf -[Accessed 18 January 2016].
[10] Willard, N. Should schools be able to regulate off campus cyber bullying? CQ Researcher Online, Vol. 20, No. 48, p. 23-24, 2008.
[11] Patchin, J. W., & Hinduja, S. Bullies move beyond the schoolyard, A preliminary look at cyber bullying. Press: Youth Violence and Juvenile Justice, 2006.
[12] Beran, T., Li, Q. The relationship between cyber bullying and school bullying. Journal of Student Wellbeing, Vol. 1, No. 2 , p. 15-33, 2007.
[13] Moessner, C. Cyber bullying. Trends and Tunes, Vol. 6 No. 4, 2007. [online] Available at < http://www.harrisinteractive.com/news/newsletters/k12news/HI_TrendsTudes_2007.pdf. [Accessed 21 June 2010].
[14] Baková, D. 2015. The authorities of social services. Life and work of social workers and their attitudes to their job. Sládkovičovo: VŠD, 2015. p. 178 . ISBN 978-80-8167-018-3.

Session: History, Sociology

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INSPIRATIONS OF ADAM OF BREMEN. COMPARATIVE SOURCE CRITICISM

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Abstract: *Adam of Bremen was one of the most important chronicles of the eleventh century. He wrote a chronicle Gesta Hamburgensis Ecclesiae Pontificum. This work is full of information. Many of them are about northern Europe, Iceland, Greenland and the mysterious Vinland. However, the question is what is true, what has been borrowed from other sources, what content has survived to our time. This paper presents criticism of the source in the context of Vinland. On individual examples, we explain what elements of the chronicler's description were borrowed, and what might be original. In addition, we try to answer a question about the multiple processing and borrowings of one source content by other documents. Finally, we hypothesize that the work of Adam of Bremen contributed to the creation of Vinland's vision in the written sagas.*

Keywords: *Adam of Bremen, Vinland, Vikings, Gesta Hammaburgensis, America*

1. Introduction

Adam of Bremen (*Adam Bremensis*) in one of the most important annalist of the 11th century. The most of his works present the economic analyses and descriptions of the Northern Germany (Holy Roman Empire), especially the archdiocese of Hamburg-Bremen. The most important and timeless his masterpiece is the chronicle: *Gesta Hamburgensis ecclesiae pontificum* [1]. In that piece of work, we can find a lot of content about Hamburg-Bremen neighbourhood, economic, society etc. Nonetheless, the most interesting and unique is a description of the Eastern and Northern Europe. Moreover, there we can come across a mysterious information about *Vinland* – the place that could be related with North America [2], [3].

Until the end of 20th century, many researchers have thought that Adam of Bremen had the fully independent, first-hand access to the most facts mentioned in his works. Certainly, descriptions of the Northern Germany could be made by himself based on his own experience. However, this conclusion related to the Northern Europe and this *Vinland* cannot be relevant. Currently the majority of historians think that the most information included in that chronicle is a chicanery or nothing less than borrowings from other authors. Nevertheless, among these elements we are able to find a unique and new information, especially about Nordic area. This part of his work is the most valuable for readers. Concurrently, the biggest challenge for historians is to recognize what is truth, fraud, borrowing or semi-genuine *litentia poetica* [4].

We cannot read Adam's papers without any reflection. In this short discussion, we would like to present how the 11th century chronicler builds his narration. What kind of borrowings and real description he was making. What kind of reality was invented based on genuine and seeming facts. Moreover, we have to define what rather imports the author made and what the reason to do that was. Certainly, this content we will understand in the background of his life, work, possibilities and experience. Finally, we present examples of his creativity and present the impact of his frauds. Here we will not depict whole of his life and works. We will focus on his opinion about the Northern Europe and this eerie *Vinland*.

2. Personal background

Adam Bremensis is one of the best example of the middle medieval chronicler and author. We have not detailed information when and where he was born. However, we expect that it be shortly before 1050. On based of his style, language and information included in his works, we assume that earliest years he spent in the East of the Kingdom of Germany, probably in Meissen (Misena) and Lusatia. We have not the "strong" proofs when he died. Notwithstanding, one of the chronicle co-author or the continuator mentioned that Adam died on 12th October. Unfortunately, he forgot to underline a year. We can expect that this moment was happened between 1081 and 1085 [1], [4].

It is extremely difficult to follow Adam's *curriculum vitae*. We do not know his family status. Probably they were noble from the middle class. He could not be the oldest son in the family whom traditionally succeed the status. Accordingly he was sent to the basic and then cathedral school in the closest diocese. This one was in Magdeburg. In 11th century, that bishopric was deeply involved in the Christianisation and aggrandising of the German influence in the East Europe (Poland, Polabian Slavs, and Czechia). Probably precisely, here he had a brush with the acting Christianization, missions and people from external territories. The most popular theory of the Adam's biography presents that he met there missionaries or knights from the Northern Europe. In addition, he could not find a permanent job in Magdeburg.

Simultaneously in Bremen on the archbishopric throne sat Adalbert – famous and one of the most important promoter of the Christian church in the Nordic countries. The theory predicates that Adalbert invited our master to Bremen. The proposition was to become the chronicler of Bremen-Hamburg archdiocese and the missions in the North. Adalbert needed more educated man to rule and register his great activity in Christianization of the northern

Europe. Therefore, Adam's relocation from the 200 km away Magdeburg was quite natural [1], [5].
Adam arrived to Bremen and Hamburg before 1069. On based of his chronicle we can suspect that he was in that time ca. 20 years old man. When he arrived there, he went to the dead centre of the multicultural, dynamic society. In that time Bremen-Hamburg archdiocese was a main point on the map of North-South relationships and Christianisation. Bishop Adalbert created very powerful and important diocese opened on the Northern affairs. Our master had a great possibility to learn there exotic languages and meet people from whole Europe, particularly Scandinavia. In the sequel, Adam could stimulate and describe these relations and stories of met people. Additionally, he had to work in the bishop's administration to note the story of Adalbert and his province. In this way, some registers and the Chronicle were created as the greatest advertisement of the bishop's work [4].

3. Adam's chronicle

The most important work of Adam is his chronicle – *Gesta Hammaburgensis ecclesiae pontificum*. This *opus magnum* was written as the gift for archbishop Adalbert. The purpose of this piece of work was to make a description of the archbishopric's power, real estates and influence. Moreover, this paper was made to spread a glory of Adalbert on the field of Christianisation of the Northern Europe. *Gesta ...* has a form of the encomium of the bishop's achievements. Probably should be also perceived as the Adalbert's hagiography. Therefore, we have to be very careful about facts, opinions and attitude included there. Advertisements always lay too much.
Adam's chronicle is segmented of five books. First three parts are devoted for the description of the dioceses' assets (real estates, funds, and library). In the second and third books, we find very interesting and informative facts about Germany and local politics with very broad description of the natural environment of Bremen-Hamburg state. There we are also informed about the bishop's life. The addendum to those volumes are so great information about German-Danish political affairs. The most mysterious book of this chronicle is the fourth part. The title *Descriptio insularum aquilonis* does not explain anything. However, in that place we can find the most revolutionary information. There we observe images of the Slavs states and Danish borderland. Moreover, Adam described this kind of lands as Norway and Sweden. It is not everything. Exactly there we discover the first written information about Island and the unknown place called *Vinland* (probably the North America) [6], [7]. This part is written on based of the witnesses' reports and opinions. In the penultimate part, we encounter thousands of borrowings from multiple works. The end of chronicle, written by the glory poem, is replete by the fantasies and cock and bull stories [1], [4].
Adam informs the reader that the Chronicle was created between 1066 and 1069. However, the narration tells us the story from 845 to 1069. Dating is not clear. Therefore, some researchers suggest that the story finishes in 1072. We do not know why the end of the masterpiece story was in that year. Probably we can explain it the death of the Adam's patron – bishop Adalbert. After that, there was no reason to continue the panegyric [5].
In this work, especially in the fourth and fifth part we can find thousands of information. Some of it is a truth on based of relations of witnesses who had visited Nordic lands and mysterious Island and *Vinland*. Many facts are vicarious. However, the most of figures are author's fantasies and very smart combinations of the ancient author's ideas, truth and inventions. Without deep knowledge and analysis, we can make plenty of mistakes in the book's interpretations. We can confound reality with fiction, facts from the 11th century and ancient mysteries. Extremely important is to define and explain what kind of Adam's descriptions are just borrowings and which are real stories from the North of the World.

3.1 Borrowings - examples

The reason of this short thesis is to demonstrate how Master Adam constructed and presented narration of his Chronicle. However, the most important is to define how he created facts based on the earlier, ancient works of other authors. Non-expert of his work could expect that content created by Adam is his own authorial job. Certainly in many points is like this. Therefore, we can use this information to describe Scandinavia, Island or Vinland (probably America) [8]. Unfortunately, the most of creatures, lands, behaviours mentioned in his work is a fake. Examples imported from other works of random authors from the ancient times. Especially in the fourth – *Vinland* chapter we find plenty of these kind of borrowings. Probably the *terra incognita* was replacing by content from other works or fantasies [1]. Look at the Adam's style.
[…] a*nd when these women come to give birth, if the offspring were of the male sex, most beautiful women. Living by himself, the latter spurn consort with man and, if men do come near, even drive them resolutely away. The Cynocephali are men who have their heads on their breasts. That are often seen in Russiaas captives and they voice their words in barks. In that region, too, are those who are called Alani or Albani, in their language named Wizzi; very hard-hearted gluttons, born with grey hair.* (Adam of Bremen, *Gesta…*, 4th chapter, XIX) [1]
Children could think that it was a part of the fairy-tale. Historians-amateurs could look for the sense, creatures and places (without effect). The professional researchers will find here some minimal facts, which reflect the reality. However, it is extremely difficult to unpick the truth. For us this passage is the best example of the technique of construction of the narration – mixing the reality with a tale, author's ideas and experience with works of other writers, testifies of witnesses and borrowings from the ancient times. Above all this kind of story is a wonderful proof of the erudition and mastery of well-educated man.
When we compare this part to works of Solinus (*De Mirabilibus Mundi*, XXX) [11], Jordanes (*Getica*, VII, 44) [10] and Martianus Capella (*De Nuptis*, 665) [9] we can observe that Bremen's master made very elegant

compilation. Moreover, he added also a bit from Orosius' interpretation of Alfred the Great [12], Vergilius (*Eneida*) [13] and Pliny the Elder [14]. It is quite easy to find accurate sentences from each opus. Consequently, there is extremely difficult to find what his own relation is. We know that Adam has never left northern Germany. He could not know the geography and society of other lands from other sources than newcomers' relations and other books. We are sure that 90% of his chronicle must be the import because also he could not experience so much. Unfortunately, in this spate of borrowed, fake information it is very difficult to find figures from the real 11th century reality.

3.2 Vinland

The legend of *Vinland* is the most interesting of the Adam's chronicle. Outside the sagas area (Scandinavia, Island) the fourth book of *Gesta ...* was only the one place where this term and place appears. Therefore, it is very important to differentiate what is just a fake or borrowing or what is a part of the real relations of witnesses of those lands (vide *Gesta ...,* 4th, 38) [1].

We can think that the chronicler describes new land in any unknown area. We can find here references to kings and nobles who left in Adam's times. In addition, we observe information about the environment, whether and phenomenon which could be presented in 11th century. However, we have real problems with the location of this area. Therefore we begin expect that this part of Adam's work also can be kind of borrowing or fiction. No witnesses testified about these times and places both for Adam or other authors. Accordingly, we find similarities in Master's favourites authors e.g. in *De Nuptis* (VI, 666) [9]

The most of researchers had thought that Adam collected relations about Scandinavia, Baltic See region and these mysterious Vinland, Ultimo Thule and Island from witnesses who were taking part in the missionary actions in the North or missionaries who spoke with indigenes. We thought that Adam or some missionaries spoke with Svein Estridsson – the Danish king deeply involved in wars and Christianisation in Norway. He had to transfer this information about Island and Vinland to Bremen [2], [7], [8]. Unfortunately, when we compare Martianus' relation to Adam's Chronicle we can see that both of contents about Vinland are very similar and sounds like this:

Winland, eo quod ibi vites sponte nascantur, vinum optimum ferentes (*Gesta ...*4th chapter, XXXVI) [9]

Is it indicative of the Adam's borrowings from Martianus? Probably it is right. We know that the king of Denmark has never been further that in the area of Oslofjorden. Therefore, he could not have information about the Northern Norway affairs from his own experience. We expect also that Estridsson has never met Adam. Simultaneously we see that Adam made many imports from other ancient fabulists. It is not right to believe that one incredible man knew a lot of Norway, Island and America [15]. Therefore, we have to deny this part of Adam's relation as his own *litentia poetica*, merged from hundreds of books, reports, ideas etc. Probably among this content we have also examples of ancient authors, northern sagas, coetaneous works and relations of witnesses. Some of them could be in the northern Norway, maybe on Island and somewhere further. However, these statements are vicarious and not reliable. We are not able to prove direction of the communication and unpick truth [6], [7], [16].

3.3 Vinland – other sources

Adam was not only one who mentioned Vinland, Island and northern Europe. Besides our chronicle the most important and plausible works about that area are sagas. Stories about the life and journeys of Nordic people (also Vikings) from 10th until 12th centuries collected and listed in 13th, 14th and 15th centuries in Scandinavia and Island. All of these histories are written on based of tradition and other smaller sources, which has not survived to our times. The content of those sagas in some parts is so similar to Adam's relations about these mysterious lands. Especially in two sagas (Erik the Red Saga and Greenlining's Saga) [17], we can expect a few information about the Far North area. Hitherto the most of researchers have thought that Adam build his chronicle on the testimonies and these sagas. His origin masterpiece had to be the compilation also with sagas. Nowadays we know that it was impossible because in 11th century sagas were not collected and written. They circled in the North in the oral tradition. Certainly, in this form, Bremen's master could hear something but it could be only rumours.

Today we can think that in 11th century Adam knew nothing about the North. Perhaps he had no relations from Svein Estridsson or he transferred only the tradition of Vinland, Island and America (oral rumours) [18]. Maybe around few words Adam created his own story about mysterious creature on based of ancient authors. Another theory springs to mind. Adam's chronicle was very popular in Europe. However, we have only one copy from 13th century at our command (only passages). Probably volumes of this masterpiece were hold also in Denmark and southern Sweden. There in Lund from 1105 existed the diocese created as the Hamburg-Bremen archbishopric affiliate for the Nordic area. In the wonderful library of Lund had to be hold the Adam's chronicle. Also in similar time (from 13th century), oral tradition of sagas was noted. It was in progress in both Lund, Denmark and Island (Flateyjarbók, Hauksbók and Skálholtsbók) [19]. We can expect that for scribes the oral tradition was not enough to create the "real" image of Viking's life. Therefore, they had to use other sources to complete these stories. Certainly, they used ancient authors. However, they main source was the Adam's Chronicle. In this way, his book become the first source for the next story. Some of his fantasies were changed in the truth mixed with other stories from the oral saga's tradition. In this way, we received the mixture of 99% of imaginations and 1% of truth. However, this situation was not happened during the Adam's work but later. Not in Bremen but in Scandinavia and maybe on Island.

We see that in some sagas also we meet the same stories, written so similar to Adam's style. Earlier we had expected that sagas influenced Adam's Chronicle. Maybe it is on

other way. Adam created his own reality (middle of 11th century). Than his Chronicle was red by thousands of educated man who created new vision of the world (12th - 13th centuries). Finally, these academics received some data from sagas, merged both information and created entirely new vision of the North (13th – 15th centuries). In this way in these sagas' content, we do not have the real vision of the oral stories but we have the compilation also with Adam's fantasies. For example, we know that in Islandic saga Hauksbók are included other sources, for example *Algorismus Vulgaris* by Johanes de Secrobosco from middle of 13th century [20]. When we trail of this example, we should look at Erik the Red Saga, chapter V [6].

We see that information mentioned in both texts are the same. This content is too similar to derive from one 11th century. Probably it is a proof that also in Erik Rauda saga we can find Adam's imaginations. This example is not a two sources confirmation of some situation. We have a brush with one source just processed thousand times by tradition, scribes, languages, culture. This masterpiece is an Adam's Chronicle.

4. Conclusions

Adam of Bremen was one of the most important chronicler of 11th century. He created wonderful chronicle - *Gesta Hammaburgensis ecclesiae pontificum.* This masterpiece deeply describes situation in the northern part of Germany and is a panegyric about the life of bishop Adalbert. However, in addition this work shows us new undiscovered lands as Scandinavia, Baltic See region, Island and mysterious *Vinland*.

When we read these kind of stories, we have to be very carefully about ideas, places, creatures and people, which are not mentioned in other sources. Very often it happened that the author creates his own reality on based of other, earlier and popular sources, oral tradition and unknown literature. It looks that in this situation it was happened. We proved that the most of Adam's chronicle is a borrowing from other authors. We presented also that Bremen's chronicler created new lands and new characters on based of older sources and uncertain oral tradition. Moreover, we have to be aware that sources interfere with other sources also years after the first recording. Probably in this situation, Adam's masterpiece in the 11th century was based on the remains of oral tradition about Vikings and *Vinland*. However in 13th and 14th centuries affected this tradition called sagas to create new, written "saga reality". Additionally across next centuries, sagas and Adam's *Gesta* were evolving and then were rewriting in thousands of versions and copies. These copies, which we obtained in 18th and 19th century, were just the one of version of those works. Famous historians who worked with these sources like Weitz, Mommsen or Magnusson tried to find the rule what was a truth or fake [5], [17]. Unfortunately, they did not think that Adam's chronicle could be both the vicarious and primary sources for sagas and could affected them so many times.

In this short study, we presented examples of this theory on based of the older researches. This paper should be beginning for the new open of the discussion of these kind of sources. However, the most important thing is to try to think about sources from different points of view. The easiest way of interpretation could not always be the only one.

References

[1] Adamus Bremensis, *Hamburgische Kirchengeschichte* Hahn, 1993.

[2] John Th. Honti, 'Vinland and Ultima Thule', *Mod. Lang. Notes*, vol. 54, no. 3, pp. 159–172, 1939.

[3] R. Bergersen, *Vinland bibliography: writings relating to the Norse in Greenland and America*. Tromsø: Universitetsbiblioteket, 1997.

[4] Adam Bremensis, *M. Adam's Geschichte der Ausbreitung der christlichen Religion durch die hamburgische und bremische Kirche in dem benachbarten Norden, von Karls des Großen bis zu Heinrichs des IV. Zeiten.* Bremen: Schünemann, 1987.

[5] Adamus Bremensis, *History of the Archbishops of Hamburg-Bremen*. New York: Columbia University Press, 2002.

[6] G. Jones, *The Norse Atlantic saga: being the Norse voyages of discovery and settlements to Iceland, Greenland and North America*. Oxford: Oxford University Press, 1986.

[7] G. Gathorne-Hardy, *The Norse discoverers of America*. Oxford: Clarendon Press, 1921.

[8] Adamus Bremensis, *Om menigheden i Norden under erkesædet i Bremen og Hamborg (788-1072): Tilligemed sammes beskrivelse af de nordiske lande*. Schønberg: P.W. Christensen, 1862.

[9] Martianus Capella, *Martianus Capella and the seven liberal arts*, vol. 2, 2 vols. New York: Columbia University Press, 1977.

[10] Jordanes, *Jordanes: the origin and deeds of the Goths.* Princeton: Princeton University Press, 1908.

[11] G. J. Solinus, 'De Mirabilibus Mundi', in *Collectanea rerum memorabilium*, T. Mommsen, Ed. Berolini: Weidmann, 1958.

[12] I. Valtonen, *The North in the Old English Orosius: a geographical narrative in context*. Helsinki: Société néophilologique, 2008.

[13] P. Vergilius Maro, *Eneida*. Wrocław: Ossolineum, 2004.

[14] Pliny the Elder, *The natural history of Pliny.* London: H.G. Bohn, 1967.

[15] J. Grove, 'The Place of Greenland in Medieval Icelandic Saga Narrative', *J. N. Atl.*, vol. 2, pp. 30–51.

[16] C. L. Phelpstead and D. L. Kunin, *A history of Norway, and the passion and miracles of blessed Óláfr*. London: Viking Society for Northern Research, 2001.

[17] M. Magnusson and Hermann Pálsson, *The Vinland sagas: the Norse discovery of America*. New York: New York University Press, 1988.

[18] H. Ingstad, *Westward to Vinland; the discovery of pre-Columbian Norse house-sites in North America*. New York: St. Martin's Press, 1969.

[19] Oddr Snorrason, *The Saga of Olaf Tryggvason*. Ithaca, NY: Cornell University Press, 2003.

[20] J. de Sacro Bosco, *Petri Philomeni de Dacia in algorismum vulgarem Johannis de Sacrobosco commentarius*. Hauniae: A. F. Host, 1897.

THEFT BETWEEN SPOUSES IN ROMAN CLASSIC AND JUSTINIAN´S LAW

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Abstract: *Furtum or theft is one of the oldest unlawful acts committed by human beings. In particular stages of evolution the society, interpretation and understanding of individual wrongful acts including the theft changes, and not just their legal qualifying, process of punishment, but also their classification as public or civil wrongs. On the other side, legal relationships between spouses also underwent significant variations based on concrete conditions of society and law. The prefatory part of this paper is dedicated to general characteristic of Roman classic law and Justinian Roman law and also contains definition of theft and marriage in these periods. The aim of this paper is to analyse the answer to question if the theft in the Roman classic law and Justinian Roman law could be committed between spouses. The last chapter of this paper points to actual legal regulations of Slovak republic related to this issue.*

Keywords: *furtum, theft, Roman law, matrimonium, spouses*

1. Introduction

The Roman Empire as a political organization passed away centuries ago, but Roman jurisprudence through its influence still remains a world power. Particular conceptual attributes of theft depended always on actual social situation and reflected priorities that were protected by society. Roman concept of *furtum* was broader in scope than the modern concept of theft. It encompassed not only the actual removal of another's thing but also a diversity of acts involving intentional interference with a movable object without the knowledge of, or contrary to an agreement with, the owner of such object. Some other cases of theft as were defined in Roman law, are in actual Criminal code incorporated as separate bodies of the criminal offences – embezzlement, unlawful enjoyment of a thing of another and fraud.

2. Prefatorial notes about Roman classic law and Justinian Roman law

Roman law reached its full maturity in classical period and this emanated mainly from the creative work of roman jurists and their influence on formulation and application of law. It is generally in juridical and historical circles acknowledged that classical Roman law is mainly the work of jurists and product of their argumentations [11] and discussions. Such statement can be simultaneously at the same time considered as just and also as false. The jurists of Roman classical period were not lawmakers and they could not create new binding legal rules; such authorization belonged only to the emperor or senate. On the other side, from the early years of the principate age the emperors customarily granted to leading jurists the right to present their opinions on various legal questions - *ius respondendi ex auctoritate principis.* Emperor Hadrian in later half of the second century laid down that concordant *responsa* of jurists with *ius respondendi ex auctoritate principis*, to concrete dispute or any other legal question, had the force of a *lex*; these opinions of jurists operated in principle as an authoritative source of law and this was the way how jurisprudence in successive steps acquired the law-making force. Classical period of Roman law reached its climax in the decade after the *Constitutio Antoniniana*, in the work of three jurists whom later ages were to be considered the most distinguished, Ulpian, Paul and Papinian.

In the post-classical period the only effective source of law seemed to be imperial legislation, as jurisprudence had ceased to be living source of law. During this period there emerged need for the codification of law and also some direction was required for the use of the classical juridical literature – vast body of legal material spanning hundreds of years of legal development [8].

In the year 527 there ascended the imperial throne at Constantinople a man whose name is forever associated with Roman law [12]. All years of the reign of emperor Justinian are characterized with intensive efforts to restore the glory of the Roman Empire. One of means to achieve this objective was Roman classic and post-classic law, but already arranged, free of archaisms and useless formalism, collisions and controversies, based on a uniform basis and usefully adapted to the new times.

Justinian directed all his energies to fulfilling his essential ambition – the restoration of the Roman Empire to its earlier grandeur. Important target of Justinian's programme was also to increase the quality of legal education that was mostly accidental, unsystematic and based on fragmentary sources. The outstanding feature of the reign of Justinian was his focus on the idea of uniformity – uniformity of the territory, religion and law [8].

3. Definition of theft in Roman law

The definition of *furtum* in such way, as was defined by the jurist Paulus: *„Furtum est contrectatio rei fraudulosa lucri faciendi gratia vel ipsius rei vel etiamusus eius possessionisve",* that could be freely translated as follows – "theft is the fraudulent interference with a foreign thing, whether with the thing itself or the use or possession of it,

with a view to gain" was the bases in the period of classic Roman law.

Furtum is defined in *Corpus Iuris Civilis* as follows: „*Furtum est contrectatio rei fraudulosa vel ipsius rei vel etiam usus eius possessionisve: φψράς quod lege naturali prohibitum est admittere. Furtum autem vel a furvo, id est nigro, dictum est, quod clam et obscure fit et plerumque nocte: vel a fraude: vel a ferendo, id est auferendo: vel a Graeco sermone, qui appellant fures. immo etiam Greci άπό τού φέρεισ φώράς dixerunt"*[7], ergo as fraudulent dealing with property, either in itself, or in its use, or in its possession, an offence which is prohibited by natural law.

Paulus in Digest adds the words "*lucri faciendi gratia"*, which meaning and conception was not limited only to monetary profit, but includes also any kind of advantage, benefit or satisfaction.

4. *Matrimonium* in Roman law

Matrimonium has in the period of Roman law specific importance, purpose and content; through the institution of marriage was ensured reproduction of roman family. Roman jurist Modestinus defined marriage as „*the union of a man and a woman, forming an association during their entire lives, and involving the common enjoyment of divine and human privileges".* Definition of the term *matrimonium* we can also find in Justinian´s codification work, where it is determined as follows: „*wedlock or matrimony is the union of male and female, involving the habitual intercourse of daily life"*[6].

Romans did not deem marriage as sacrament or as a contractual relationship but simply as a social circumstance with granted legal consequences.

In Roman law we can recognize three different regimes of customization referring to the rights of property between spouses. It was the regime of total absorption of the property of wife with property of husband, regime of total separation of such properties and lastly the regime of dowry as a compromise between above mentioned regimes.

5. Theft between spouses in Roman law

In connection to legal and family union created between spouses and the problem of theft under review there arise a question, if wife can commit a theft towards her husband. In general, it is possible to point out that a person who was found guilty of committing theft, was obliged not only to pay a penalty in amount of multiple of value of stolen thing; conviction a person was also connected with an abstract stamp of infamy. *Infamia* consisted not only in certain public label of shame, but its negative consequences were also reflected in multiple sphere of private law. Concerning the persons of spouses or ex-spouses it is possible to declare that Roman classical and also Justinian´s law adopted relatively accommodating and lighter attitude. In classical Roman law no broad or explicit rule prevented spouses from bringing infaming lawsuits against each other, but such proceeding was increasingly discouraged. In Digest we can find a regulation of the procedure and action to recover property which has been removed (*rerum amotarum iudicium, actio rerum amotarum).*

An issue that separates roman jurists into two antipoles, consist exactly in the answer to questions, if a wife during marriage really cannot steal from her husband or she can steal but the infaming action of theft is inappropriate or impossible in her case. The problem here might most commonly have arisen when a couple divorced and the departing ex-wife took with her a property that according to the opinion of ex-husband was his own [4]. Nerva a Cassius have thought that wife did not commit a theft, because the partnership of married life rendered her, to a certain extent, the owner of the property in question. Others, such as Sabinus and Proculus hold an opinion that she does, in fact, commit a theft, just as a daughter can steal from her father, but that no action for theft was established by law. Gaius [5] refuses an action against the wife with regard to respecting a honour connected to the institution of marriage. Paulus within this context uses the term *reverentia*, by which he explains why husband cannot use penal action towards his wife for theft committed against him before marriage: „*propter reverentiam personarum"*. [9]

The same term we can find in the fifteenth book of Digest, in connection to the issue of returning the dowry [3]. Ulpian [2] says that it is not possible to apply action for theft against wife even in the case if she hired and introduced professional thieves into the house of her husband in order to help her to remove the property. On the other side Paulus establishes that it is possible to bring an action for theft against a woman where her slave has committed the theft. Further more closely specifies that in the action for recovery the property wrongfully appropriated there will be included any assets, that woman at the time of divorce consumed, sold, donated or used in other way. Paulus further adds that if a woman appropriates property after the death of her husband, she does not commit theft, because theft of a property belonging to an estate which is not yet in possession of anyone cannot be committed. Ulpian declares, that also a wife is entitled to an action against her husband for the recovery of property fraudulently appropriated.

In a case of applying *actio rerum amotarum* it made no difference whether the parties were living together or separately, such action for property wrongfully appropriated could be even brought against a woman who took appropriated things into a house in which she was not living with her husband. Where a wife stole property belonging to her husband from a person to whom her husband lent it, this person was entitled to an action for theft against wife, although her husband could not bring such action. [10] In connection with the problem of theft-boot, it is necessary to point at another fragment contained in Digest [13], where Ulpian says that when anyone gives aid or advice to a wife who steals the property of her husband, he will be liable for theft; even if he commits theft with her, he will be liable to the action for theft, while she will not be liable.

6. Theft between spouses in Slovak law

Legal regulation of marriage is included in the Act No. 36/2005 on family and on amendment of some other acts.

The first part named "Marriage", the first title "Beginning of marriage" and paragraphs 1 and 2 of § 1 have following wording [1]:

(1) Marriage is a union of man and woman that originates on the basis of their voluntary and free decision to conclude marriage after fulfilling conditions established by this Act.

(2) The purpose of marriage is to create a harmonic and permanent life companionship that will ensure proper education of children.

The criminal protection of proprietary rights, regardless of the kind and form of property, ensures Criminal Code especially in its part two – special part, chapter four – offences against the right of property. In this chapter we can find criminal offences that have the only one or the primary object of the criminal offence and this object is property right or rights related to property right. That is the reason of categorisation the theft to the chapter four of the special part of Criminal Code, concretely in § 212.

Paragraph 1 of § 212 has following wording:

Any person who appropriates a thing belonging to other by seizing it and thus causes small damage shall be liable to a term of imprisonment of up to two years.

On the present, by conclusion of marriage arises an undivided co-ownership of spouses that can be designated as specific type of co-ownership, by which, in contrast with divided co-ownership there are not expressly determined shares on joint thing.

Undivided co-ownership of spouses comprises all property that may be owned and acquired by any of the spouses during the marriage, except for property acquired by inheritance or donation as well as things whose nature indicates that such serve the personal needs, or the exercise of a profession of only one of the spouses, and things returned within the scope of the regulations governing property restitution to the ownership of one of the spouses who had the thing in his ownership prior to entering into the marriage or to whom the thing was returned as a legal successor of the original owner

In point of law is every spouse the owner of the whole thing belonging to undivided co-ownership of spouses, that means neither wife nor husband can commit theft of particular thing in such undivided co-ownership of spouses, if he or she appropriates a thing from the disposal of the other spouse without his consent.

7. Conclusions

In general, it is possible to conclude that only small part of Roman law concerning *furtum* made its way into the modern legal systems. Theft is nowadays a criminal offence and part of public, criminal law. Roman legal sources also introduce a system of roman family law that diverges sharply from anything we know in the modern world. This area of law is interesting even today because, although many parts of it seem at least generally familiar, Roman family law was organized and developed on lines that are radically different from any modern legal system.

As regards the answer to a surveyed question, if it is possible to commit theft between spouses, reasons for any argumentation are undoubtedly interesting. Whereas in Roman law between grounds for reasoning can be included for example mutual honour between spouses, in actual legal system of law of Slovak republic the answer can be interpreted directly from the wordings of particular generally binding acts.

References

[1] Act No. 36/2005 on family and on amendment of some other acts

[2] D 25,2,19

[3] D 24,3,14,1

[4] FRIER, B. W. – McGINN, T.A.J. *A casebook on Roman Family Law.* Oxford: Oxford University Press, 2004. p. 101

[5] Gai. D 25,2,2 pr.

[6] Inst. 1,9,1

[7] Inst. 4,1

[8] MOUSOURAKIS, G. *Roman Law and the Origins of the Civil Law Tradition*. Cham: Springer, 2015, p. 3, 210

[9] Paul. D 25,2,3,2

[10] Paul. D 25,2,28

[11] STEIN, P. *Roman Law in European history*. Cambridge: Cambridge University Press, 1999, p. 17

[12] STEIN, P. *Roman Law in European history*. Cambridge: Cambridge University Press, 1999, p. 32

[13] Ulp. D 47,2,52, pr., Ulp. D 47,2,52,1

CITY-STATE *KOŠICE**

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Abstract: *The paper deals with common features of the city state in Antiquity, and the free royal city in the Middle Ages. Despite the temporal and spatial distance, there are some common features to which post wants to point out, because there will always be some characters that will emerge in the creation and the management of human community, without following.*

Keywords: *Košice, Athen, city-state, free royal city*

1. Introduction

The first thing comes to mind after reading the name of this post is that any misprint apparently occurred here. But, there were no. Our intention was to take the reader name, and we will focus on specific (ancient) city state – Athens and (medieval) free royal city - Košice. These two forms of the functioning of society at different times and in different places seem to us as an island of apparent democratic governance of community in its time. At the beginning of writing this post, we did not want to focus our attention to specific cities, but then we changed our minds and chose the specific locations. In our prior study, we found some similarities to which we want to point out and perhaps inspire to the development of considerations in this direction. Post wants draw attention to these similarities, but we do not identify the ancient city with the medieval city in any way. City in Antiquity was mainly political and religious place, while the city in the Middle Ages was more commercial and artisanal centre.

2. The conceptual definition

First, we should introduce City State. Today City State is an independent administrative area which has the character of the state, but the area of the city. We can identify the Vatican and Monaco for the city-state. City-state in ancient times, on which we will discuss in this post, namely the Greek city-state was created by uniting of tribal settlements. The city was the political centre of major city-states; other settlements have autonomous status.

In the classical period the social and political life of the Greeks was not organized in one big state, or in many smaller cities, but just in a kind of intermediate stage, the so-called. city-state. The Greek city-state is called "polis". The origins of the polis fall into the earlier period. Polis went through the first development in the Archaic Period. City States gone through complicated internal development, which is caused by the rise of craft industry and development of trade, which caused a significant strengthening of not aristocratic social groups, which are gradually coming to power. [1] Each Greek city-state was ruled by itself. The Greek city-state, the polis, was smaller territorial unit, whose core consisted of a fertile plain, which was naturally bounded. The central village, which was developed into a city, was initially administrative and later political centre. Polis was a sovereign, independent and economically self-sufficient political organization of citizens who were the ruling social group and formed always merely a kind part of the population. Citizens formed a privileged layer in all city-states. [2]

Free royal city was the city in the Hungarian Kingdom, which had an important position and therefore was more popular for the king as other cities and due to this possessed by more significant privileges. In the medieval city, the city administration and the judiciary were overlapped with each other, some free royal cities could judge not only the offenders but also to carry out punishment on them. Against decisions of free royal cities was not relied to another city, but directly to the sovereign, respectively. to its senior officials, the tavern or the staff. Based on this, the free royal cities tend to divide on tavern and personnel. Free royal cities, *libera regiae civitas*, were cities in the Hungarian Kingdom, which were not subject to the county authorities of the region. The right to participate in meetings of the Hungarian Parliament [3] had only free royal cities. Just free royal cities could issue statutes by which could modify their internal situation, the right to freely dispose of municipal property. [4] Later free royal cities gained many privileges that were given to the level of nobility.

3. The Hungarian Kingdom

Hungarian Kingdom was a multi-ethnic state formation (in any case it is not possible speak about Hungarian Kingdom and the Hungary as about same), which was preceded by the Principality. We speak about the kingdom since 1000, when Stephen I was crowned as the first king. The territory of Hungarian Kingdom was part of the Habsburg monarchy since 1526. In the conception of this post is the most interesting and most important 13th century in which the first cities begin to be formed in the legal sense and in which also the German colonization intensified with which German urban law was getting to the land. Developed urban law can be regarded as key criterion for institutional city.

4. Košice

Košice [5] were not always city, the oldest written mention is from 1230 and is in a document issued by the Chapter of Eger, in which the Košice are referred as "Villa Cassa", or larger village with its own church. [6] Košice were developed and transformed gradually to the urban organism due to its strategically and geographically advantageous location. In the years 1240-1241 the Tatars led by Khan Bata, invaded to the country, [7] and ravaged the country until their departure, and after their departure, the land remained desolate and depopulated in some places, so there was followed the resumption of settlement by colonization process. Saxony Germans come to Košice and settled near Slovak villages and gradually formed the foundations of today's historic city centre. [8] The basic original privilege of city could not be maintained, but we know that the document was issued in the years immediately after the Tartar invasion, however, before the year 1249. Belo IV. granted these original privileges to Košice and granted the same privileges in a document for Sena from 13th April 1249 and, moreover, he speaks about Košice as about his city in this document. During this period, Košice was divided into Upper and Lower. Upper Košice with the castle were not so significant what the deed by Stephen V. of year 1261 testifies, thanks to which Upper Košice have been donated to two guests from Lower Košice, to Samphlenoben and Oblo. [10] In 1290 Kosice gained the status of city under the granted privilege of fortified city [11] by sovereign Ladislaus IV. Kumanski. In 1319, Košice got a tariff privilege, which freed Košice merchants from all duties and tolls on area "between the Tisza and salty - along Komitas Bereg" for assistance to King Charles I of Anjou against Omodej of Rozhanovce. [12] On 28 January 1342, the Hungarian king, Charles Robert, granted an important privilege which provides full jurisdiction [13] to mayor and sworn of Košice and determined by a court of the king or the royal tavern for review body, [14] directly referring to the Battle of Rozhanovce in which is formulation *"ad instaraliarum capitalium civitatum nostrarum"* or "on way of our other royal cities." [15] Legal and proper custom of Košice becomes the model for the entire eastern region. [16] In 1344 Košice received a partial right of storage [17] on all goods of traders from Russia and Poland by King Louis IV. Košice became one of the royal towns, behind Budín. Three years later, 28. 7. 1347 Košice received a great privilege. [18] Year 1347 is memorable since Košice took legal rules of Swabia mirror to the case law from Budín. [19]

5. Greece

The oldest civilization on the Greek mainland was Mycenaean culture. It is believed that the social and political system was like the theocratic despotism. In the second half of the second millennium B.C. advanced Mycenaean culture disappeared. Explicit reason or the main cause of extinction is not precisely known, the most frequently cited reason in literature is an eruption on the island of Thera, which had devastating consequences together with the tsunami. [20] Today, many members of the scientific community are not satisfied with this simple statement. It is likely that several factors, not just a natural disaster has contributed to the demise of culture. Only some areas were not completely subjugated by Dorian, for example. Attica, Cyprus, Euboea. After the demise of the Minoan and Mycenaean culture, the society came a step back to the trunk and the establishment of gender.

The political system of ancient Greece was not monotonous; all forms of government has been replaced over time at individual locations. We must say that the ancient Greek civilization reached its peak in Athens during the reign of Pericles.

Pericles was the leader of the moderate democracy, he treasured freedom and noble culture. However, not all considered democracy as the right form of government Platon considered democracy as government of incompetent people. [21] Democracy was one of the things that did not affect Europe as such as science or art.

6. Athens

Athens [22] were on the smallish plan between the mountains of Aigaleo, Pentelike and Hymétte, hidden in the myth of the unification of Attica by king Thess who allegedly united 12 independent city-states. In fact, this unification was achieved by gradual expansion of Athens. [23]

Athens was the political centre of the whole Attica in the 7th century BC. The Kingdom was replaced by government aristocracy. [24] The highest state officials were chosen from members of the aristocracy - Archons, whose number stood at nine and their term of office took one year. After one year in office, the archon became a life member of advisory body/aerophagy. Aerophagy/Advisory body was aristocratic council called by Ares hill to the west of the Acropolis, where they met. [25]

Official proprietary populations did not exist in Attica, but many Attica farmers have fallen into addiction of aristocratic landowners and had to pass on part of their harvest. The status of farmers with debt have been much worse, because they had been guaranteed personal freedom in this period, the debtor and his family fell into the so-called. debtor slavery. In the 6th century. BC. Solon becomes archon and introduced known reforms. [26] His political aim was to eliminate or at least reduce, disputes and collisions between members of the aristocracy and the rest of the population. He chose the path of compromise and did not consider compromise for not achieving its objectives, but rather as an ideal solution when "you can have the best of both world". Solon cancelled debts of those who ended up in slavery and even redeem the Athenians, who were sold into slavery. It was forbidden liable for the debts of their own freedom or freedom of his family. [27] Solon divided the population into four asset classes by revenue from landed property, on which were graded rights and duties of citizens. Solon's reforms strengthened the development of the Athens craft and trade and this has led to a strong middle class of craftsmen and traders. However, this led to the establishment of tyranny in Athens. Peisistratos, who came to power, was the representative of the poorest citizens of Athens. His

government, although it was dictatorial, was relatively mild and brought economic development power of Athens. Kept in force Solon's constitution, but all the important offices were occupied by his relatives or supporters.
After a time, in 508 BC., the Cleisthenes became the lead of Athens and laid the foundations of democracy in Athens. The arbitrary citizens became the ruling layer.

7. In what we see some similarity?

1. The gradual development of the city

As mentioned, Košice has gradually evolved from a village with its own church to the royal city and Athens were formed over many years. Free royal town has come to the level of nobility. It decided on their own issues and was "itself master" even though it was always possible to appeal to the sovereign in legal disputes. Athens also manage themselves due to the Greek city-state.

2. The development of craft and trade

Košice became an important city mainly because they were at the crossroads of trade routes. A certain degree of division of labour was needed to become a city, artisans were divided from farmers and trade began to develop in greater extent. Trade and craft began to thrive in Athens during the reign of Solon by means of his reforms. Over time, a thick layer of traders and artisans was formed in Athens. In Košice, this layer became the bourgeoisie.

3. Constituent bodies

In Košice from the beginning, although city authorities were not occupied by free choice of the population, but loyal to the king took over offices. Over time, as the city has shaped and developed, it acquired the possibility to elect their own representatives of city. Constituent bodies were more of Athens, Athens residents voted for members of the various offices who met certain criteria. Several forms of government have gradually been replaced in Athens and members of various segments of the population hold the power in their hands.

4. Organizations / Associations

As Kosice been associated with other cities (we can talk about Pentapolitane or also the tavern towns), to improve trade and economic relations also cities in ancient times were associated, Delian League is known and combined many city-states, primarily due to defence against enemies from other countries.

5. Own law and its enforcement

Cities in Hungary, thus Košice gradually formed its own municipal law, and its basis can be found in the root royal privileges granted by German colonists who came to the territory of Hungary. Because of the original customs incurred in society, oriented mainly to agriculture and the economy did not meet with the market economy. The standards are gradually transferred from city to another city, and apply not only to the German colonists, but gradually also for locals. The standards are developed and complement but was adapt to held ratio, as in Athens. The various reforms only to the territory of the city-state, created appropriate climate for advancement of Athens and the people that live there. Laws (nomoi) were formed by citizens at the People's Congress and had general application, applied by offices polis in individual cases - ie Enforcement of the law by state. Similarly, Košice with its own municipal court remembered for maintaining order in the city.

References

[*] Post originated as part of the project *VVGS – 272 - 2016 – The enforceability of law in context of development of society - legal, historical and political basis and problems of application practice*
[1] PEČÍRKA, J. *Dějiny pravěku a starověku. Hlava I – IX*. Praha : Státní pedagogické nakladatelství, 1989. s. 455.
[2] PEČÍRKA, J. *Dějiny pravěku a starověku. Hlava I – IX*. Praha : Státní pedagogické nakladatelství, 1989. s. 456-458.
[3] King Sigismund of Luxembourg invited representatives of royal cities, towns and free villages on the meeting of the Assembly in 1405. In 1432 representatives of cities were also on the proper assembly of the Estates, which has become a regular phenomenon since 1445. Since 1608 the Assembly was divided into Upper and Lower houses. Prelates and secular lords were in the Upper house. Palatine was the head of upper house and was also the head of the whole Assembly. The lower house was determined to other aristocracy, feudal lords and cities. The royal staff was the head of the lower house.
[4] LEHOTSKÁ, D. Príspevok k základnému rozdeleniu stredovekých miest na Slovensku. In *Historické štúdie*. XIX. Bratislava : Veda, 1974, s. 25.
[5] Košice - metropolis of Eastern Slovakia, the second largest city in the state, about 240 000 inhabitants.
[6] LUKAČKA, J. – ŠTEFÁNIK, M. a kol. *Stredoveké mesto ako miesto stretnutí a komunikácie.* Bratislava : Historický ústav SAV, 2010. s. 25. ISBN 978-80-970302-1-6.
[7] SUGAR, F. P., HANÁK, P., FRANK, T. *A History of Hungary*. [online] Bloomington : Indiana University press, 1994. s. 26. [quo. 2016-11-03] Dostupné na: <https://books.google.sk/books?id=SKwmGQCT0MAC&printsec=frontcover&dq=A+history+of+Hungary&hl=sk&sa=X&ved=0ahUKEwi174XRlo3QAhUJCywKHX6cA7kQ6AEIGzAA#v=onepage&q=A%20history%20of%20Hungary&f=false>
[8] VARSIK, B. *Zo slovenského stredoveku*. Bratislava : Vydavateľstvo SAV, 1972. s. 211.
[9] JUCK, Ľ. *Výsady miest a mestečiek na Slovensku (1238-1350).* Bratislava : Vydavateľstvo SAV, 1984 s. 39.
[10] ŠTENPIEN, E. Košice ako sídlo Abovsko-turnianskeho komitátu. In *Košice a dejiny – Dejiny Košíc*. Košice : UPJŠ, 2011. s. 70.; JUCK, Ľ. *Výsady miest a mestečiek na Slovensku (1238-1350).* Bratislava : Vydavateľstvo SAV, 1984 s. 43.
[11] VARSIK, B. *Zo slovenského stredoveku*. Bratislava : Vydavateľstvo SAV, 1972. s. 217.
[12] HALAGA, O. R. *Právny, územný a populačný vývoj mesta Košíc.* Košice : Východoslovenské vydavateľstvo, 1967. s. 16.
[13] The original is not preserved, the text from transept of the main tavern Stephen from 21th May 1344
[14] Part of the Archives of Košice city is digitized and available on <http://mol1.arcanum.hu/dldf/opt/a150506htm?v=pdf&a=start> the serial number of document: 269

103 from 28. january 1342 [quoted on 2016-03-22]; elaborated Latin text is also available in: JUCK, L. Výsady miest a mestečiek na Slovensku (1238-1350). Bratislava : Veda, 1984. s. 133-134.
[15] ZSOLDOS, A. Cesta Košíc po udelenie výsad v roku 1347. In *Košice v súradniciach európskych dejín*. Košice : Mesto Košice, Archív mesta Košice, 2014. s. 52.
[16] HALAGA, R. O. *Archív mesta Košíc*. Praha : Archívna správa ministerstva vnitra, 1957. s. 12.
[17] BARTL, J. a kol. *Lexikón slovenských dejín.* Bratislava : Slovenské pedagogické nakladateľstvo, 1997. s. 277.
[18] Elaborated Latin text of privilege is available in JUCK, Ľ. Výsady miest a mestečiek na Slovensku (1238-1350). Bratislava : Veda, 1984. s. 147-149. Slovak text is available in BREZOVÁKOVÁ, B. Pramene k dejinám Slovenska a Slovákov 4. Pod vládou anjouovských kráľov. : Slovensko po vymretí Arpádovcov a nástupe Anjouovcov na uhorský trón, Karola Róberta, Ľudovíta Veľkého a jeho dcéry Márie. Bratislava : Literárne informačné centrum, 2002. s. 158-160. Original granted privilege is stored in the Archive of Košice, Privilege, no. 3 (A), which is also available on the Internet: http://archives.hungaricana.hu/en/charters/40925/?query=WJEL%3D%28U%20722%29 [cit. dňa 2016-05-02].
[19] HALAGA, O. R. *Archív mesta Košíc*. Praha : Archívna správa ministerstva vnitra, 1957. s. 23.
[20] HRADEČNÝ, P. a kol. *Dějiny Řecka.* Praha : Nakladatelství Lidové noviny, 1998. s. 16.
[21] PLATON, *Ústava*. Praha : Oikoymenh, 2001. s. 245 – 276.
[22] Athens - the capital and largest city of Greece, about 750 000 inhabitants
[23] PEČÍRKA, J. *Dějiny pravěku a starověku. Hlava I – IX*. Praha : Státní pedagogické nakladatelství, 1989. s. 485.
[24] V Aténach nazývaní „eupatridi" – synovia dobrých otcov.
[25] HRADEČNÝ, P. a kol. *Dějiny Řecka*. Praha : Nakladatelství Lidové noviny, 1998. s. 29.
[26] Pozri viac: OWENS, R. *Solon of Athens: Poet, Philophoser, Soldier, Statesman.* Brighton, Portland, Toronto : Sussex Academic Press, 2010. s. 97-146.
[27] RANDALL, B. *Solon: The lawmaker of Athens.* [online]. New York : The Rosen Publishing Group, 2004. s. 51. [quo. 2017-03-05]. Dostupné na: < https://books.google.cz/books?id=CJCf-dPdPmoC&dq=solon&hl=sk&source=gbs_navlinks_s>

INTERDICTS OR THE EXTRAORDINARY PROCEEDINGS IN ROMAN LAW

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Abstract: *This article briefly deals with the issue of Roman interdicts and their special proceedings. The author of this article points out the typical phases of procedure under interdicts. Procedure under interdicts constituted a simplified and extraordinary way of action which was applied in addition to the classical civil Roman process. This article in the end offers a comparison of this Roman law institute and one similar modern legal institute, which was enshrined into the new Civil Litigation Procedure Code in Slovak Republic.*

Keywords: *interdict, Roman law, proceedings, sponsio*

Introduction

The current legal awareness always recognized the need to provide and to put into different legal systems, procedures and means of redress, or complementary due process procedures, which often brings complicated and cumbersome methods necessary to enforce the rights of individual. These trends are not a novelty, on the contrary, they have their roots in ancient Rome and Roman interdict was also one of the means by which the society sought to enrich civil procedure. Interdict had specific nature of regulation of praetor [1] (something like formal words) resulting from his *imperium* as unlimited power substituting the judicial power which had the nature of the administrative act protecting the public interest and thus indirectly the interests of the individual. Interdict directed against the party which violated or endanger the public or private interest and praetor encourages it to voluntarily refrain from unlawful conduct or a prohibited further unlawful conduct, or commanded it to something done to remove the offending state. Main characteristics of interdict are concluding voluntary subjecting of the decision of praetor, which was one of the major point of interdict, and providing that the party which requested for interdict had right until proven otherwise. *Interdicta*, orders or prohibitions issued by the praetor, at the request one of the party against the other serving to "remove" the dispute between them, were type of cases when praetor was not limited by *litis contestatio*, but he followed the disputed presentation of request by the applicant, and the other party addressed command or prohibition.

1. Characteristic of procedure under interdicts

The enforcement of law in Roman law with the help of interdicts used special type of procedure which was called procedure under interdicts. It was process which begins by issuing interdict. Term review of procedure under interdicts by several leading experts on Roman law made some significant and very important hypotheses. The first group of experts examined the similarity of procedure under interdicts and the classical process in the proceedings *in iure* and thought about their formal analogy. [2] Different perception of this issue can be seen for example in work of Betti, who did not recognize in procedure under interdicts process *in iure* and he did not think that this procedure had an individual or specific nature. Betti thought that interdict was just one of several regulations of praetor, and in his opinion the greatest importance had final decision itself – *ex interdicto*. [3] Another hypothesis consisted claims of Bekker and Scialoja who did not consider procedure under interdicts, from the purely procedural perspective, as deviations from the classic concept of the process, but perceived it as a pre-treatment (preliminary) procedure prior to the court proceedings, which was up to court to resolve the conflict. [4] The last hypothesis under our examination was completely different point of view created by Biscardi who saw obvious differences between procedure under interdicts and classic process in front of court, reflecting mainly in the form of special protection, based on basic historical sources governing this procedure. [5] All this hypothesis offered a different view of the fundamental nature of procedure under interdicts, and therefore it is necessary to find those that served conclusions about its true nature among them.

1.1. Right to sue and procedural legitimation

Procedure under interdicts was based on foundation of relationship and all successive steps in the proceedings was based on this relationship. This relationship, which acquired a legitimate form by the intervention of praetor was created between two private parties, one was entitled party (applicant) and the other was obliged (the person from whom something was requested). [6] With references to the mentioned parties Roman historical sources to designate them used the term customary in the ordinary civil procedure: *actor* and *reus*. [7] These names are indeed occurring in many Latin texts, but Biscardi in his study draws attention to use these names in connection with the application of interdict, especially the importance of distinguishing that procedural relationship from the relationship which developed on the basis of the action. Namely identical mark did not automatically equal procedural status. In the Roman system of law (as opposed to the current) parties became the procedural parties (*actor et resu*) after *litis contestatio*, which was typical for classic (ordinary) procedure. [8] In procedure under interdicts was

not something like *litis contestatio*, parties became *actor et reus* right after applicant´s request addressed to praetor and praetor issued interdict. Their position crystallized immediately at the beginning of the whole procedure under interdicts, regardless of *litis contestation* typical for the process *per formulae*. Interesting fact is that the defendant incumbent this title (*reus*) without making any activity.
Procedural stand (active or passive) was based on the applicant´s request turned to praetor, which gave the applicant specific interdict for his specific situation. As the number of interdicts was not negligible, it is difficult to determine general conditions that plaintiff and the defendant should have fulfilled according to the circumstances. On the other hand, we can define summary for each group of interdict or separately for each of the number of interdicts.

2. The phases of procedure under interdicts
Procedure under interdicts can be divided into the procedure of issuance of interdict and proceedings concerning to the legal validity of interdict. The first stage (which was clearly much easier) ended with the release of interdict by praetor and the second one meant dispute over the validity of the interdict and the decision of judge about it. [9]

2.1 Proceedings of issuance of interdict
The first phase began on the initiative of the individual who saw himself as injured party, or has reason to believe, that was threatened or has been violated some public interest, on whose behalf he acted. At this stage, the two sides (or only the plaintiff) appear before the praetor, and may did so even in *dies nefasti*. [10] Through this fact it highlights the special nature of procedure under interdicts because the fact that party came before praetor did not mean that litigation in procedural way truly started. The possibility procedure under interdicts during the *dies nefasti* was also evidence of a lesser formality of this special process. After pronouncing the applicant´s request for extradition of interdict (*interdictum postulatio*), praetor decided to grant it (*interdictum reddere*) or not after the proper investigation the case or after hearing the defence of the other party. Praetor was entitled to reject the interdict on similar grounds, which served to dismiss the action. Part of forms of some interdicts, which were declared in the praetorian edict had an obligated defence. According to these forms praetor issued corresponding interdict (or interdict which was closest to this dispute) that could be modified or extended according to the individual characteristics of the dispute. [11]

2.2 Proceedings concerning to the legal validity of interdict
Procedure under interdicts had nature of expedited and simplified procedure, or even the preliminary procedure, by which praetor tried to prevent to change factual situation and tried to restore order in society, with provisionally acceptation the applicant´s claim to be true or at least probable. That is why the second phase of procedure under interdicts boarded when the liable party disobeyed interdict. This phase was more complicated compared to the first stage and had bearing certain procedural risks inherent, for example, in stricter sanctions and higher claims. [12] This stage could take a place as proceedings *per sponsionem* or proceedings *per formulam arbitrariam* which launched in late classic period. [13]

2.2.1 Proceedings *per sponsionem*
The fundamental question of procedure under interdicts was how to force to process obligatory party, who did not find itself to be bound by the interdict. For this situation served proceedings *per sponsionem*. This type of procedure was a twofold distinction according to the type of interdict. Its simpler form was applied in the cases of simple interdict (*interdicta simplicia*). Proceedings was pending before arbitrator or judge and the parties concluded a special type of contract – *sponsio* (promise) or *stipulatio* of monetary sanction like compensation for a party which turned out to be right in the end, or whose claims were shown to be true. [14] Compensation for damages had to bind both parties. [15] If the applicant´s argument was correct, the arbitrator held that the defendant should obey the interdict, and that he precluded it without legal grounds. On the basis, the arbitrator (judge) sentenced the defendant to pay the fines of the contract (*sponsio*) as well as the obligation to submit a resume or what was sought by interdict (unless he has already done it) – *de re restituenda vel exhibendo*. If the judge assumed that defendant was right, and his allegations were proved to be true, he condemned the applicant´s obligation to compensation under the concluded contract.
Much more complicated was procedure in the case of application of bilateral interdicts (*interdicta duplicia*), mainly due to the fact that both sights held the position of the defendant and the applicant. The court in this procedure was conducted in-depth investigation the whole case. The complexity of this procedure consisted in particular regulation to conclude at least two *stipulatio* and two *restipulatio* respect to duplicate position of both parties. [16]

2.2.2 Proceedings *per formulam arbitrariam*
Proceedings *per formulam arbitrariam* was much more recent procedure and started for similar reasons as the procedure *per sponsionem*. Proceedings *per formulam arbitrariam* was the process *sine poena* [17] and could be made on the fulfillment of two conditions: 1. Issued an interdict was either *exhibitory* or *restitutory* (that may not be prohibitive), 2. Following the interdict, defendant requested appointment of judge (or arbitrator). In this proceedings, the applicant largely amounted to in-kind benefits, but major disadvantage was that it could be used only in the proceedings of two kinds of interdict. Curiosity of proceedings *per formulam arbitrariam* was an unavoidable initiative of defendant, who requested from praetor *formula arbitraria*. [18]
Based on this formula arbitrator or judge himself asked the defendant for voluntary compliance of the interdict and in case of failure to comply this regulation, the defendant was sentenced to the award of damages. All of this was done

only if the arbitrator concluded that the conditions for issuing of interdict were complied. If the conditions have not been met and the defendant complied with the order, he was acquitted and had more to pay compensation. Since in this proceeding was missing *sponsio* as the financial penalty, has been increasingly used in practice alongside proceeding *per sponsionem*, with clear advantages of easier, cheaper, faster and more efficient process. [19]

3. Common features of procedure under interdicts and preliminary hearing of the disputes in the legal system of Slovak Republic

Procedure under interdicts was using alongside classical Roman civil process as extraordinary proceedings. As we already mentioned, experts on Roman law perceived procedure under interdicts differently. We were impressed the most by the attitudes and opinions of Bekker and Scialoja who thought that the first phase of interdict process had only preliminary or pre-treatment character that could result in termination of the dispute, but also the continuation of proceedings in a second stage of procedure under interdicts, which they assumed that was the same as the classical civil procedure. This view impressed us particularly because such a concept has been adopted to some extent even in the current legislation of the Slovak Republic in the new Civil Litigation Procedure Code. The institute, which meets similar criteria as a first phase of interdict proceedings in Roman law was named "preliminary hearing of the dispute" and is treated in § 168 to § 172 of Act No. 160/2015 Coll. Civil Litigation Procedure Code, as amended. This institute is considered a novelty in the legal system of the Slovak Republic and despite the fact that it is an optional legal institution, the legislature assumes that its use will be the rule rather than the exception. As stated in the Explanatory Statement to that law, this institute has to be a tool to streamline and speed up litigation. Preliminary hearing of the disputes should serve to clarify the subject-matter and discussing the procedural options, including the possibility to terminate the dispute in a peaceful way. [20] Therefore, the court mandatory attempt to settle the dispute by conciliation or shall recommend that the parties try mediation for reconciliation. [21]

The advantage of this institute is the possibility of court ("where possible and practical") to decide at this stage for the main proceedings. The new legislation therefore serve a similar purpose as meet the first phase of procedure under interdicts, except that the first phase of procedure under interdicts was played out in front of praetor (even if he has been determined too substituting the power judicial) and not directly in front of judges or arbitrators, which significantly relieve the courts. If the current legislation legislator expects and hopes for accelerated procedures, it does not guarantee relief of judges, because be it in order provisional hearing of a dispute or not, the case will have to discuss (of course if there is no example in the withdrawal of the application, etc.), the unlike procedure under interdicts in Roman law, which some of judicial powers transferred to another office, thus many disputes did not go to court, thereby reducing the number of cases pending before the court. It is undisputed that is similarity between the mentioned legal institutes.

Where preliminary hearing of disputes expects termination of dispute in a peaceful way, or just familiarity with the dispute before the trial itself, procedure under interdicts envisaged the conclusion of dispute voluntary by subsided of obligor and some experts for Roman law as we already mentioned, regarded it as a pre-treatment prior to the conduct of classical civil procedure for litigation (at least in the first phase of the procedure under interdicts).

4. Conclusions

Procedure under interdicts had in history of the Roman legal system its specific place. Brought a new perspective on the issue of law enforcement, but at the same time enriching it means serving to accelerate and simplify the process under action that also to some extent relieve the then judiciary and offer solutions of diverse conflicts in a society based on extraordinary type of proceedings. Examination of modern institutes and search possibility for comparison with the Roman interdicts as a legal remedy is therefore undeniable important. Legal institute of preliminary hearing of the dispute is only one of many examples that provides similar legislation as Roman interdicts. This example is only a reflection of the real need to explore and look at the wisdom of our Roman ancestors and seek inspiration in the solutions already solved contentious situations and thus formulate proposals *de lege ferenda* and try to improve the contemporary legislation.

References

[1] As senior officials in Rome.

[2] Proponents of this approach have been, for example UBBELOHDE, A. *Comentario alle Pandette di Frederico Gluck, libri 43 - 44*. Miláno: Societa editrice libraria, 1899. s. 397. SCHMIDT, K. A. *Das Interdiktenverfahren der Römer in geschichtlicher Entwickelung*. Leipzig, 1853.

[3] BETTI, E. *Corso di istituzioni di diritto romano*. Padova: CEDAM, 1928. p. 339 – 341.

[4] BEKKER, E. I. *Die Aktionem des romischen Privatrechts: Pratorisches richterliches kaiserliches Recht*. Berlin: F. Vahlen, 1873. p. 51.; SCIALOJA, V. *Procedura civile romana: esercizio e difesa dei diritti*. Rím: ARE, 1936. p. 222.

[5] BISCARDI, A. *La protezione interdittale nel processo romano.* Padova: CEDAM, 1938. p. 24 – 53.

[6] In view of the different status when we use *interdicta simplicia* a *duplicia.*

[7] Gai. Inst. 4, 157: *„Siplicia sunt veluti in qiubus alter actor, alter reus est, qualia sunt omnia restitutoria aut exhibitoria; namque actor est, qui desiderat aut exhiberi aut restitui, reus is este, a quo desideratur, ut exhibeat aut restituat.“*

Ulp. D. 43, 17, 3, 1: *„Hoc interdictum duplex est et hi, quibus competit, et actores et rei sunt.*

[8] PUGLIESE, G. *Il processo civile romano: Il processo formulare*. Milano: Giuffré, 1963. p. 254 and 302. *„L'attore viene designato dai Romani con le espresioni 'actor' e 'petitor', piú spesso con le circonlocuzioni 'is qui*

agit', 'is qui petit', talvolta anche 'is qui agere vult', col che si intende l'attore prima delle litis contestatio e si lascia capire che prima delle litis contestatio no c'é ancora un vero attore."

[9] GANDOLFI, G. *Contributo allo studio del processo interdittale romano.* Milano: Giuffré, 1955. p. 44 etc.

[10] *Dies nefasti* were days that have been consecrated to God and which were not allowed to litigate, because the gods do not permit this. *Dies fasti* were just the opposite days that were intended for contracting and litigation.

[11] VÁŽNÝ, J. *Římský proces civilní.* Praha: Melantrich A.S., 1935. p. 81.

[12] BARTOŠEK, M. *Dějiny římského práva: ve třech fázích jeho vývoje*. Praha: Academia, 1995. p. 94.

[13] Gai. Inst. 4, 161-170.

[14] *Sponsio* was not a contract in the right way, but the prosecutor asked the defendant the obligation to pay a certain "criminal" amount in the event that the claim proves to be false, the defendant answered this *restipulatio* and order the applicant to payment of the same amount in the event that is as false show the applicant's arguments. On that basis, then created two *actiones certae creditae pecuniae*. Between the parties, however, there was also a third *litis contestatio* which amounted to issue what was demanding by interdict. ZULUETA, F. *The Institutes of Gaius. Part II Commentary.* Oxford: Clarendon, 1953. p. 296.

[15] „*Temeritas tam agentium quam eorum cum quibus agitur, coerceri modo pecuniaria poena modo iurisiurandi religione modo metu infamiae coercetur."* (Gai. Inst. 4, 171).

[16] ZULUETA, F. *The Institutes of Gaius. Part II Commentary.* Oxford: Clarendon, 1953. p. 297.

[17] In this sense, the proceedings *sine poena* meant that linger stipulatio about possible "criminal" amount, but it originated here only to issue what was demanding by interdict by the party whose allegations prove to be false.

[18] COSTA, E. *Profilo storico del processo civile romano.* Roma: Athenaeum, 1918. p. 106 - 107.

[19] BUCKLAND, W. W. *A text-book of Roman law from Augustus to Justinian.* Cambridge: University press, 1950. p. 736 - 737.

[20] HORVÁTH, E. – ANDRÁŠIOVÁ, A. *Civilný sporový poriadok: komentár.* Bratislava: Wolters Kluwer, 2015. p. 373.

[21] § 170 Act No. 160/2015 Coll. Civil Litigation Procedure Code, as amended.

THE "UNCONQUERABLE FORCE": PLINY THE ELDER ON DIAMOND

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Abstract: *Diamond (in Latin "adamas", in Greek* ἀδάμας *– "unvanquished", from* δαμάζω *– "vanquish") was the highly valued gemstone in antiquity. Thinking about a brilliant jewel we may think that this value was determined by beauty, but the impression is wrong. Diamond was called "indomita vis" – "unconquerable force" because of its extraordinary properties. The paper is based on paragraphs 55-62 of 37th book of Pliny the Elder's "Natural History".*

Keywords: *diamond, Pliny the Elder, antiquity, precious stone, gemstone*

1. Introduction

Diamond is the most expensive and the best-known mineral in the world. It is hard to believe that this brilliant gem, delighting our eyes is a form of carbon [1]. In *Gentlemen Prefer Blondes*, the movie from 1953, Marilyn Monroe (as Lorelei) sang: "Diamonds are a girl's best friend" [2]. What was the beginning of the fame of this amazing gemstone? Let us go back in time to antiquity to find the answer.

1.1 The most valued and the hardest

Pliny the Elder described diamond in 37th tome of *Natural History* as the most highly valued of all human possessions, not only precious stones [3]. What is interesting, he did not mention its usage as a jewel, but as a tool using by engravers of gems, because it was so hard that they could make hollows in the hardest materials [4]. Indeed, diamond is the hardest natural mineral known to man [5]. Its hardness is determined by Mohs scale, basing on scratch resistance of minerals, through the observation that the harder material scratches the softer one. The Mohs scale is an ordinal scale, where 1 point marks the softer material, and 10 marks the hardest – diamond [6].
If diamond is the hardest natural mineral, how did ancient people crash it into smaller pieces to make tools?

1.2 Diamond and a goat

In Latin, diamond is *adamas*, in Greek ἀδάμας – "unvanquished", from δαμάζω – "vanquish". Moreover, the same noun mean "steel", so it can be confusing for an inexperienced reader.
Pliny added that diamond had been called *indomita vis* – "unconquerable force", because its hardness was indescribable, and it never became heated by fire [7]. But the gemstone could be broken in a very specific way: it had to be steeped in fresh and warm goat blood. Then it needed a lot of hammer blows, and it could break the iron if the blows were not good enough. When the diamond was properly crashed, it was disintegrated into pieces so small, they were barely visible [8].
As I said before, diamond is the hardest natural mineral, however, it is fragile, so more than one real gemstone had been crushed because of these unreasonable idea [9].
Let us consider the goat blood again. Even Pliny wondered what assumption could have led anyone to submerge the highest valued thing in the blood of the foulest animal [10]. As I was informed by mineralogists, there is no way to ease breaking the gemstone with goat blood, so maybe the whole story is only a myth. As Pliny said, surely it was the will of gods, and there is no reason to look for logic in any part of nature [11].

2. Varieties

According to Pliny, there were 6 varieties of diamond. The Indian was similar to rock-crystal in its transparency and cubic shape, with smooth sides. However, it could be as big as a hazelnut. The Arabian resembled the abovementioned, but it was smaller [12]. The *cenchron* was a variety in size of a millet seed. The Macedonian diamond was comparable with a cucumber seed [13], but this needs to be specified: was it similar color, shape, or size? The *Cyprius*, found on Cyprus, had shade of copper, and the *siderites* of iron, moreover, it exceeded the rest in weight [14].
Actually, diamond is an octahedral solid, less often cubic than other. Its shade is usually light yellow, tawny, grey or colorless, and rarely yellow, milky, orange, pink, red, blue, black etc. [15]. The Indian variety is colorless, probably the Arabian too. A copper hue of the *Cyprius* can be interpreted as brown or orange, but I would be cautious with conclusions. We must remember that in antiquity people distinguished gemstones basing on colors – they did not have knowledge about their chemical properties, and they made mistakes on their physical properties, which they had already known. Therefore, *Cyprius* could also be not a variety of diamond, but a completely different kind of gemstone. We can interpret the siderites the same way – as a grey diamond or a different precious stone. Unfortunately, Pliny did not indicate the shade of the *cenchron* and the Macedonian diamond, so I cannot identify them having only a brief description.

3. Place in the hierarchy

What is interesting here, Pliny compared the Indian diamond to rock-crystal, which probably means the latter was better known and more popular. The first clue is in the first paragraph of its description. The author claimed that for a long time diamond was known only to very few kings [16]. Moreover, rock-crystal was described before, in 37th tome of *Natural History* [17] as the second most precious stone, meanwhile diamond was the fifth, after mysterious *myrrhina*, rock-crystal, amber, and *lyncurius*. Why these four kinds were more important than the most highly valued of human possessions?

On the other hand I can see some logic in this order. Maybe those four kinds of gemstones were put at the beginning of the book, before the part about gemstones which were acknowledged as such (where diamond is described first), because Pliny did not know where to put them? In some way, they were special, more popular among populace, but not as valued as diamond and the following gems.

3.1 The most beautiful?

Having a vision of a beautiful diamond cut in a brilliant, with an adamantine luster, it is hard to imagine Isidore's (bishop of Seville and an author of *Etymologies*, the first medieval encyclopedia) words, that this gemstone is small and ugly [18]. Admittedly, Pliny did not say the same, but also he did not say that diamonds were beautiful. Therefore, the diamond's value was in fact its hardness and resistance.

4. The "knot of gold"

Diamond was called the "knot of gold". Pliny said that is because it was found very rarely in mines, but always next to gold. For that reason people thought it was only formed in gold [19]. Actually, the gemstone occurs in very rare igneous rocks, kimberlites, also called "blue ground", because of their color. However, kimberlites become yellow through weathering ("yellow ground") [20]. The "knot of gold" may in fact be the "knot of the yellow ground".

5. Conclusion

Despite that in antiquity people did not have specialized knowledge about minerals, most information about diamonds that Pliny wrote is useful and comparable with the truth. Of course it is hard to determine if everything is true or possible, sometimes the only one possibility is to make a hypothesis.

Diamond was the most highly valued precious stone in antiquity because of its extraordinary hardness and resistance to fire, scratches, and blows. Pliny described it as an engraver's tool, *indomita vis*, and the "knot of gold". In fact it was a "king's best friend" rather than a "girl's best friend".

References

[1] Sobczak N., Sobczak T., *Wielka encyklopedia kamieni szlachetnych i ozdobnych*, Wydawnictwo Naukowe PWN, Warszawa, 1998, p. 129.
[2] http://www.tcm.com/mediaroom/video/497401/Gentlemen-Prefer-Blondes-Movie-Clip-Diamonds-Are-A-Girls-s-Best-Friend.html
[3] Plin. *Nat. hist.* 37, 55.
[4] Ibid., 60.
[5] Sobczak N., Sobczak T., *Wielka encyklopedia kamieni szlachetnych i ozdobnych*, Wydawnictwo Naukowe PWN, Warszawa, 1998, p. 129.
[6] Ibid., p. 41-42.
[7] Plin. *Nat. hist.* 37, 57.
[8] Ibid., 57; 59-60.
[9] Maślankiewicz K., *Kamienie szlachetne*, Wydawnictwa Geologiczne, Warszawa, 1983, p.113.
[10] Plin. *Nat. hist.* 37, 60.
[11] Ibid.
[12] Ibid., 56.
[13] Ibid., 58.
[14] Ibid.
[15] Żaba I.V., Żaba J., *Atlas naturalnych kamieni szlachetnych i ozdobnych*, Wydawnictwo SBM, Warszawa, 2016, p. 30.
[16] Plin. *Nat. hist.* 37, 55.
[17] Ibid., 23-29.
[18] Isid. *Et.* XVI 13, 2.
[19] Plin. *Nat. hist.* 37, 55.
[20] Maślankiewicz K., *Kamienie szlachetne*, Wydawnictwa Geologiczne, Warszawa, 1983, p.127-128.

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Published in March, 2017 by Sciemcee Publishing, London.
Proceedings document published in collaboration with SCIEMCEE - Scientific Conference Platform.
The proceedings with all papers are available at www.sciemcee.org.

ISBN 978-0-9935191-4-7