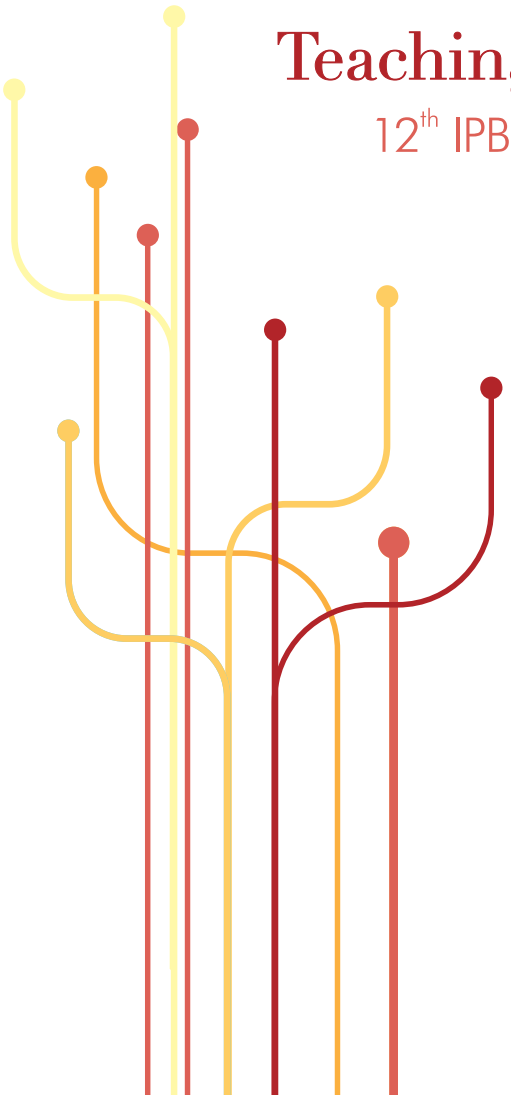

Teaching Crossroads

12th IPB Erasmus week

Edited by

Elisabete Silva
Clarisse Pais
Luís S. Pais

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Preface

Elisabete Silva, Clarisse Pais, Luís S. Pais

The Editors

We have to start off this preface by congratulating the IPB for its achievement. It has been positioned in the top 50 best Higher Education Institutions in the area of Food Technology and Science by the renowned Shanghai ranking. For 4 years in a row the IPB has been considered the best Polytechnic Institute in Portugal by the U-Multirank. Therefore, we have to take our hat off to the IPB.

It goes without saying that our compliment is also addressed to the authors, reviewers and everyone who made this publication possible. This is now the 6th number of *Teaching Crossroads* which started in 2012 when we came up with the idea of publishing research work presented in the Erasmus Weeks endorsed by the IPB. Since then we have had over 40 articles published and over 6,000 downloads. Actually, the top five countries doing downloads include France, Germany, Sweden, The Netherlands and the USA.

We aim to reach not only other researchers but also students who can find relevant information in the articles for their areas of study. Not only do we have a clear, well-structured publication to make it more appealing to the reader, but also we look for interesting and in-depth discussions, ideas and projects to promote serious research work developed in Europe. This has been our main motto since we started.

This year's publication includes the areas of Economy and Management, Health, Mathematics, Mechanical and Electrical Engineering. In conjunction with this, as in

the three last previous numbers, we have included the specific area on International mobility, Intensive Programmes and Erasmus+.

To entice you to read these informative and thoughtful articles, we highlight some of the main ideas that the authors delved into in their research works.

Marcin Bogdanski's research focuses on regional development in Poland. The study covers the period between 2000 and 2014 throughout which the author analysed the level of economic development in Polish provinces. Moreover, the author reflects on the ineffectiveness of EU cohesion policy aiming at economic convergence within the EU member countries.

Malgorzata Okreglicka presents a study which analyses the selected aspects in the area of current assets management, such as trade credit and inventories, in a varied and large number of Polish enterprises. The statistical work developed is of considerable advantage as it will allow a comparison between the diverse values obtained among the different companies and therefore this reveals crucial for the improvement of management methods and tools.

Elzbieta Broniewicz compares environmental protection costs and revenues in Portugal and Poland bearing in mind the domains of environmental protection and economic sectors. Detailed and accurate survey results are shown and by doing so the author calls our attention to the importance of environmental protection and the need for government expenditure in this specific field. This study also illustrates how the world economy influences government expenditure in environmental protection both in Portugal and Poland which has been decreasing over the last three years.

Juan Antonio Torrénts Arévalo's study is rather valuable as it indicates a guideline about strategy management useful for any company. The author presents and describes several strategic methods, e.g. SWOT and Porter, and all the process linked to them, namely the definition of objectives, the analysis of the competitive environment and the internal organisation of companies, just to name a few. This study also focuses on the performance of Spanish economy in 2011.

Robert Florkowski focuses on the person-centred approach and rehabilitation. The crux of the study is the comparison between two main paradigms regarding health rehabilitation, the medical and Rogerian paradigms, highlighting differences and control skirmishes between them and other scientific patterns. The author also provides his own professional accounts in the field of physiotherapy, clinical psychology and psychotherapy as a significant supplement to his study.

Kamila Misiakiewicz-Has explores the topic of fertility in males. The author provides scientific data resulting from experiments performed in rats treated with endocrine-disrupting chemicals. These substances proved to confirm they alter endogenous hormones causing thus major influences on the estrogen–androgen imbalance in the male reproductive system.

F.T. Pachón-García and A. Berenguer-García present a study carried out in secondary schools with the purpose of checking students' mathematical skills at this level of education. The procedure chosen to conduct the study was based on mathematical tests whose results were then compared with national data and analysed. Taking into account the results obtained the authors present some innovative solutions to improve deficiencies that students have had in specific mathematical areas.

Alexandre Pereira presents a study which is part of his doctoral thesis. This article introduces the topic of soft matter highlighting its use and behaviour. The study focuses mainly on a Polymer called Ionic Polymer Metal Composite.

Mariana-Rodica Milici and **Laurentiu-Dan Milici** study the conditions, consequences and practical applications of the resonance phenomenon. Focusing on the RLC series circuit under sinusoidal steady state, the authors provide valuable explanations and warnings regarding the resonance condition and applications of this phenomenon.

Cristina Mesquita briefly describes the Expeducom project, financed under Erasmus+ K2, in which she participated in representation of the IPB. This was a joint project between 7 European Higher Education Institutions with the aim of developing and implementing innovative pedagogical practices related to experiential learning in the kindergarten and primary school context.

Appetizers served, we do hope you enjoy your reading and, most of all, you find it useful in your academic life.

Economy and Management

Regional development in Poland

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Abstract

The paper focuses on describing the most important aspects of the process of regional economic development in Poland between 2000 and 2014. It contains the analyses of the level of economic development of the provinces and its changes over time, and presents the most important determinants of the changes being observed.

The analyses do not allow for a clear evaluation of the processes of economic development of the Polish regions, especially in the context of the dynamics and scale of the processes of economic convergence. Focusing on the diversification of economic development within the country, it should be emphasised that the year 2000 saw relatively large disparities in the level of GDP per capita for the provinces. And during the period analysed these disparities have increased.

At the same time, it was possible to observe an ongoing convergence process in relation to the average level of economic development of the EU countries and regions. And what is more important, this process was not limited only to the wealthiest provinces.

In a result, the paper raises the important issue widely discussed in the subject

literature, which is the determinants of economic convergence and effectiveness, or even purposefulness of EU`s Cohesion Policy. The results of the study support the thesis that at regional level there are significant differences in the economic potential of regions and these differences (which are quite stable) prevent the achievement of economic convergence. Thus, many efforts taken within the EU Cohesion Policy understood as a "simple" decreasing of disparities in the level of economic development of regions will be ineffective.

Keywords: ***regional development, economic convergence, Poland***

Introduction

The issues related to the functioning of regions and their economic development are occupying an increasing part of the analyses carried out in social sciences, including economic sciences. This is due to the fact that in a dynamic contemporary macro-economic environment, which requires relatively frequent changes of economic policies and tools, the regional level is the most effective and efficient method of conducting this kind of policy. The regional and local authorities are able to take advantage of the resources present in the area more effectively provided they are able to shape their economic policy in a self-governing fashion and have the proper administrative and financial tools to do so. Such steps, in turn, provide the basis for the economic development of the area. Hence, this is one of the reasons why the economic policy of the European Union focuses primarily on the regional level.

The growing interest in the issues of regional development also results from the increasing disparities in the level of their economic development. The scale of the observed differences is particularly large for the economies of China and the US, where metropolises and metropolitan regions are absorbing an increasing part of economic potential (Dijkstra, Garcilazo & McCain, 2013). This, in turn, causes negative social phenomena and processes, manifested, among others, in the weakening of ties between social and professional groups and regional communities, the disintegration of existing social structures, and the escalation of unrest and conflicts (Jasiński, 2012).

Recognising the importance of this issue, this paper focuses on describing the most important aspects of the process of regional economic development in Poland between 2000 and 2014. The paper analyses the level of economic development of the provinces and its changes over time, and presents the most important determinants of the changes being observed. Particular emphasis was put on the resolution of the question of whether the processes of economic convergence, i.e. the gradual reduction of existing developmental disparities, have occurred between the regions in the analysed period. Some of the analyses were also carried out in relation to the average level of economic development in EU regions.

Poland has been a member of the European Community since 2004. However, several years before its accession to the EU Poland had been a beneficiary of European funds aimed, on the one hand, at increasing the dynamics of the development of Polish regions, and on the other hand at reducing the existing regional disparities. Similar goals were adopted in the 1999 reform of the territorial organisation of the country, which established 16 new provinces.

At this point, it seems reasonable to ask about the effectiveness of these measures. Has the level of economic development grown dynamically in the regions over the last several years? Has this growth helped decrease the developmental disparities existing at the beginning of the 21st century? Finally, have these differences been reduced also in relation to the average level of economic development of the EU regions? Answering these questions will give the incentive to raise a discussion on the assessment of the effectiveness and efficiency of the processes of economic and social transformation in Poland commenced in 1989 after the collapse of socialism and symbolically finalised in 2004 when Poland entered the European Union.

1. Methodology of the analysis

The achievement of the objective established for the analyses necessitated the selection of the appropriate measure of the economic development of the regions. One can find many different methods of measuring development in the literature. Some of them are synthetic in nature and encompass various dimensions of this process. However, their frequently complicated structure makes it difficult to interpret the results and requires access to a set of statistical data. On the other hand, simple measures used for certain aspects or effects of the process of economic growth ignore its complexity and may lead to some simplistic conclusions.

Given the purpose of this work and its size, it was decided that the value of GDP *per capita* would be the most appropriate measure. It is one of the most widely used measures of economic development. It shows the value of global production of goods and services in the region per person, roughly reflecting the wealth of the society. Despite the high degree of data aggregation, it makes it possible, among other things, to take into account the structure of the business activity conducted in the region, the structure of the expenditures of production factors, price ratios and demographic factors (Strahl, 2009, p.17). In addition, the simplicity of the interpretation of the results means that it is relatively frequently used for both scientific analyses and designing economic policies and tools (Bogdański, 2010).

Then the processes of economic convergence were analysed. The analyses of the processes of economic growth usually distinguish between two types of convergence. The first of them, beta-convergence, comes in two versions. The first one – absolute convergence – occurs when the poorer regions develop faster than the rich areas, but the growth of their GDP *per capita* gets faster if the t level of economic growth was lower. The second one – conditional convergence – occurs when regions with

similar structural characteristics become more alike (e.g. the educational level of the population, the structure of production). Regions with different structural parameters trend towards different long-term income levels (Wójcik, 2008).

To determine whether beta-convergence occurs between economies, one can use the following equation (Kudłacz & Woźniak, 2009):

$$\frac{1}{T}\ln\left(\frac{y(T)}{y(0)}\right) = \alpha_0 + \alpha_1 lny_0$$

Where:

y(T) – the value of GDP per capita in the ending year;
y(0) – the value of GDP per capita in the starting year;
T+1 – the number of years.

Using the values of parameter α_1, it is possible to calculate parameter β, which indicates what percentage of the distance from the long-term equilibrium state the economy covers in one year (ibid).

The second type of convergence is sigma-convergence. It occurs when the diversification of income between economies decreases over time. The basic measures of this diversification are the standard deviation and the coefficient of variation of GDP per capita. The occurrence of the beta convergence is a necessary – but insufficient – condition for obtaining the sigma-convergence (Próchniak, 2004).

The time frame of the analysis covered the period between 2000 and 2014, and was largely limited by the possibility of obtaining comparable statistical data. The starting year of the analysed period is the second full year of the functioning of the new provinces after the introduction of the reform of the territorial organisation of the country. The ending year is 2014, which was the last year for which it was possible to obtain comparable statistical data, the source of which was the Eurostat database (http://ec.europa.eu/eurostat/data/database).

2. The concept of economic development and its measures

Defining the concept of economic development is a complicated and complex task, regardless of its spatial scale. In addition, its understanding has changed over time due to the evolution of research on the nature of the various socio-economic processes and civilisational changes taking place in the world. This is a result of the complexity and multidimensionality of the processes of economic development. Hence, to know it fully and understand its essence requires a comprehensive and multidisciplinary approach based on the categories of economic, social, spatial, ecological and local order (Kosiedowski, 2001).

The deliberations on the nature of economic growth and development and their determinants have been at the heart of most analyses in economic theory practically

since its emergence as an independent scientific discipline. At the same time, this is still an issue that requires continuous research (Bocian, 2002). Economic development is usually defined as "(...) the process of changes in the economy that is caused by the development of productive forces and entails both quantitative and qualitative changes in the production ratios and the production method" (Przygodzki, 2012, p.43). In other words, it is defined as economic growth with some simultaneous processes of qualitative changes. These changes occurring in the material, ownership and institutional structures of the economy exert a stimulating influence on the dynamics of the economic changes, particularly on the production growth rate, the size and structure of employment, and the distribution of income (Korenik, 1999).

The literature includes a wide diversity of definitions of economic development, also in relation to the economic development of regions. They are related to various aspects of the process and emphasise its different conditions and dimensions. Hence, it seems more reasonable to identify some characteristics of economic development that are common to most definitions. Thus it can be assumed that (Chądzyński, 2012):

1) Development is multidimensional – it combines many interdependent processes and phenomena of social, economic, political and cultural nature.
2) Development is a broader category than growth – it also contains structural changes. Development results in an increase in the number of elements of the economic system, which leads to a more complex structure. In the case of growth, however, only the "size" of these elements increases.
3) Development is a dynamic category – the relations between various developmental components are not constant and are subject to some slow evolutionary changes under normal conditions.
4) Development is spatially diversified.

Being a complex and multidimensional process, regional development consists of various components. The most important of these include: economic growth, employment growth, the rise in prosperity and quality of life, the increase in investment attractiveness, technological development and the implementation of innovations, the processes of the restructuring of economic activity, the development of human and social capital, the development of the institutional infrastructure, the improvement of the image of the regions, and the integration of the regions (Szewczuk, 2011).

In the debate on the nature of economic development, the fundamental question is what relations connect it to economic growth. Is it possible to have economic growth without economic development (or vice versa)? Are the factors determining economic growth and economic development the same? How should they be measured?

Although the relations between economic growth and economic development are not always clear and are not universal, it seems that growth is the primary process. First, care must be taken to increase the level of wealth and create an appropriate financial and material foundation so that it is later possible to support the development of the non-material spheres. It is these material foundations (work and the income related to it) that determine the ability to achieve the higher-order objectives – spiritual development and securing lifetime achievements and opportunities for future generations (Chądzyński, 2012).

One consequence of the complexity and multidimensionality of the processes of regional economic development is the difficulty in measuring the level and dynamics of the changes. Its comprehensive measurement requires that many different quantitative and qualitative variables should be included and measured. For this purpose, complex synthetic multi-measure indices are designed to comprehensively measure the level of economic development of the selected spatial units. This, however, raises important methodological challenges (related to the proper selection of diagnostic variables, assigning the appropriate weights to them, and assigning numerical values to qualitative variables) as well as practical challenges which result from the availability and frequency of publication of statistical data. Furthermore, the interpretation of such indices may pose some difficulties, especially in the context of conclusions for economic policy (Michalos, 2007; Pater, Harasym & Skica, 2015).

One relatively frequently used synthetic measure of the level of economic development (also in relation to regions) is the value of Gross Domestic Product per capita. This indicator represents the average value of the global production generated in a given area per person. It reflects an approximation of the wealth of the society as the basic component of its economic development. The simplicity of calculation, the ease during the interpretation and development of various comparisons and summaries, and the widespread availability of statistical data cause it to be one of the most widely used measures of economic development at different levels of data aggregation despite some flaws and limitations (Michalek & Zarnekow, 2011). In the case of regions of countries of the European Union (EU), the use of GDP per capita as the basic criterion for the assessment of the development level is also justified by the fact that its value is decisive for the qualification of the region for support under the Convergence objective of the EU Cohesion Policy (Puigcerver-Penalver, 2007).

3. The local government system in Poland

One of the factors that may affect the level and dynamics of regional economic development is the system of territorial organisation of the country. The size of the region, the method of the delimitation of its borders and – most importantly – the level of autonomy of the regional authorities are not without impact on the socio-economic processes and on the possibility to shape them under the pursued policy.

It is assumed in the economic and social sciences and practice (including the framework of the EU Cohesion Policy) that the region is "(...) a territorial unit with a political representation directly subordinated to the central level" (Waldziński, 2005, p.22). If one accepts this as a decisive criterion, one must note that the function of the regions in Poland is performed by provinces (in Poland called voivodeships).

Currently, the Polish territory is divided into 16 provinces. They were established by the Act of 24 July 1998 on the introduction of the three-tier administrative division of the country. This event played an important part in the systemic and economic transformation initiated in Poland after the collapse of the socialist economy in 1989. The new larger provinces started functioning on 1 January 1999 and replaced the previous 49 smaller provinces. But more importantly, under the said act the provincial authorities have regained the capacity to self-govern guaranteed by the Constitution and have been properly equipped with real instruments that enable the shaping of their socio-economic situations for the first time since the end of World War II (Heller & Bogdański, 2013).

The purpose of the reform was to boost the economic development of Poland by, among other things, increasing the degree of economic and legal independence of the 16 provinces at the NUTS II level. After five years, significant adjustments were made to the reform. From 1 January 2004 on, there was a significant increase in the revenues of local governments. In practical terms, these changes were aimed at increasing the decentralisation of the country. The rising income had two sources, the first being the increased grants and subsidies from the state budget, and the second being the increase in local governments' own revenues (Heller, 2011, p.102).

In accordance with the Polish legislation, the provincial government is responsible for the implementation of a number of mandatory tasks (goals) whose efficient and effective performance also contributes to raising the level of socio-economic development. The main goals include tasks in the area of:

1) public education, including higher education;
2) the promotion and protection of health, social security and support for families;
3) the modernisation of rural areas, environmental protection and water management, including flood protection;
4) spatial development;
5) consumer rights protection;
6) public security and defence;
7) counteracting unemployment and reviving the local labour market.

In order to accomplish the tasks above, the provincial government has a specified budget in which the most important sources of income include: shares in the taxes that form the income of the state budget, income from provincial properties and

grants from the state budget and special purpose budgets (the Act of 13 November 2003 on the income of local government units – legal status as of October 2016).

4. Results

Table 1 presents the values of GDP per capita for the Polish provinces between 2000 and 2014 as an approximate measure of the level of economic development. It also presents the values of similar measures for the whole country as well as the EU average. For comparative purposes, it was decided that all data presented in them should be expressed on the basis of purchasing power parity.

When analysing the data presented in Table 1, one can see some clear patterns. Firstly, Poland is a country with a strong diversification in the level of regional economic development. At the beginning of the analysed period, the difference between the richest (Mazowieckie Province) and the poorest region was more than double (2.14). Moreover, these disproportions increased over the analysed period, and they were 2.3:1 in 2014.

Compared to other regions, the capital region (Mazowieckie Province) has the highest level of development, which largely results from its favourable location (the central part of the country) and above all the presence of Warsaw – the capital of the country, the largest Polish city, and the location of the largest and most important organisations and enterprises in the country. Other regions characterised by a relatively high level of economic development include the provinces of Śląskie, Dolnośląskie and Wielkopolskie. Their significant part belongs to the most urbanised areas in the country whose central cities (Katowice and the whole Silesian conurbation, Wroclaw and Poznan, respectively) are among the largest city centres in Poland. At the same time, they are highly industrialised regions with long-term traditions in many branches of the secondary industry. In relation to the national average, the average level of GDP per capita in these provinces in 2000 was higher by 17.4 percentage points. At the end of the analysed period, this value increased to 20.8 percentage points. At the same time, in 2000 the share of the four most developed provinces mentioned above in the creation of the national GDP was equal to 50.85% (and 20.4% for Mazowieckie Province). At the end of the analysed period it increased to 52.68% (22.12% for Mazowieckie Province).

At the other extreme, when it comes to the level of economic development measured by the value of GDP per capita, there are the 5 provinces of eastern and north-eastern Poland: Podkarpackie, Świętokrzyskie, Lublin, Podlaskie and Warmińsko-Mazurskie Province. The level of GDP per capita in this group of provinces in 2000 was lower than the national average by 16.1 percentage points on average. Moreover, subsequent years saw the constant deterioration of this relation. Thus in 2014, the value of GDP per capita in these regions was lower than the national average by 23.7 percentage points. Similarly, the share of these provinces in the creation of the national GDP during the 15 years under analysis decreased:

Table 1 – GDP per capita of voivodships in Poland during years 2000-2014 (in euro, PPS – purchasing power parity standard)

Province	2000	2002	2004	2006	2008	2010	2012	2014	Dynamics 2000=100%
Lódzkie	8 200	9 000	10 100	11 400	13 100	14 600	16 400	17 400	212,20
Mazowieckie	14 100	15 000	16 600	19 000	21 500	25 000	28 100	29 800	211,35
Malopolskie	8 300	8 800	9 700	11 100	12 600	13 800	15 600	16 600	200,00
Slaskie	9 800	10 700	12 300	13 100	15 100	16 800	18 700	19 300	196,94
Lubelskie	6 600	7 100	7 800	8 500	10 000	10 800	12 400	13 000	196,97
Podkarpackie	6 700	7 300	8 000	8 800	10 100	10 900	12 300	13 200	197,01
Swietokrzyskie	7 200	7 800	8 700	9 600	11 600	12 100	13 200	13 500	187,50
Podlaskie	6 800	7 500	8 100	9 000	10 300	11 500	12 600	13 400	197,06
Wielkopolskie	9 800	10 300	11 800	13 100	14 900	16 500	18 700	20 000	204,08
Zachodniopomorskie	9 100	9 500	9 900	11 100	12 600	13 400	14 800	15 600	171,43
Lubuskie	8 200	8 700	9 800	11 100	12 200	13 300	14 600	15 600	190,24
Dolnoslaskie	9 500	10 200	11 100	13 200	15 200	17 700	20 000	20 800	218,95
Opolskie	7 700	8 000	9 400	10 100	12 100	12 900	14 200	15 000	194,81
Kujawsko-Pomorskie	8 300	8 900	9 700	10 700	12 100	13 000	14 300	15 100	181,93
Warminsko-Mazurskie	7 100	7 500	8 300	9 200	10 400	11 400	12 600	13 300	187,32
Pomorskie	9 100	9 900	10 800	12 200	13 500	15 100	17 200	17 700	194,51
POLAND	9 200	9 900	11 000	12 300	14 100	15 700	17 600	17 900	194,56
EU-28	19 600	21 100	22 400	24 500	26 000	25 400	26 500	26 700	136,22

Source: Eurostat, http://ec.europa.eu/eurostat/data/database

it was 15.98% in 2000 and 15.26% at the end of the analysed period. These regions form the so-called eastern wall of Poland – an arbitrary macro-region with a low level of economic development. It consists of the provinces with a relatively low population density, a poorly developed urban network, and a relatively uncompetitive production structure in which a relatively important role is played by the agriculture industry. An additional common trait of these provinces is the fact that all of them have hallmarks of peripheral regions to a large degree. Their peripherality is not only of a geographic nature (location along the eastern border of the country) but of economic, social and cultural nature, as well (Heller& Bogdański, 2015).

One of the measures most commonly used to determine disparities in economic development between spatial units is the coefficient of variation of GDP per capita. Fig. 1 shows its values estimated for all the Polish provinces between 2000 and 2014.

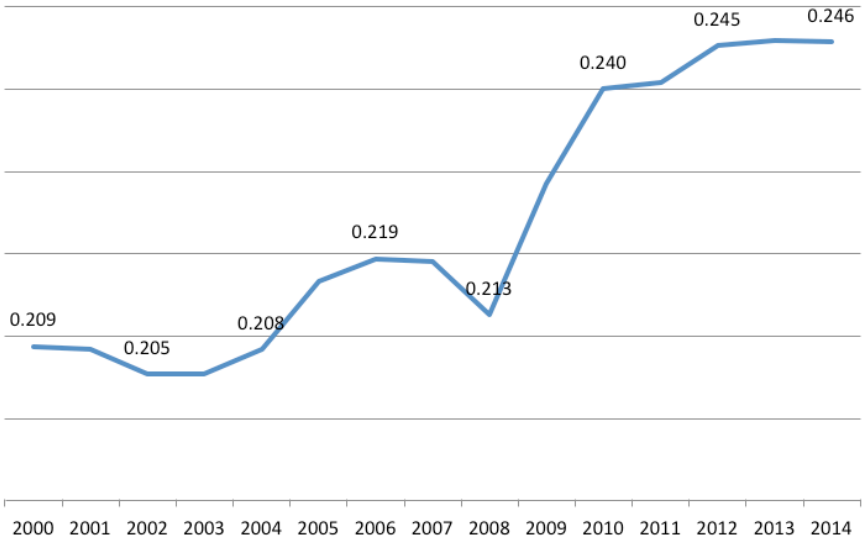

***Figure 1**: The values of the coefficient of variation of regional GDP per capita in Poland between 2000 and 2014.*

Source: author's own calculations based on Eurostat data, http://ec.europa.eu/eurostat/data/database

As the data presented in Fig. 1 suggest, practically the entire period being analysed saw an increase in the diversification of the level of economic development of the provinces. The values of the coefficient of variation decreased only in 2002 and 2008. A particularly dynamic growth in these disproportions occurred between 2008 and 2012 – the period when the Polish economy was gradually experiencing the negative effects of the global economic crisis that resulted from the collapse of the mortgage markets in the USA. This also suggests that the economies of the

relatively richest and most developed provinces were characterised by a greater resistance and flexibility to the global economic downturn, which is evidence of a higher level of competitiveness.

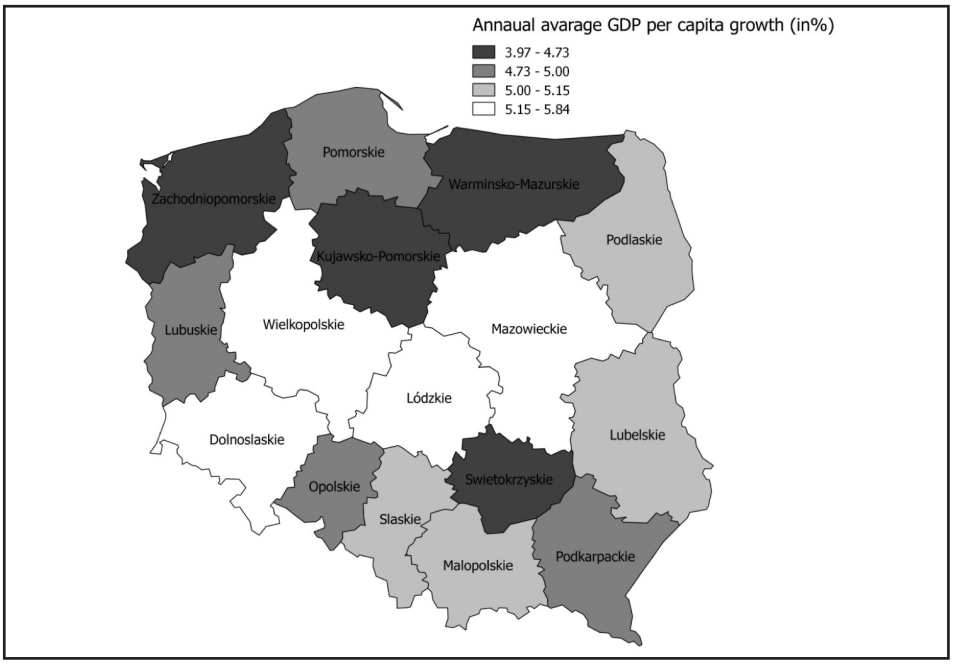

***Figura 2**: The average annual growth rate of GDP per capita in the provinces between 2000 and 2014.*

Source: author's own calculations based on Eurostat data, http://ec.europa.eu/eurostat/data/database

The increase in the regional developmental gaps was a consequence of the lack of beta-convergence, i.e. the relatively faster development of the economies of the provinces that were characterised by a higher level of development at the beginning of the period. The average annual growth rate of GDP per capita in the analysed period in Poland was 5.19% (Fig. 2). For the provinces that were the four most developed regions in Poland in 2000, it was higher by almost 0.2 percentage points per annum. As a result, this yielded a more-than-double increase (208.1%) in the regional production per capita for this group of regions at the end of 2014 compared to 2000. In the same period GDP per capita across the country increased by 202%. The average annual growth rate of GDP per capita for the five poorest provinces of Poland between 2000 and 2014 was 4.86%. This means that the value of this indicator in this group of regions at the end of the analysed period was higher by an average of 193% compared to 2000. The province with the highest average annual GDP growth rate (5.84%) in this period was Dolnośląskie. Thus, the value of GDP per capita in this province at the end of 2014 was higher by 219% than in

the analogous period in 2000. The lowest average growth rate, in turn, was that of Zachodniopomorskie Province (3.97%).

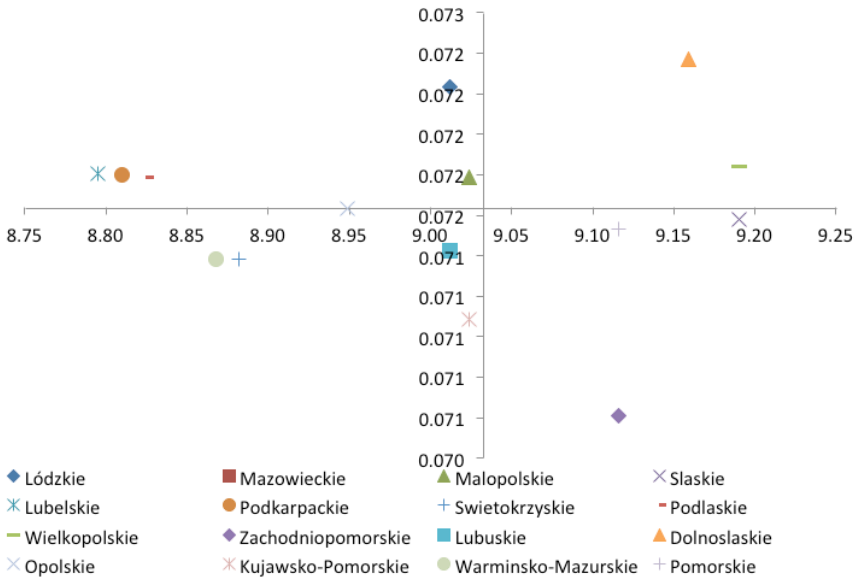

***Figure 3**: Processes of beta-convergence of the provinces between 2000 and 2014*

Source: author's own calculations based on Eurostat data, http://ec.europa.eu/eurostat/data/database

The thesis about the lack of beta-convergence between the Polish regions is also confirmed when using slightly more advanced statistical analysis methods. Fig. 3 shows the relation between the initial level of economic growth in the provinces (the measure of the level of development was based on the natural logarithm for GDP per capita in 2000) and the average annual growth rate of GDP per capita as a method of measuring the dynamics of growth processes (in this case, the measure was the natural logarithm of the average annual growth rate of GDP per capita between 2000 and 2014). The vertical line marks the average level of economic growth of all the provinces in 2000, and the horizontal line indicates the average annual growth rate of GDP per capita between 2000 and 2014.

The analysis of the data shown in Fig. 3 reveals a weak correlation between the initial level of economic growth and the dynamics of changes in GDP per capita. The provinces that were initially characterised by a relatively low level of economic development usually developed more slowly in the coming years. This is reversed for the regions that are relatively highly developed but the trend is not clear. The coefficient of the correlation between the natural logarithm of GDP per capita at the beginning of the analysed period and the dynamics of its growth in subsequent years adopts a positive value, which may indicate the existence of beta-divergence

processes, but both its value (0.09) and the level of statistical significance do not allow for confirmation of this thesis.

The regression equation describing the relation between the initial level and the subsequent growth dynamics for the Polish provinces between 2000 and 2014 took the form:

$$\frac{1}{T}\ln\left(\frac{y(2014)}{y(2000)}\right) = 0.0697 + 0.0002 ln y_0$$

(p = 0.000) (p = 0.715) $R^2 = 0.09$

The positive value of the coefficient before the explanatory variable indicates that in the case of the Polish regions between 2000 and 2014 it was possible to observe processes of slow beta-divergence, which consisted in a relatively fast growth of the relatively rich provinces, and these differences increased at a rate of 0.02% per annum. One should exercise caution with these conclusions because of the low value of the coefficient R^2 of the estimated regression function, and due to the statistical insignificance of the calculated slope of the function.

The obtained results could be influenced to some extent by the specific nature of Mazowieckie Province – its superior position in the social and economic system of Poland and by far the highest level of economic development. Therefore, it was decided to evaluate the regression function again but this time excluding the capital region. The obtained results are as follows:

$$\frac{1}{T}\ln\left(\frac{y(2014)}{y(2000)}\right) = 0.0723 - 8E - 05 ln y_0$$

(p = 0.000) p = 0.929) $R^2 = 0.006$

In this case, they may indicate the processes of slow convergence between the Polish regions, but both its rate and the low statistical significance of the estimated coefficients of the regression equation do not allow for clear confirmation of this thesis, either.

Determining the level of economic development of spatial units is relative in nature, i.e. the indication whether a given country or region is at a high or low development level depends on the choice of the units it is compared against. In the case of the Polish economy and its regions, the natural point of reference is the average level of economic development of the European Union and its regions. The accession of Poland to the economic and political structures of the EU, which occurred on 1 May 2004, was a symbolic turning point in the history of the country that finalised the key stage of the processes of economic and political transformation commenced in 1989 after the collapse of the centrally planned economy. For these reasons, Table 2 shows data representing the value of GDP per capita for Polish regions in relation to the average value of this indicator in the EU.

As the presented data suggest, the level of economic development of the Polish regions in relation to the average level of development measured by the value of

Table 2: GDP per capita of Polish voivodships in relation to the EU average (PPS, in percentage)

Voivodship	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Change in percentage points
Lódzkie	42	41	43	44	45	46	46	49	51	54	57	59	62	62	63	21
Mazowieckie	72	71	71	72	74	76	78	82	83	92	98	102	106	107	108	36
Malopolskie	42	40	42	42	43	44	45	47	49	52	54	57	59	59	60	18
Slaskie	50	49	51	51	55	54	53	56	58	63	66	69	70	70	70	20
Lubelskie	34	34	34	34	35	35	35	37	39	41	43	45	47	47	47	13
Podkarpackie	34	34	35	35	36	36	36	37	39	42	43	45	46	47	48	14
Swietokrzyskie	37	36	37	38	39	38	39	42	45	47	48	49	50	49	49	12
Podlaskie	34	35	36	36	36	37	37	39	40	43	45	47	48	49	49	15
Wielkopolskie	50	49	49	50	53	54	54	56	57	64	65	68	70	72	73	23
Zachodniopomorskie	46	45	45	44	44	45	45	47	49	51	53	54	56	56	57	11
Lubuskie	42	41	41	41	44	45	45	47	47	50	52	53	55	56	57	15
Dolnoslaskie	48	47	48	49	50	51	54	58	59	64	70	73	75	75	76	28
Opolskie	39	37	38	38	42	41	41	45	47	50	51	53	54	54	55	16
Kujawsko-Pomorskie	42	42	42	42	43	43	44	46	47	49	51	53	54	55	55	13
Warminsko-Mazurskie	36	35	35	36	37	37	38	39	40	43	45	46	47	48	48	12
Pomorskie	46	45	47	47	48	49	50	52	52	58	59	62	65	64	64	18
Poland	47	46	47	48	49	50	50	53	54	59	62	64	66	67	68	21

Źródło: obliczenia własne na podstawie danych Eurostat, http://ec.europa.eu/eurostat/data/database

GDP per capita is low in most cases. At the beginning of the period it ranged from 34% (for Lubelskie and Podkarpackie Provinces) to 72% (Mazowieckie Province) of the EU average. This approach also clearly exposes the groups of provinces with a relatively good economic situation (Mazowieckie, Śląskie, Dolnośląskie and Wielkopolskie) as well as the relatively poor regions (the so-called eastern wall). However, subsequent years saw a gradual improvement in this relation in favour of the Polish regions. The rate and scale at which the developmental gaps decreased were not uniform, though.

Mazowieckie Province definitely stands out as its value of regional GDP per capita in relation to the EU average over the analysed period increased by 36 percentage points. It is also the only Polish region in which the value of the analysed indicator exceeded its average value throughout the Community from 2011 on.

The provinces reducing the developmental gap with the EU at a relatively fast pace are also Dolnośląskie (change of 28 percentage points), Wielkopolskie (23 percentage points), Łódzkie (21 percentage points) and Śląskie Province (20 percentage points). All of them were among the relatively highly developed regions at the beginning of the period. Again, this indicates the deepening of the inter-regional disparities in Poland between 2000 and 2014. The presented data also show that the reduction of the developmental gap between the entire country and the EU average by 21 percentage points was, first of all, due to the relatively rapid development of those very regions that were already at a relatively high level of development at the beginning of the period.

In the case of provinces that were characterised by the lowest values of regional production per capita in 2000, one can also observe the process of economic convergence with respect to the average level of development in the EU. The dynamics of this process, however, are clearly lower than those of the regional economic leaders. Of the five regions that had the lowest values of GDP per capita in 2000, the economies of Podlaskie (15 percentage points) and Podkarpackie Provinces were the fastest at reducing the developmental gap with the EU. On the other hand, in the case of Warmińsko-Mazurskie and Świętokrzyskie Provinces, the disparities decreased by only 12 percentage points.

5. Conclusions

The analyses do not allow for a clear evaluation of the processes of economic development of the Polish regions, especially in the context of the dynamics and scale of the processes of economic convergence. Focusing on the diversification of economic development within the country, it should be emphasised that the year 2000 saw relatively large disparities in the level of GDP per capita for the provinces. The highest levels of development were those of Mazowieckie, Śląskie, Dolnośląskie and Wielkopolskie. These are regions with large industrial and manufacturing tradi-

tions, a modern production structure and relatively large capital cities. On the other hand, the regions with the lowest level of development were the peripheral provinces (located along the eastern Polish border) where agriculture and the relatively technologically underdeveloped processing industry played an important role in the production structure. In addition, these regions have a low population density and an underdeveloped city network. The observed differences in subsequent years increased steadily. This was despite the fact that after 2007 Poland was the greatest beneficiary of EU funds allocated to the implementation of the Cohesion Policy.

At the same time, it was possible to observe an ongoing convergence process in relation to the average level of economic development of the EU countries and regions. Importantly, this process was not limited only to the wealthiest provinces. Also, the Polish regions that belonged in 2000 to the least developed regions gradually reduced the development disparities in comparison to the EU average, although the rate of convergence processes was much lower in this case. It should be noted, though, that similar tendencies to increase the regional development disparities within national economies and reduce them between regions of the various EU countries can also be seen in most Member States of the European Community.

The persistence of the regional economic disparities in Poland gives reasons to believe that they will continue to increase in the coming years with all their negative consequences. Currently, the only regions characterised by a positive balance of internal migration are those that are already highly developed. The phenomenon of migration applies mainly to highly skilled and educated young people. As a result of the outflow of the most valuable workforce resources, the development potential of the poorest regions will be reduced, which may lead to the acceleration of the processes of divergence. Analysing the debate on the determinants of regional development in Poland the results of the paper should give a new impulse for changing at least some of the goals and tools of regional policy. It follows that a stronger emphasis in its goals should be put in creating for less developed regions more effective ways of using the dynamic growth of regional leaders to improve their economic potential and, in the long term, to improve their dynamics of regional economic development.

These findings raise questions about the effectiveness of the EU Cohesion Policy and other measures undertaken to boost the development of the least developed areas. Is it possible to effectively and efficiently combat disparities in development in the face of the persistence of the developmental conditions and the dynamically changing macroeconomic environment? What economic policies should be used? Does supporting the economic development of underdeveloped regions not limit the competitiveness and development potential of the richest regions, and as a result also of the whole country? Similar questions about the point and relevance of the Cohesion Policy are periodically raised in scientific and political discourse during the assessment of its effectiveness. The inability to resolve them does not undermine

the point of asking questions or, even more, searching for answers. However, it will probably require a change in the approach to designing the guidelines and tools of the Cohesion Policy.

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Management of current assets in the Polish corporate sector – selected aspects

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Abstract

Management of current assets in an enterprise is a flexible process which depends on a range of endogenous and exogenous factors, including the macroeconomic situation. Effective management of the elements within working capital helps in the liquidity maintaining profitability increasing and survival. Therefore, the way in which trade credit, inventories, among others, are organized, managed and monitored is of crucial importance to ensure the increasing performance of the economic entities. The aim of this paper is to identify and analyse the selected aspect in the area of current assets management in Polish enterprises, classified according to the size of employment, as micro, small, medium-sized and large enterprises. To achieve this aim, a questionnaire survey was conducted in 2015 in a group of 380 enterprises in Poland. It enabled identification of statistical relationships with reference to selected categories of enterprises and verification of the research hypothesis. The studies show that the area of current assets in Polish enterprises is managed in an unprofessional and sketchy way, on the basis

of intuition or ad hoc actions, which improve financial management methods and tools.

Keywords: ***working capital, inventories, receivables, management, current assets***

Introduction

The importance of working capital has been investigated from different perspectives in previous studies. Working capital is defined as the difference between current assets (cash, accounts receivable, inventories) and current liabilities and is often used to measure a firm's liquidity level (Mun & Jang, 2015; Okręglicka, 2014). The objective of working capital management is to ensure that the economic entity is able to meet its operating expenses and also remain in a position to pay short-term obligations. Enterprises with higher working capital investment are considered to be more liquid; hence they have lower bankruptcy risk (Dunn and Cheatham, 1993). By managing working capital efficiently, enterprises can reduce their dependence on external funding, reduce their financing costs and use the released cash for further investments, improving the company financial flexibility (De Almeida & Eid, 2014). The mismanagement of working capital may lead to a liquidity crisis and a reduction in profitability, hence affecting the ability of the firm to continue to operate as a going concern (Ukaegbu, 2014). So, working capital may act as a stock of precautionary liquidity, providing insurance against future shortfalls in cash (Fazzari & Petersen, 1993). Efficient working capital management is recognized as an important aspect of financial management practices in allorganizational forms (Enqvista et al., 2014). The particular importance of working capital management is required in small and medium-sized companies because of higher financially constrained they need to face (García-Teruel & Martínez-Solano, 2007; Haviernikova et al., 2016).

The most commonly described elements of working capital management in economic literature are: receivable (trade credit) management and inventory management. The effectiveness in their management can bring the improvement in business performance and ensure the day to day survival of the company.

The aim of this paper is to identify and analyse the selected aspect in the area of current assets management in Polish enterprises, classified according to the size of employment, as micro, small, medium-sized and large enterprises.

The next section presents a review of prior literature related to working capital management. The research methodology and data are discussed in the second section, and then the results and discussion are presented in the third section followed by the conclusions and potential contributions of the study.

1. Theoretical background

There is substantial literature on trade credit policy and inventory management. Many authors emphasize the importance of taking into account the interactions between the various working capital elements that is receivable accounts, inventories and payable accounts (Sartoris & Hill, 1983). However, there are still not so many attempts to integrate both credit policy and inventory management decisions into one coherent policy.

The investment in receivable accounts and inventories represents an important proportion of a firm's assets, while trade credit is an important source of funds for most firms (Baños-Caballero et al., 2014). It is presented in literature that a higher investment in extended trade credit and inventories might increase corporate performance for several reasons. Larger inventories can reduce supply cost, provide hedge against input price fluctuations, and minimize loss of sales due to potential stock-outs (Blinder & Maccini, 1991; Corsten & Gruen, 2004). In addition, they allow enterprises better service for their customers and avoid high production costs arising from high fluctuations in production (Schiff & Lieber, 1974).

In turn, trade credit to customers may affect positively sales of the company because it allows for price discrimination, serves as a warranty for product quality, and fosters long-term relationship with customers (Summers & Wilson, 2002; Long et al., 1993). Also, it encourages clients to acquire merchandise at times of low demand (Emery, 1987; Ben-Nasr, 2016) and allows them to verify product and services quality prior to payment (Smith, 1987; Lee & Stowe, 1993). Granting trade credit may encourages customers to buy products when it is difficult to differentiate products (Shipley & Davis, 1991; Deloof and Jegers, 1996)

Excessively high level of receivables or inventories brings many negative effects since greater receivable and inventory levels indicate a need for additional capital, which enterprises must finance and it involves financing costs and opportunity costs (Aktas et al., 2015). Moreover, too much cash tied up in net operating working capital might also impede companies from implementing value-enhancing investment projects in the short run (Ek & Guerin, 2011).

When we keep stock available, it brings costs such as warehouse rent, losses in stock or insurance and security expenses, just to name a few. The higher the level of inventories is the higher costs are generated (Kim & Chung, 1990).

Accordingly, extending trade credit suggests that the risks inherent in delaying the receipt of payment for goods are outweighed by the rewards. Increased risk of delay or lack of payment is often associated with market power position and competitiveness, technology changes and customer concentration. Additionally, issues such as seasonal demand, capital rationing and financial distress can contribute to delinquency and default risk (Paul and Wilson, 2006). At the same time, the researches indicate that companies that suffer most from late payment tend to be those with poor credit management practices. This suggests that the way in

which trade credit is organized, managed and monitored is of crucial importance to ensure effective risk management (Paul & Boden, 2008).

2. Data and methodology

The aim of this paper is to identify and analyse the selected aspect in the area of current assets management in Polish enterprises, classified according to the size of employment, as micro, small, medium-sized and large enterprises. In view of the main aim, the following research hypothesis has been formulated: *There are still poor management practices in the area of current assets management in Polish enterprises.*

In order to examine hypotheses, the researcher conducted studies in 380 enterprises from southern regions of Poland. The research group selection had an accidental character and this is why study should be treated as a seed research, identifying trends, which should be confirmed, based on representative sample. The study group consisted of 68.9% of microenterprises, 21.8% of small enterprises, 5.3% of medium enterprises and 3.9% of large enterprises. The studies have a form of a direct questionnaire and were carried out in the first half of 2014 and were addressed to enterprises' owners or managers, who were completing survey questionnaires in a paper form in the presence of an interviewer. Despite the fact that the studies referred to enterprise's finance, they had a qualitative character. This resulted from the fact that there were microenterprises in the study group which conduct limited financial reporting; therefore, an access to the quantitative data was restricted. This is why the statistical analysis of the material was conducted on the basis of Spearman's rank correlation coefficient. The studies had seed character and constitute the basis for the preparation of extended research in the future.

3. Results and discussion

Management of current assets, i.e. receivables, inventory and cash, is a very wide subject, so it is difficult to present all aspects of this issue. Based on empirical studies, the author carried out a broad analysis, but only selected aspects thereof will be discussed in this article.

In the first place, attention was paid to receivables, particularly those of commercial character. Problems with enforcement of commercial receivables represent a big challenge for Polish companies and are one of the main causes of loss of financial liquidity. Hence, effective management of receivables has become a priority. Studies have shown (see table 1) that the majority of companies in Poland do not have significant problems with timely settlement of payments by counterparties, although such problems occur more often in larger companies than in smaller entities.

***Table 1**: Problems with inflow of receivables*

	Size of the enterprise				total
	micro	small	medium	large	
yes, big	5,7%	12,0%	9,5%	35,7%	8,4%
yes, but to a limited extent	40,1%	55,4%	71,4%	35,7%	45,0%
no	54,2%	32,5%	19,0%	28,6%	46,6%

Source: own research

Changes in company's income were indicated by surveyed entrepreneurs as the main reasons for the change of internal policies concerning the determination of the level of receivables. Nonetheless, there are visible differences depending on the size of the company, i.e. profitability is more important for the smaller companies, while the level of already owned receivables is of greater importance in case of large companies (see table 2).

***Table 2**: Reasons for changing the policy concerning shaping receivables in a company (extension/ shortening of invoice payment terms for consumers)*

	Size of the enterprise				total
	micro	small	medium	large	
changes in the company's turnover	22,9%	16,9%	23,8%	35,7%	22,1%
profitability of the company	19,8%	22,9%	23,8%	14,3%	20,5%
changes in the level of receivables	9,2%	22,9%	19,0%	28,6%	13,4%
changes in payment terms from suppliers	19,1%	10,8%	23,8%	21,4%	17,6%
others	29,0%	26,5%	9,5%	0,0%	26,3%

Source: own research

When assessing their own policies towards recipients of goods and services among competitors, respondents most frequently evaluated them as moderate or mild (see table 3). In this case, a weak statistical relationship between the size of the company and the applicable policies was noted, i.e. larger companies often use more rigorous policy of enforcement of receivables from their customers than smaller companies.

***Table 3**: Company policies towards customers when granting deferred payment dates in the opinion of entrepreneurs*

	Size of the enterprise				total
	micro	small	medium	large	
very mild	13,0%	1,2%	9,5%	21,4%	10,5%
mild	26,7%	27,7%	9,5%	14,3%	25,5%
moderate	46,9%	53,0%	52,4%	42,9%	48,4%
rigorous	9,2%	13,3%	19,0%	21,4%	11,1%
acute	4,2%	4,8%	9,5%	0,0%	4,5%

Spearman's rho correlation coefficient = 0,134, p = 0,009
Source: own research

When assessing the factors that determine the granting of a deferred payment date to a counterparty it is visible that individual negotiations with a given customer and the quality of up to now cooperation are most important ones. In the case of medium and large companies, order size becomes very important, since it gives the opportunity to utilize economies of scale (see table 4).

***Table 4**: Factors influencing the granting of a deferred invoice payment term to a counterparty*

	Size of the enterprise				total
	micro	small	medium	large	
practice applied in the whole industry	18,2%	19,6%	12,5%	18,1%	17,6%
individual negotiations with a customer	56,1%	63,9%	47,6%	50,0%	57,1%
history of cooperation with a customer	43,5%	57,8%	52,4%	42,9%	47,1%
counterparty's period of operating in the market	9,2%	13,3%	28,6%	7,1%	11,1%
financial and asset situation of a counterparty, analysed on the basis of available information	11,8%	22,9%	28,6%	28,6%	15,8%
counterparty's reputation	14,1%	18,1%	19,0%	35,7%	16,1%
possibility to recommend our company to other customers (business contacts)	11,8%	9,6%	9,5%	7,1%	11,1%
size of the order	26,0%	30,1%	52,4%	57,1%	29,5%
references from other customers	5,3%	3,6%	9,5%	0,0%	5,0%

Source: own research

When analysing the causes of delays in payment of invoices, entrepreneurs mainly point to bottlenecks in payments on the market, i.e. delays overlapping in supply chain, and difficult financial situation of counterparty (see table 5). No less important, especially among the smallest companies, is social acceptance for

delays in settling own liabilities, which usually cannot be combined with financial consequences for the debtor.

***Table 5**: Main reason for contractors' delay in invoice payment*

	Size of the enterprise				total
	micro	small	medium	large	
contractor has problems with the recovery of his own receivables	25,2%	30,1%	19,0%	21,4%	25,8%
contractor is in the deteriorating financial situation	25,2%	21,7%	23,8%	14,3%	23,9%
contractor is not afraid of the consequences in relation to the delay i.e. to the penalty interests	16,8%	15,7%	19,0%	14,3%	16,6%
contractor is dishonest	11,8%	6,0%	9,5%	35,7%	11,3%
in Poland there is a social consent to make the payments after due date	21,0%	26,5%	28,6%	14,3%	22,4%

Source: own research

Resulting payment delays of the counterparties are not without impact on the economic health of a company. Arrears reduce the level of working capital and can undermine the accounting liquidity of a company. This is confirmed by empirical studies, indicating that lack of payment for supplied goods or provided services most often causes delays in payments for own purchases (see table 6). The results are similar in all size groups of companies. The need to reduce investment activity, hampering the development of a company, is another important factor.

***Table 6**: Problems arising in a company as a result of delays in collecting receivables from counterparties*

	Size of the enterprise				total
	micro	small	medium	large	
we cannot continue our own investments	36,6%	42,2%	42,9%	35,7%	38,2%
we cannot settle our own liabilities in a timely manner	60,3%	63,9%	66,7%	71,4%	61,8%
we have to raise prices for our own products	9,9%	10,8%	14,3%	0,0%	10,0%
we need to reduce employment and salaries	5,7%	10,8%	4,8%	7,1%	6,8%
we have to take out a bank loan as we are lacking money	11,1%	28,9%	28,6%	28,6%	16,6%
we cannot introduce new products or solutions	23,7%	19,3%	38,1%	21,4%	23,4%

Source: own research

Despite the problems that generate delays in collecting receivables to companies, most of the surveyed entities do not take any actions aimed at enforcing penalty interests on arrears, fearing a negative reaction of customers in the form of resignation from commercial cooperation (see table 7). Only 11,3% of companies charge penalty interests to be borne by customers, while there is a weak statistical relationship between the size of the company and the frequency of use of this form of disciplining the customers.

***Table 7**: Charging the penalty interests for the delay in invoice payments*

	Size of the enterprise				total
	micro	small	medium	large	
Yes, always	10,7%	9,6%	19,0%	21,4%	11,3%
Yes, in some cases	24,0%	42,2%	42,9%	50,0%	30,0%
No, never	65,3%	48,2%	38,1%	28,6%	58,7%

Spearman's rho correlation coefficient = -0,192, p = 0,000
Source: own research

Effective management of receivables is not just enforcement of arrears and shaping the policy towards counterparties, but also reducing the risks associated with cooperation with trading partners. One of the elements of risk mitigation may be the insurance on receivables in the event of the insolvency of counterparty. It may be noted that few companies in Poland take advantage of this form, while the frequency of insuring the receivables depends to some extent on the size of the company, i.e. larger companies much more often take advantage of such an opportunity than smaller ones (see table 8).

***Table 8**: Use of insurances in case of contractors' insolvency*

	Size of the enterprise				total
	micro	small	medium	large	
yes, always	9,2%	10,8%	14,3%	50,0%	11,3%
yes, but only in case of the largest orders	8,8%	14,5%	19,0%	28,6%	11,3%
only in exceptional cases	15,3%	27,7%	28,6%	0,0%	18,2%
never	66,8%	47,0%	38,1%	21,4%	59,2%

Spearman's rho correlation coefficient = -0,245, p = 0,000
Source: own research

Another important area of management of current assets is inventory management. Having stocks is an essential determinant of smooth sales of goods, influencing temporary "freezing" of current assets at the same time. Most companies covered by the study highlighted an average level of stocks compared to competitors

known to them (table 9). Analysing the level of stocks in individual size groups of companies, it is visible that larger companies more often maintain high storage levels than small entities, probably to their specificity and large-scale production.

***Table 9**: Level of inventory balance*

	Size of the enterprise				total
	micro	small	medium	large	
high level of inventory balance	10,7%	19,3%	28,6%	35,7%	14,5%
sufficient (average) level of inventory balance	73,7%	69,9%	71,4%	57,1%	72,1%
low level of inventory balance	15,6%	10,8%	0,0%	7,1%	13,4%

Spearman's rho correlation coefficient = -0,184, p = 0,000
Source: own research

When analysing the factors that influence or force to maintain a certain level of stock by a company, the highest score was achieved by an answer indicating the absence of a coherent policy in this respect (see table 10). Companies implement temporary measures, make orders (if necessary), thereby foregoing market possibilities which may occur. The only factor which is taken into account is the possibility to obtain a volume discount, which requires planning and raising a specified amount of funds for the eventuality of increased orders.

***Table 10**: Key factors determining the volume of purchases of goods to the warehouse*

	Size of the enterprise				total
	micro	small	medium	large	
product availability	24,4%	27,7%	33,3%	28,6%	25,8%
discount to be obtained for larger purchases	40,5%	49,4%	52,4%	28,6%	42,6%
terms of payments for supplies	21,0%	27,7%	33,3%	21,4%	23,2%
desire to reduce costs of maintaining the warehouse	6,5%	10,8%	4,8%	42,9%	8,7%
desire to reduce transport costs	9,2%	20,5%	33,3%	7,1%	12,9%
inflation (later it will be more expansive)	6,1%	6,0%	9,5%	28,6%	7,1%
orders tailored to the needs – we do not follow delivery conditions	50,4%	39,8%	42,9%	28,6%	46,8%

Source: own research

The above results are also confirmed by the analysis of methods/techniques of replenishment of stocks (table 11). The companies rarely use the techniques indicated in the theory of economic sciences. Most often, they replenish stocks to a predetermined level or take ad hoc decisions, often guided by intuition (which essentially involves small-scale economic actors).

***Table 11**: Techniques of stock replenishment*

	Size of the enterprise				total
	micro	small	medium	large	
having a predetermined stock level and we make an order if the stock differs from this level	33,2%	33,7%	33,3%	21,4%	32,9%
using a computer system in order to control the stock and on this basis we make a decision	11,8%	26,5%	28,6%	28,6%	16,6%
applying an economic model to determine the optimal stock level	3,4%	4,8%	9,5%	21,4%	4,7%
following the market practice in relation to the stock level	8,0%	3,6%	9,5%	7,1%	7,1%
making decisions Ad hoc – we act intuitively, without particular analyses	30,9%	28,9%	14,3%	7,1%	28,7%
other	12,6%	2,4%	4,8%	14,3%	10,0%

Source: own research

The above approach of entrepreneurs in the field of shaping stock levels may result in part from the fact that they do not perceive stocks as a factor that limits the liquid capital in the company (table 12). Most companies have not found any relationship between stocks and problems with accounting liquidity. At the same time, a weak statistical relationship was noted here, indicating that smaller companies suffer less from accounting liquidity problems due to "freezing" cash in the form of stocks.

***Table 12**: The need to have goods in stock as a source of accounting liquidity problems (lack of cash – cash frozen in the form of goods)*

	Size of the enterprise				total
	micro	small	medium	large	
yes, to a large extent	4,2%	6,0%	9,5%	7,1%	5,0%
yes, but slightly	29,4%	38,6%	28,6%	42,9%	31,8%
no	66,4%	55,4%	61,9%	50,0%	63,2%

Spearman's rho correlation coefficient = -0,102, p = 0,047
Source: own research

An important element of management of current assets is cash management, including ensuring an adequate level of current assets. Polish companies in a vast majority finance themselves using accumulated own resources and this trend deepens with decreasing size of a company. Other forms of financing are only a complement to the own resources, becoming meaningful in case of large companies only (see table 13).

***Table 13**: Current working cash has been obtained from:*

	Size of the enterprise				total
	micro	small	medium	large	
own (private) resources	82,8%	83,1%	76,2%	71,4%	82,1%
working capital loan	11,8%	25,3%	38,1%	35,7%	17,1%
overdraft	7,6%	15,7%	19,0%	0,0%	9,7%
supplier credit (receiving invoices with payment terms)	15,6%	16,9%	14,3%	21,4%	16,1%
customer credit (prepayments)	0,8%	3,6%	0,0%	7,1%	1,6%
private loans	5,7%	10,8%	4,8%	7,1%	6,8%
others	11,1%	7,2%	9,5%	42,9%	11,3%

Source: own research

Among the reasons for the shortcomings in the working capital, the surveyed companies most often indicate sales with deferred payment date, problems with enforcement of receivables and the need to invest, which moves own resources from the current operations area to the development operations area and relates in particular to larger economic operators (table 14).

***Table 14**: Reasons for shortages of working capital in a company*

	Size of the enterprise				total
	micro	small	medium	large	
low profitability of a company	21,8%	19,3%	9,5%	0,0%	19,7%
sale on invoice with payment term	19,5%	41,0%	38,1%	35,7%	25,8%
the need to prepay the supply of materials, goods, etc.	20,2%	20,5%	14,3%	35,7%	20,5%
problems with enforcement of payments from counterparties – untimely payment of invoices	22,1%	34,9%	47,6%	28,6%	26,6%
increased sales volumes	6,9%	6,0%	23,8%	7,1%	7,6%
price fluctuations, exchange rates, etc.	3,8%	8,4%	19,0%	28,6%	6,6%
need for constant investments	22,1%	28,9%	38,1%	50,0%	25,5%
others	29,8%	21,7%	14,3%	7,1%	26,3%

Source: own research

The above results are only selected aspects of management of current assets in the Polish corporate sector. Studies aimed not only at identifying selected volumes, but also at finding statistical relationships between them and the size of companies, which worked out only in certain areas of research.

4. Conclusions

Constant analysis and effective management of current assets is a key element in maintaining accounting liquidity and surviving in the market. Polish corporate sector is often affected by the problems related to the maintenance of liquidity, which is the main cause of bankruptcies of small companies, particularly start-ups.

According to the main aim of the paper, the identification and analysis of the selected aspect in the area of current assets management in Polish enterprises were conducted. This allowed for a partial confirmation of a hypothesis. The studies clearly indicate that the area of current assets in Polish enterprises is managed in an unprofessional and sketchy way, on the basis of intuition or ad hoc actions. This conclusion points to the necessity of improving management methods, including the use of professional methods and management tools to a larger extent, which refers particularly to small-scale business entities.

The contribution of this paper to the literature is the presentation of national results of the research which could be compared with the analogical data from other countries or regions. In addition, it shows the differences between results in micro, small and medium-sized enterprises, which allow the further development of the studies.

The main limitation of the performed studies is the lack of the possibility to compare the results with the situation in other countries due to the local nature of the studies. Certainly, they can provide valuable comparative basis for the results of studies conducted by scientist among companies operating in various regions of the world.

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Comparison of environmental protection costs and revenues in Portugal and Poland

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Abstract

Environmental protection expenditure should show the effort being made to prevent, reduce and eliminate pollution resulting from the production or consumption of goods and services. The paper presents definitions and survey results of environmental protection expenditure in Poland and Portugal. Investment expenditure on environmental protection is broken down into end-of-pipe and integrated projects. The current costs of environmental protection were also analyzed. Analyzes were made according to the domains of environmental protection and economic sectors. The main source used was Database of Statistical Office of European Union – Eurostat.

Keywords: ***environmental protection expenditure, costs and revenues.***

Introduction

Environmental protection is defined as all activities directly aimed at the prevention, reduction and elimination of pollution or any other degradation of the environment.

Environmental protection expenditure represents the economic resources devoted to environmental protection. According to UE methodology environmental protection expenditure consists of outlays and other transactions related to:

- investment expenditures – capital formation and the buying of land (investment) for environmental protection activities and users' outlays to buy environmental protection products;
- current expenditures – inputs for environmental protection activities (energy, raw materials and other intermediate inputs, wages and salaries, taxes linked to production, consumption of fixed capital);
- transfers for environmental protection (subsidies, investment grants, international aid, donations, taxes earmarked for environmental protection, etc.).

Environmental protection is defined according to the Classification of Environmental Protection Activities (Eurostat, 2000), which distinguishes nine different environmental domains:

1. Protection of air and climate
2. Wastewater management
3. Waste management
4. Protection and remediation of soil, groundwater and surface water
5. Noise and vibration abatement
6. Protection of biodiversity and landscapes
7. Protection against radiation
8. Research and development (R&D)
9. Other.

Environmental expenditure has been divided, according to the property sectors, into:

- public sector – government institutions (central public administration, regional and local governments as well as public organizations and institutions mainly classified in NACE, Rev. 2 as 84),
- business sector – commercial enterprises, financial and insurance institutions as well as non-commercial institutions (all activities except NACE 84),
- producers specialized in environmental protection (NACE 36-39) whose main activity is to provide services for environment protection, mainly waste collection disposal and sewage treatment,

- household sector – there is no clear distribution into investment and current expenditure in this sector; the specificity of household activities combines all the types of expenditure together.

Surveys of environmental protection costs are conducted in all UE countries, according to EU methodology (European Commission, 2005; OECD & Eurostat, 2005a; Eurostat, 2007). Data on environmental expenditure are collected by the statistical office of the European Union – Eurostat through the Joint OECD/Eurostat Questionnaire on Environmental Protection Expenditure and Revenues (OECD & Eurostat, 2005b).

1. Total environmental protection costs in UE

The basic indicators used to analyse the dynamics of environmental expenditure are:

- contribution to Gross Domestic Product (GDP),
- expenditure per inhabitant.

The level of total environmental protection expenditure in 2012 was highly variable among countries of the European Union. Austria has one of the highest values in the European Union, in this country environmental protection expenditure was 1209 euros/inhabitant). In other EU countries this indicator was 250 to 802 euros/inhabitant – Figure 1.

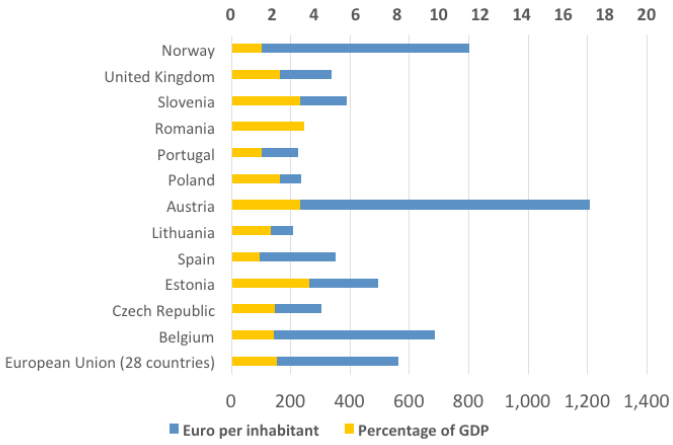


***Figure 1**: Total environmental protection expenditure per inhabitant and as percentage of GDP in 2012*

Source: (Eurostat, 2016)

Portugal and Poland were among the countries with low spending on environmental protection. In Portugal it was 225,1 euros per inhabitant and 3,31% of GDP, in Poland – 236,0 euros per inhabitant and 2,36% of GDP.

The biggest share of environmental protection expenditure in the 28 countries of UE in 2003-2013 was put forth by specialized producers – 1,0-1,17% share of GDP. Public sector had a contribution to Gross Domestic Product at the level 0,62-0,75% and industry – approximately 0,4% of GDP – Figure 2.

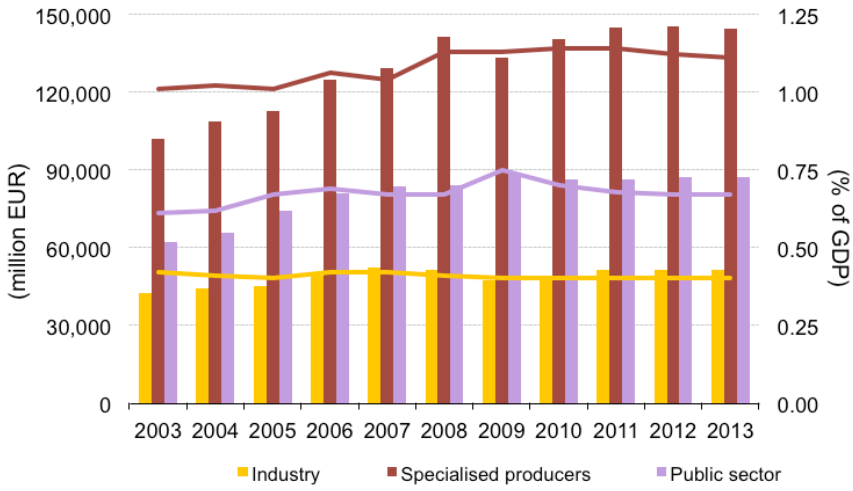
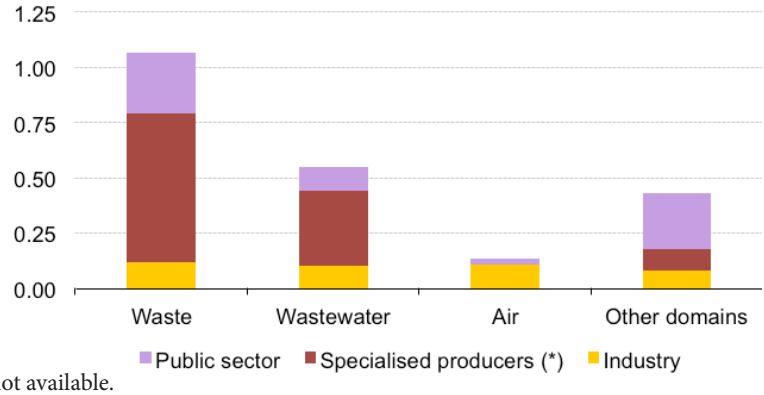


***Figure 2**: Total environmental protection expenditure, EU-28, 2003–13*
Source: (Eurostat, 2016)

In 2013, the leading environmental expenditure domain in the 28 EU countries was waste management (1,12% of GDP). The other important area of such expenditure was wastewater management, which accounted for 0,55% of GDP. Other domains accounted for 0,4 % of GDP. The structure of expenditure by the environmental domains in 28 EU countries in 2013 is shown in figure 3.



(*) Air: not available.

***Figure 3**: Total environmental protection expenditure by domain, EU-28, 2013, [% of GDP]*
Source: (Eurostat, 2016)

2. Environmental protection investments expenditure

Following the methodology applied in the European Union (European Commission, 1994), the investment expenditure includes end-of-pipe and integrated investments:

- the end-of-pipe investments (pollution treatment) – they do not affect in the production process itself (the production may be carried out without this kind of investment), but they reduce the impact of pollutants generated in the production process – Figure 4,
- integrated technology (pollution prevention) – they lead to reduction of generated pollution through the modification of technological processes. As a result of this modification, production is cleaner and more environmentally friendly – Figure 5. Environmental costs are considered as additional costs compared to cheaper and efficient but less environmentally friendly equipment.

"Pollution treatment" is defined as methods, practices, technologies, processes or equipment designed for collecting and removing pollutants (for example air emissions, effluents or solid waste) after their creation. There are also treating and disposing of the pollutants, monitoring and measuring the level of pollution. Pollution treatment mainly involves the use of "end-of-pipe" methods, techniques or equipment, for instance, air emission filters, waste-water treatment plants, waste-collection and - treatment activities (OECD & Eurostat, 2005a).

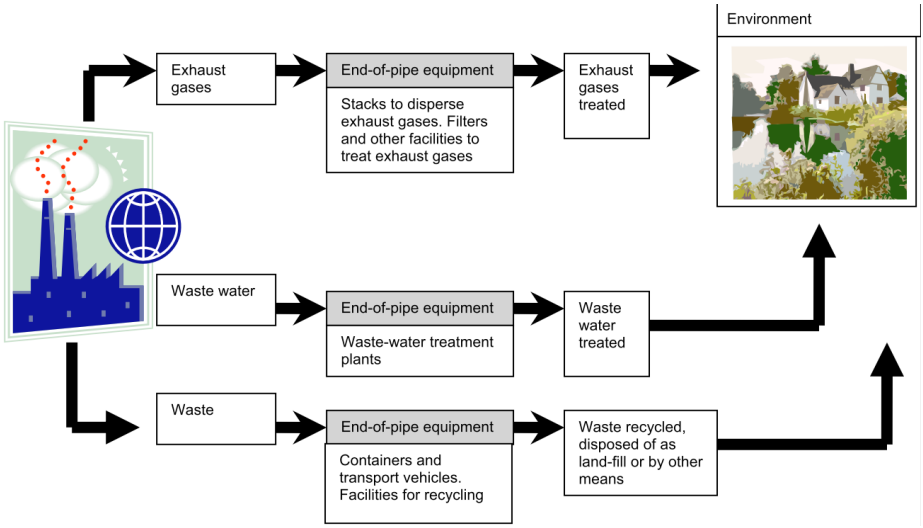


***Figure 4**: Pollution treatment investment*

Source: (European Commission, 2005, p. 25)

"Pollution prevention" is defined as methods, practices, technologies, processes or equipment designed for preventing or reducing the pollution created at the source thereby reducing the environmental impacts associated with the release of pollutants and/or polluting activities. Prevention of pollution can be an integral part of the production process. Prevention of pollution may involve various types of activity, for example (European Commission, 2005, p. 14):

- modifying equipment or technology,
- choosing new, improved technology,
- reformulating or redesigning products,
- substituting cleaner and/or renewable raw materials,
- changing practices, (improving housekeeping, maintenance, training or environmental management).

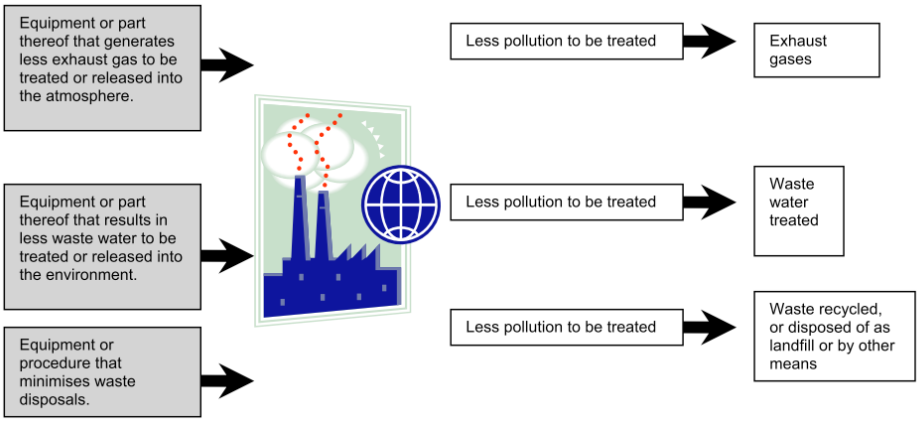


***Figure 5**: Pollution prevention investment*

Source: (European Commission, 2005, p. 26)

The trend for pollution prevention investment in Portugal and Poland has been decreasing from 2003 to 2013 – Figure 6. One of the reasons for such situation could be the global economic crisis, which found its reflection in the low values of investment expenditures in both countries. After 2007, there is a slow increase in the value of investment in environmental protection.

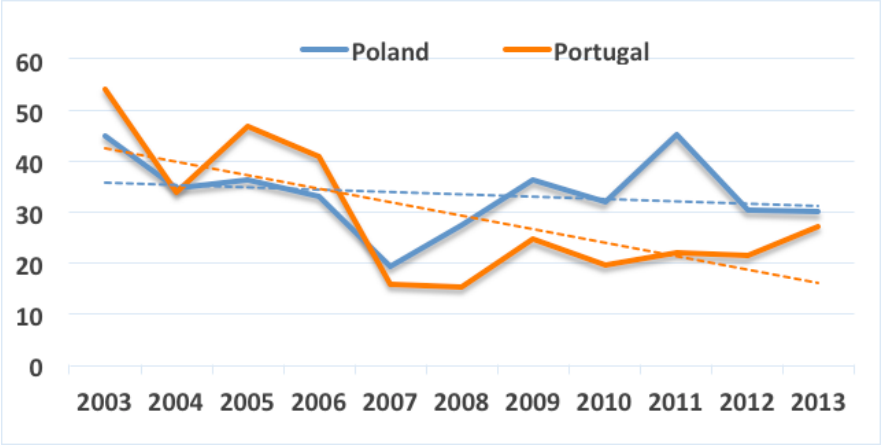


***Figure 6**: Pollution prevention investments as % of total environmental protection investments in Portugal and Poland in 2003-2013*

Source: own elaboration on the basis of Database of Eurostat (Eurostat, 2016)

Pollution prevention investments are generally argued to be preferable to end of pipe solutions in the long run since clean technologies reduce emissions at the source, which means that the emissions are never discharged (Hammar & Lofgren, 2010). Such kind of investments follows the principles of environmental policy of the European Union such us: precaution, prevention and rectifying pollution at source. However, they are not always applicable. The public sector and specialized producers invests mainly in the end-of-pipe equipment (for example, sewage systems) – Figure 7.

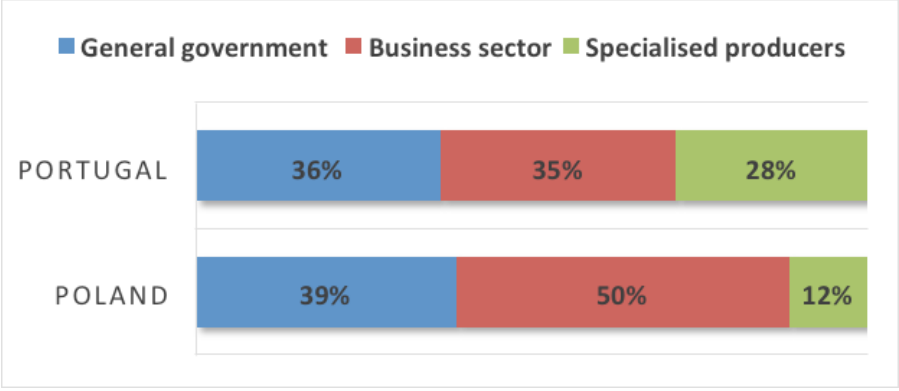


***Figure 7**: The structure of investments expenditure by economic sectors in Portugal and Poland in 2012 [%]*

Source: own elaboration on the basis of Database of Eurostat (Eurostat, 2016)

Moreover, investments in these two countries are applied mainly in wastewater management (in Poland) and waste management (in Portugal) – Figure 8. There are the environmental domains, in which most of investments have a pollution treatment character, for instance landfills, wastewater treatment.

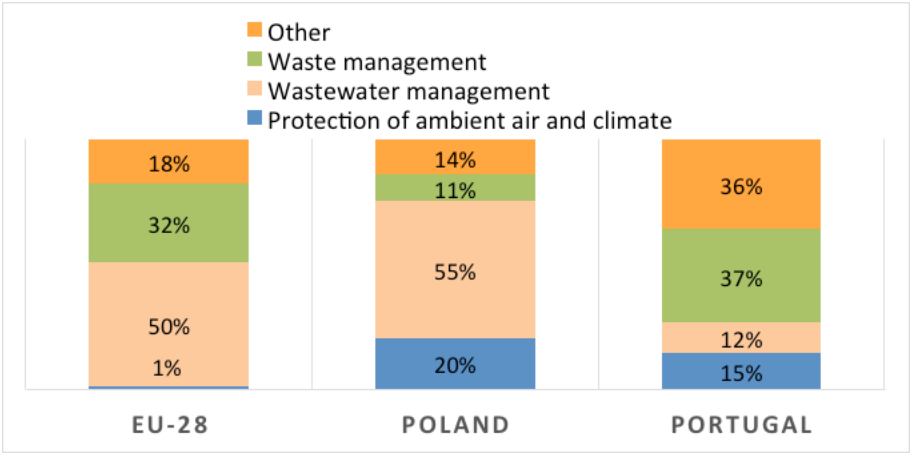


***Figure 8**: The structure of investments expenditure by environmental domains in EU-28, Portugal and Poland in 2012 [%]*

Source: own elaboration on the basis of Database of Eurostat, (Eurostat, 2016)

Poland, accordingly to its environmental policy, has been striving to increase its share of waste management since 10 years. Unfortunately, the existing neglect in the field of sewage management (for example, villages without public sewage systems) is the reason for this investment expenditure structure.

3. Environmental protection current costs and revenues

Current expenditure on environmental protection consists of:

- labour costs,
- payments of rents,
- use of energy and other material goods,
- purchases of services,
- where the main purpose is to prevent, reduce, treat or dispose pollutants, reducing pollution or any other degradation of the environment resulting from the operating activity.

Current expenditure on environmental protection in Portugal and Poland accounts for the majority of the total environmental protection expenditure. The same structure of environmental protection expenditure we can observe in all UE countries – Figure 9.

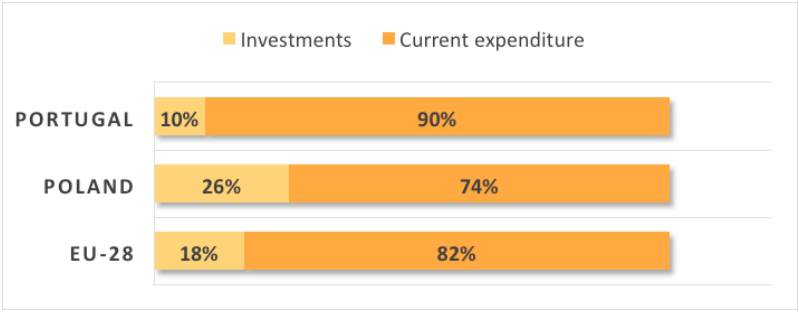


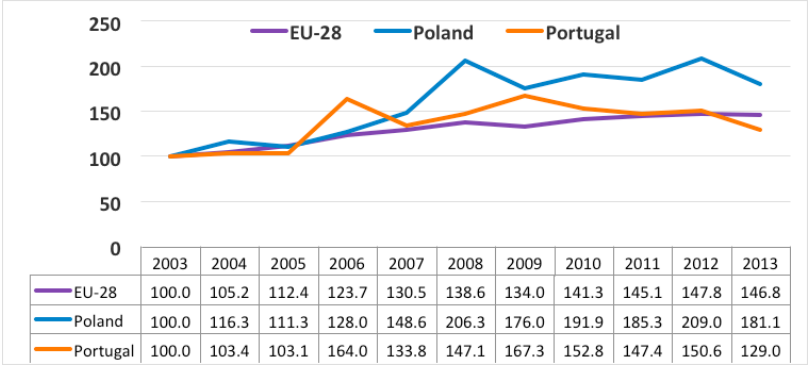
***Figure 9**: Investments vs. current costs of environmental protection in 2012 [%]*

Source: own elaboration on the basis of Database of Eurostat, (Eurostat, 2016)

Gross current expenditure on environmental protection consists of some variables:

Gross current costs
(minus)
Receipts from by-products
(minus)
Revenues from environmental services
(plus/minus)
Current subsidies/transfers
(equal)
Net current costs

Gross current expenditure on environmental protection has an increasing trend in all countries of the European Union. In the period 2003-2013 such increase was 50%. In Poland the increase was close to 82% – Figure 10.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
EU-28	100.0	105.2	112.4	123.7	130.5	138.6	134.0	141.3	145.1	147.8	146.8
Poland	100.0	116.3	111.3	128.0	148.6	206.3	176.0	191.9	185.3	209.0	181.1
Portugal	100.0	103.4	103.1	164.0	133.8	147.1	167.3	152.8	147.4	150.6	129.0

***Figure 10**: Environmental protection current expenditure (gross) in EU-28, Portugal and Poland in 2003-2013 [index 2003=100%]*

Source: own elaboration on the basis of Database of Eurostat, (Eurostat, 2016)

In Portugal in 2012 the most substantial share in current expenditures on environmental protection was made by producers (54%) and then by the general government (35%). Only 11% of current expenditure was spent by the business sector. The reverse situation happened in Poland – the business sector was responsible for 46% of current expenditure in Poland, and only 11% of total value was spent by the public sector.

The main environmental domains of current costs in Poland, Portugal and the EU in 2012 were waste management and wastewater management. Other environmental protection activities, like general administration, education, information and environmental management had a share ranging from 13% to 18% – Figure 11.

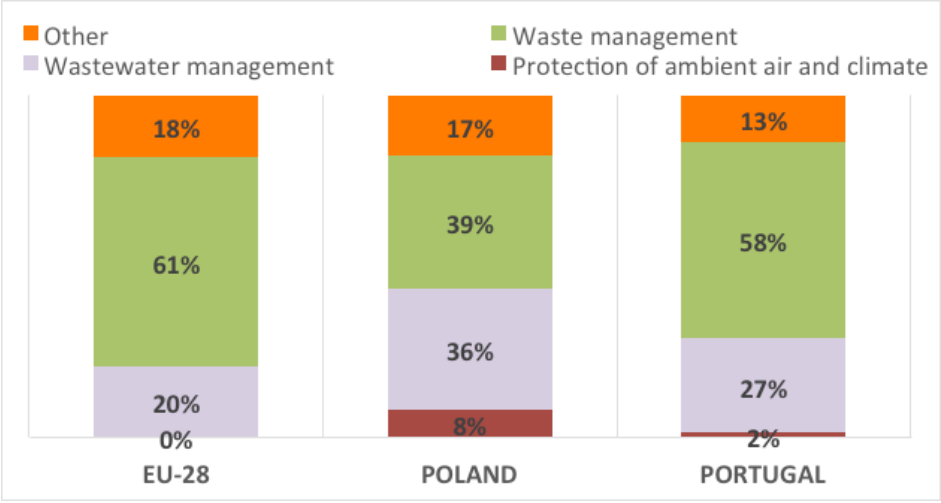


***Figure 11**: The structure of investment expenditure by environmental domains in Portugal and Poland in 2012 [%]*

Source: own elaboration on the basis of Database of Eurostat, (Eurostat, 2016)

Sometimes environmental protection activities produce by-products that have an economic value: energy generated, waste paper, material recovered as a result of waste treatment. **Receipts from by-products** are the sum of the sales value and the value of the cost-saving (if used internally) related to these by-products.

Revenues for environmental protection services occur in public sector and specialised producers. There are mainly revenues for waste treatment and wastewater treatment.

The structure of net current costs, receipts from by-products and revenues for environmental protection services are shown in Figure 12.

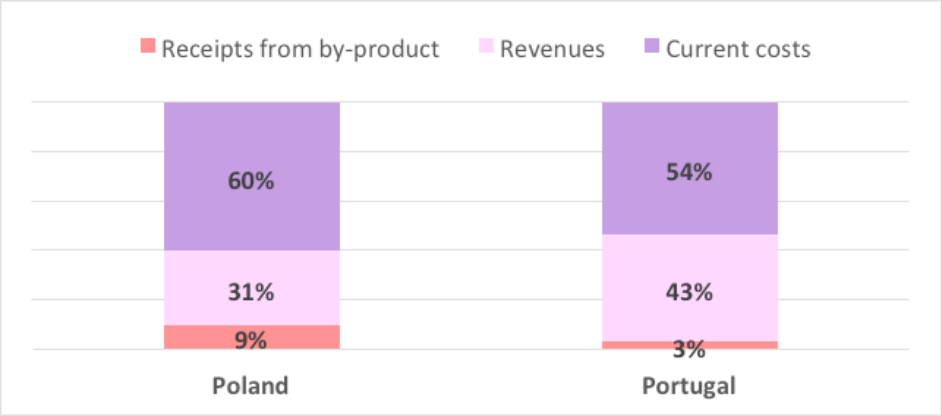


Figure 12: Costs and revenues in Portugal and Poland in 2012

Source: own elaboration on the basis of Database of Eurostat, (Eurostat, 2016)

4. Conclusion

European Statistical Office, Eurostat, has collected data not only on environmental protection (air pollution, energy, water consumption, wastewater, solid waste) but also data related to its economic perspective, such as environmental protection expenditure. This data enable policymakers to consider the environmental impacts of economic activities, for example on resource consumption, air or water pollution, and waste production, and to assess actions (such as investment and current expenditure) used to limit the causes and risks of pollution. The analysis of spending on environmental protection has a strategic interest and allows an evaluation of environmental policies.

The article presents a comparison of environmental costs in two EU countries: Portugal and Poland. The analysis showed many similarities in both countries, for example quite low levels of environmental costs (per capita, as% of GDP) compared to other EU countries. In both cases, there is the descending trend in investment expenditure for environmental protection and the growing trend in current costs. Current environmental costs account for about 80% of total environmental expenditure, both in Portugal and Poland. On the other hand, the structure of expenditure by environment is different. You may find Poland's delay in relation to Portugal, but also in all EU countries, in the field of waste water management. This area of environmental protection has been the most cost-consuming for several decades.

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Strategy management

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Abstract

This article presents the concept of strategy management and the process involved in the idea. It provides overall direction for a company, and involves specifying the organisation's objectives, developing plans designed to achieve those goals, and allocating resources for implementing the plans. Indeed, strategy management involves setting objectives, analysing the competitive environment, examining the internal organisation, evaluating strategies, and ensuring that management rolls out these strategies across the organisation.

After a description of the process, it follows a description of strategic methods, like SWOT (Strengths, Weaknesses, Opportunities and Threats), Porter, Value Chain, and Balanced Scorecard.

Finally, we show a SWOT analysis of Spain's Economy in 2011, when Spain suffered one of the worst financial crises in its history.

Therefore we want to present a guideline about strategy that can implement a strategy for any company.

Keywords: ***Strategic Management, SWOT, Porter, Value Chain, Balance Scorecard.***

Introduction

Strategy emerges from a question that many businesses ask: why do some companies under go rapid growth while others fail or stagnate? Are the current market leaders the same as they were 50 years ago? The evolution of companies clearly depends on their performance, and their relationship with the environment in which they are found. This has led to a concept of strategy that has no single, universally accepted definition. The term is used differently by executives and business experts. Mintzberg defines it as an effort to systematise different meanings, and he identifies four definitions or approaches that characterise the concept of strategy: planning, guidelines, position, and perspective.

Strategic management (Johnson & Scholes, 1999,) is not only concerned with making decisions about the major issues facing an organisation. It also involves ensuring that any strategies are put into effect. **Strategic Management** includes *strategic analysis*, in which the strategist seeks to understand the strategic position of the organisation; *strategic choice,* which relates to the formulation of possible courses of action, their evaluation and the choice between them; and *strategy implementation*, which includes both planning how the choice of strategy can be put into effect, and managing the changes required.

The scope of strategic management is broader than that of any single area of operational management. It is concerned with the complexity arising out of ambiguous and non-routine situations with organisation-wide rather operation-specific implications. This is a major challenge for managers who are used to managing the resources they control on a day-to-day basis. It may be particularly problematic because of the background of managers, who will typically have been trained, perhaps over many years, to undertake operational tasks and take operational responsibility.

Other concepts render strategy a multidimensional element, one that includes all parts of the company.

Thus strategy per se (Arnoldo Hax 1997) can be considered as:

- A means of establishing the purpose of the company
- A definition of the competitive field of business
- A response to external opportunities and threats, as well as internal strengths and weaknesses
- A way to define corporate, business and functional tasks
- A model of coherent decisions
- A definition of the financial contribution to areas of interest
- An expression of strategic objectives
- A means of developing the company's core competencies
- A route for investing in tangible and intangible resources to develop the capabilities that ensure a sustainable competitive advantage

We can define strategy, understood as being competitive, as a set of measures and actions that a company takes to ensure a sustainable long-term competitive advantage. This is not necessarily an easy issue, as the profits sought come at the expense of present and potential competitors, while these enterprises in turn also seek a competitive advantage. We therefore find ourselves in a market where each company is taking action to maintain its own long-term sustainability.

Strategy (Ramos, 1996, p.4) "is a plan, a course of conscious, voluntary, deliberate action aimed at managing a certain situation".

For this reason, strategy has two very distinct characteristics:

- It is developed prior to being implemented, i.e., thought precedes action
- It is developed in a conscious and deliberate manner

Plans may be general or specific, depending on a company's environment. If they are general, they affect all companies equally, encompassing all relevant elements, and if specific, they only directly affect the company concerned, creating a competitive environment. Within this type of strategy we can include mistakes, as a manoeuvre by a company to compete differently from its competitors.

An illustrative example is when a company sees that its competitor is initiating plans to build a plant, so it publicises its own construction of a new plant with modern technology. The idea here is not the investment, but rather the threat.

Strategy (Ramos, 1996 p.6) "needs not only to be conceived, but also implemented. Its definition must therefore include performance subsequent to the implementation of the plan, which should allow for a sequence of logical actions. In short, strategy is the continuation of performance in the long-term".

A company's consistency in performance may be the result of a specific plan, or may be unintended, with no predetermination. Some experts and authors have stated that a certain amount of chaos in companies is desirable, as strategic planning can become bureaucratic and prevent the company from releasing all its valuable energies and capacity for continued growth.

In summary, plans may not be realised, and guidelines may appear without prior planning. We can thus identify the following types of strategies:

Deliberate strategy: previously existing intentions are developed and made tangible.

- Emerging strategy: guidelines are developed unintentionally.
- Unrealised strategy: existing intentions are not made tangible in reality.
- Realised strategy: the strategy is ultimately implemented.

Obviously, there is no single direction when determining a strategy, but it emerges according to a number of both exogenous and endogenous factors that decisively influence the implementation and definition of the competitive strategy.

As it strategy allows (Ramos, 1996, p.10) "the company to position itself in the market, we must consider it to be a mediating force between the company and its environment. It is not an individual element, unrelated to society, it belongs to

society and has a strong relationship with it: the company cannot be understood alone, without this connection to the outside". Therefore, internal and external dimensions must be related to reach a favourable market position, corresponding to the company's capabilities and resources, and these obviously need to be sustainable over time. This external dimension, which enables positioning of the company, requires resources and effort in order to discover and understand the forces that move the market, the purpose of which is simply to choose the most appropriate positioning for the company.

Some companies consider marketing to be the core of their business, such as IBM (technical excellence), HP (new printer models), or El Corte Inglés (service and customer care). This idea can be associated with an individual's identity: just as each of us has our own personality, a company has its own way of seeing things and transmitting that to the outside world.

Figure 1, below, could be called a "Circle of Competitive Strategy" (based on Porter, 1996); it articulates key aspects of competitive strategy in a single figure.

***Figure 1**: (Proprietary work, 2016)*

Porter determines strategy (competitive) to be a combination of ends (goals) that a company is striving to achieve and the means (policies) it is using to reach them. In the centre of the circle we can see the company's objectives, which form the general definition of how it wishes to compete and its specific economic and non-financial objectives. The radio of the circle is the key operating policy with which the company seeks to achieve these goals. Depending on the nature of the business, management may be more or less specific when articulating these key operating policies; once they are specified, the concept of strategy can be used to guide the overall performance of the company. Like a wheel, the spokes (policies) must radiate from the centre and shows objectives, and must be connected to each other or the wheel will not turn. A business strategy must include a clear definition

of the objectives in order to focus on and dedicate resources to those objectives, with all the parts of the company being involved. Clear cases of this are seen in Microsoft, El Corte Inglés, BMW, Audi, just to name a few.

Competitive strategy (Porter, 1982, Jarrillo 1992) could be more broadly formulated by determining a company's limits related to achieving success. The company's assets and skills comprise its strengths and weaknesses compared to its competitors, including all key areas of business, such as financial resources, technological position, brand identification, and so on. A company's values are the motivating factors and needs of key executives and personnel directly involved in the chosen strategy. Strengths and weaknesses, combined with value, determine the internal limits of the competitive strategy that a company can successfully adopt.

On the other hand, external limits are determined by the sector in which the company carries out its activities, as well as its environment, understood to be the whole context that includes the company. In addition, the opportunities and threats in that sector determine the competitive environment, with its accompanying risks and future profits. Society's expectations reflect the impact of exogenous factors, such as the political situation, social interests, and habits.

This requires a proper analysis of the environment. A useful tool is the "strategic profile", which can be explained as follows: firstly, a list of key environmental factors or significant variables should be written up and categorised into environmental dimensions, such as the sociocultural dimension (values and attitudes, social groups, labour conflict, labour market, unions, consumer advocacy), financial dimension (GDP, inflation, balance of payments, unemployment, productivity, capital markets, energy resources, industrial policy), technological dimension (R&D policy, scientific and technological knowledge, scientific and technological infrastructure, technological maturity, availability of new technologies), and political-legal dimension (political situation, financial policy, socioeconomic legislation, social policy). Secondly, the performance of each key factor is valued in terms of negativity and positivity, using a Likert scale, which runs from very negative through negative, indifferent or balanced, positive, to very positive. In addition, the subjective aspects of this assessment by the company and its executives must always be considered.

It is necessary to add that this analysis should not only be carried out for the present scenario, but also for the future, as both opportunities and threats should be known not just for the short-term, but also in the long-term.

The method is the same as for the present situation, however, the uncertainty of the future increases the risk. Currently, the majority of environments are very turbulent and uncertain. In these situations, prospective techniques are needed, as past facts and events cannot be relied upon. The forecast is the appreciation, accompanied ultimately by a certain degree of confidence (in statistical terms, a probability) of the evolution of certain variables specific to a time horizon. This quantitative assessment is based on short-term technical validity, adjusted by func-

tions (linear, logistic, and exponential), time series analysis, econometric models, among other.

Nevertheless, in a scenario of potential and uncertain futures within a complex environment, it is very difficult to apply these types of quantitative techniques, so prospective techniques are required to analyse the situation in a more qualitative, rather than quantitative, manner. Among these techniques are methods such as Delphi and cross-impact analyses.

The last step of the competitive strategy is the need for proper formulation, correlating the external and internal analysis, setting objectives that allow us to, not only determine, implement and, most importantly, monitor a strategy, but also assess the results obtained and ensure that they are adapted to the company's reality and its strategic aims.

It is appropriate to mention in this section the fact that the environment moves faster than the company, so we must articulate systematic mechanisms for adaption to change, in other words constant innovation within the company and the business model, creating unique value spaces. This requires thinking outside the box, understanding that strategy has to be innovative if it is to generate real long-term value. An optimal combination of strategy and organisation must be developed that facilitates the achievement of the company's long-term objectives and ensure it is in-tune with the market, able to react quickly to sudden changes that may occur and focused on solving problems, not only developing products.

1. Business Strategy Models

Michael Porter, in the book published in 1982, including *"Competitive Strategy"*, outlined a framework for assessing competitiveness in the business world.

A competitive advantage must not be understood by perceiving a company as a single entity, but as a set of discrete activities that the company carries out, such as logistics, production, marketing or sales. **The value chain** emerges from this idea, where the company is present throughout the process from the origin of the raw materials to the end consumer.

Thus, for the study of each of the distinguishable parts is therefore necessary to retain a permanent competitive advantage for the company. This is imperative as the entire company, especially if it is relatively large, is a complex organism composed of discrete parts, and the structural characteristics of the sector, in which competitive strategy must be sought, affect the various parts of the company very differently.

A company buys products and services abroad (inputs), processes them somehow, even if that is only moving them from one place to another, and sells those products to customers (outputs).To do this, it must provide primary activities (delivery of inputs to the company; processing; convince customers they want to buy the product; deliver this to clients; sell the product and provide an after-sales service, etc.) and support activities, such as funding operations, accounting opera-

tions, production process design, strategy, etc. The company's specific core business activities are an issue that every company must clarify for itself.

The important thing (Jarrillo, 1992, p.38) is to clearly differentiate the elements of the company as it stated in figure 2:

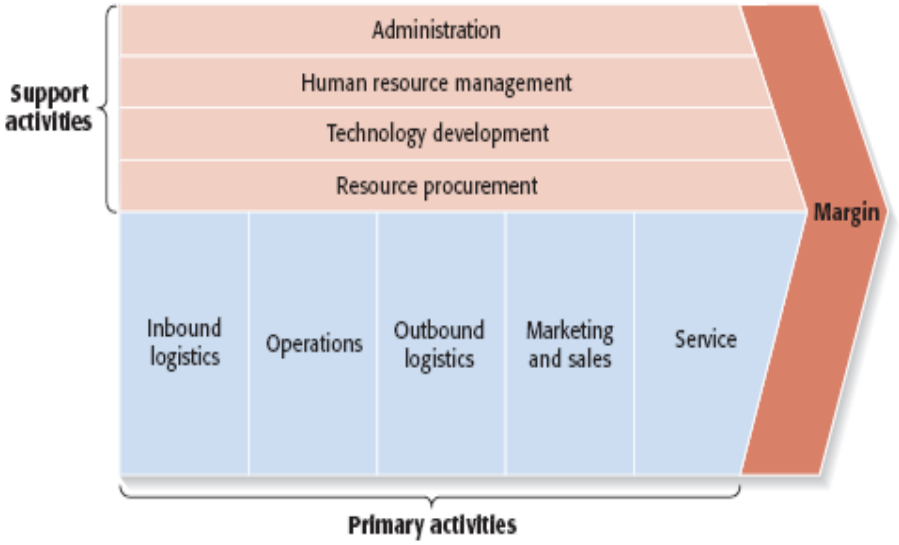


***Figure 2**: Value Chain (Jarillo, 1992, p. 38)*

Primary activities can be defined as follows (Porter, 1996) (Teece, 2010):

- Procurement: this includes activities related to reception, storage, material handling, inventory control, purchasing of materials.
- Operations: processing of raw materials into finished products in the case of physical products; this stage does not exist for services.
- Outbound logistics: distribution of finished product (scheduling sales orders, goods forwarding operation).
- Marketing and sales: inducing and facilitating the product purchase process for buyers (sellers, sales panels, advertising campaigns, advertising testing).
- After-sales service: like brand loyalty, increasing product value through service guarantees, free spare parts, repairs, installations.

Support activities can be defined as follows:

- Human resources: human resources management activities can range from payroll, recruitment, psychometric tests, to medical check-ups. As is the case with other support activities, personnel management takes place in different parts of the company.

- Infrastructure: computer networking services, computer installation, maintenance of laptops.
- Technological development: research centres, development and technology.
- Support services: accounting, receivables management, payment management, communication with banks, taxes, financial operations, government administration.

Businesses today focus on primary activities, which generate real value for shareholders and where the company is strong, in other words, in the Core Business, which is the heart of the company, support activities are being outsourced to companies specialising in such activities.

We can add even further, exhaustive detail to the value chain in the profit and loss account, which shows the value the company adds to the inputs it purchases externally. This should be done taking into account the constituent activities of the company. For this reason, the depth reached is a matter of common sense which, strangely enough, is sometimes a scarce commodity in the world of economy and business. Separable activities should be differentiable, have individual characteristics, and be large enough to be useful for analysis: splitting the company into activities representing 1% of the added value of the company is not logical.

However, as mentioned earlier, the separation of activities must make economic sense; it seems logical in this latter case because, as we can intuit within a company process, particularly an industrial one, the manufacturing process is a vital piece of the puzzle and analysing this may indicate mismatches involving loss of efficiency and therefore money.

Moving away from Porter, we can now talk about a **business model based on resources.** Here the model is based on factors, that is, capacities and resources. In the short term (Prahalad, 1990), the competitiveness of a company is derived from attributes such as price and product development. In the long term, however, competitiveness is based on the ability to produce at lower costs and ensure ultimately movements take place faster than the competitor in the market.

There are (Prahalad, 1990) three tests that can be applied to identify key competencies in a company. The first is that a key skill provides access to a wide variety of markets. The second is that the same skill must contribute significantly to the customer's perception of the benefits of the product, and finally this skill should fall within a set of knowledge, abilities and technologies to which added value for the clients has to be added by the company.

On the other hand, **Porter's five forces analysis** is a framework that attempts to analyse the level of competition within an industry and business strategy as exemplified in figure 3.

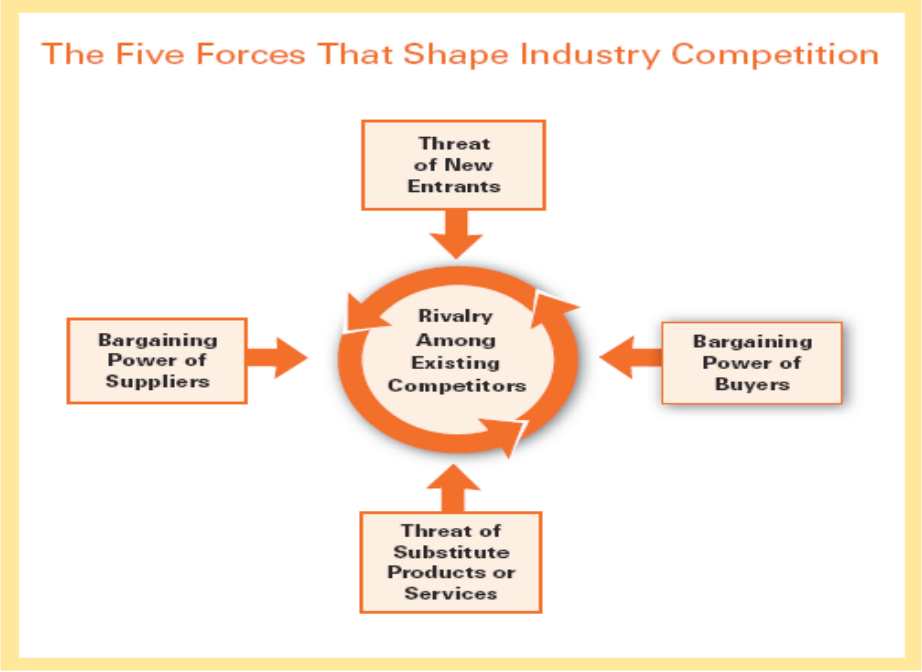


***Figure 3**: Porter's five forces (Porter, 1996, p.24)*

The five competitive forces shown in the graph determine the intensity of competition in the industrial sector, which is mainly what this model refers to, and are those which determine, and are key to ultimately, strategy formulation. The essence of strategy is to link the company with its environment, because as an element that is part of a whole, it is related to it and needs it in order to survive.

The aim of strategy is to find a position for the company within its sector, to defend itself against competing forces, and ultimately redirect them in its favour.

From the model we can highlight the following points:

- Threat of entry of new competitors. Whether the market or segment is attractive or not depends on whether the market can be easily entered by new players, who may arrive with new resources and capabilities, and take control of market share.
- Rivalry among competitors. It is more difficult for a company to compete in a market, or one of its segments, when there are either many competitors, these are very well positioned, or fixed costs are high, as they will be continuously when facing price wars, aggressive advertising campaigns, promotions and entry of new products.

- Supplier bargaining power. A market or market segment will not be attractive when suppliers are well organised, have strong resources and can impose price and order size. The situation is even more complicated if the inputs they supply are essential, there are no substitutes, or these are few and expensive. The situation will be even more critical if, going forward, it is in the supplier's strategic interest to integrate.
- Customer bargaining power. A market or segment is not attractive when customers are very well organised, the product has various substitutes, and the product is not very differentiated or is low cost, as this means substitutions must be produced at an equal or lower cost. i.e., to enter the market the product must have a lower cost than existing offers. The more well-organised consumers are, the stronger their demands for lower prices, higher quality and better services, and in turn the company is forced to decrease its profit margins. The situation becomes more critical when it is beneficial for consumer organisations to strategically unionise.
- Threat of substitute products. A market or segment is unattractive if there are real or potential substitute products. The situation is compounded if the substitutes are more technologically advanced or can enter the market at a lower price, reducing profit margins for the company and industry.

Following the examination of the strategic business models, we now describe the **SWOT** (*Strengths, Weaknesses, Opportunities and Threats*) analysis that can be developed for a company, product, place, industry, or person. This involves specifying the objectives of the business venture or project and identifying the internal and external factors that are favourable and unfavourable with regard to achieving that objective.

The concepts mentioned above could be defined as:

- Strengths: characteristics of the business of project that give it an advantage over others
- Weaknesses: characteristics that place the business or project at a disadvantage when compared to others
- Opportunities: elements that the project could exploit to its advantage.
- Threats: elements in the environment that could cause trouble for the business or project

From the combination of these four variables come four types of strategies:

- Reorientation: a combination of the company's competitive advantages and dependence on the environment
- Survival: used by companies under severe pressure due to either the environment or the company's own weaknesses
- Defensive: this improves operational efficiency, e.g. the objectives are achieved with the minimum possible resources

- Offensive: these are oriented at innovation and closely related to the introduction of new products.

The approach is intended to help a firm to (Tidd & Bessant, 2013):

- Be conscious of trends in the competitive environment.
- Prepare for a changing future.
- Ensure that sufficient attention is focused on the longer term, given the pressures to concentrate on the day to day
- Guarantee coherence in objectives and actions in large, functionally specialised and geographically dispersed organisations.

A SWOT analysis (Johnson & Scholes, 1999) summarises the key issues by looking at the business environment and the strategic capability of an organisation. The aim is to identify the extent to which current strategy, and its more specific strengths and weaknesses, are relevant to, and capable of, dealing with the changes taking place in the business environment. It can also be used to assess whether there are opportunities for further exploiting further the organisation's unique resources or core competencies.

The new environment and therefore the strategy should be recalibrated using the following aspects:

Economics: values are central

Politics: actions cut across political space and political actors

Legal: the law should address deep structural causes

Psychology: emotions and rationale in the decision making process

Social sciences: challenge-dominant discourse and political structures

Nowadays, the rapid changing (Elgoibar, Euwema, Martin & Mundate 2016,) socioeconomic environment leads organisations to high speed adaptation, jeopardising traditional relationships such as national or sectoral collective bargaining. This should be included in the SWOT. The challenges here are:

- Decreased working conditions. Although some examples increase job quality, improving working conditions and decreasing precarious working situations stays a major challenge.
- Deinstitutionalisation and alternative forms of employee representation. Trade union membership is almost universally in decline.
- Globalisation. Many businesses have become international: they are transnational in ownership and their production strategies encompass the context of global markets.
- Decentralisation in collective agreements from sectoral to organisation level and a decrease in collective bargaining coverage.
- Individualisation of employment relations. There is a steady decline in the percentage of workers whose wages are set by collective agreement.

- Participative decision making process. Societies with strong social dialogue perform better. Social dialogue is a form of competency and this is becoming a challenge to industrial relations.
- Adaptation to environmental changes. New laws and regulations and new needs such as sustainability and green issues require decisions to be made collectively, often at the organisational level.
- Supporting diversity and gender equality. The inequality and insecurity are the most significant labour problems of our time.
- Digital workplace. Rapid advances in technology have changed workplace behaviour and are promoting the so called "new ways of working", where employees are able to work free of time and pace constraints.
- Ageing and youth employment. Managing differences between generations and rights of starters has become a major issue in many societies.

Finally, we have the **Balanced Scorecard** developed by R.S Kaplan and D.S Norton (Kaplan & Norton, 2001, p.16) that "provides a company vision and strategy and shows its performance from four perspectives: financial, customer, internal process, and innovation and learning".

This scorecard is a system that is not only tactical or operational, but facilitates continuous assessment of how a company's strategy develops, which many companies use together with their long-term strategic management system.

It is clear that the balanced scorecard is aimed at achieving productive efficiency as a result of, firstly, improved cost, and followed by an appropriate portfolio of products, thereby achieving an optimal combination of products and customers. Added to these elements is a human resources policy that affects key elements such as training, incentives, and the need for employees to feel part of something important or, in other words, proud. All these strategies facilitate good economic-financial growth, achieving high returns for shareholders and therefore creating value for them.

The balanced scorecard (Kaplan & Norton 2001, p.31) "has evolved since it was first developed and introduced as a framework for measuring a company's activity and results. The intention of the original proposal was to overcome the limitations of managing using only financial indicators. These indicators reported on results (lagging indicators) but did not indicate what future result drivers would be, drivers that show how to create value through investment in customers, suppliers, employees, technology and innovation". The scorecard provides a framework for considering the strategy used in creating value from four different perspectives:

- **Financial:** strategy for growth, profitability and risk seen from the shareholder´s perspective.
- **Customer**: strategy for creating value and differentiation from the customers' perspective.

- **Internal business processes**: strategic priorities for different processes that ensure customer and shareholder satisfaction.
- **Learning and growth:** priorities for creating a climate of support for change, innovation and growth of the company.

The need to include indicators in a management system is also added. To take advantage of this force in its entirety, the indicators should be integrated into a management system. Thus, we are able to refine the concept of a balanced scorecard and show that it can be more than just a results measuring system and become the organisational framework of a strategic management system. This can be shown graphically as follows:

Management control system

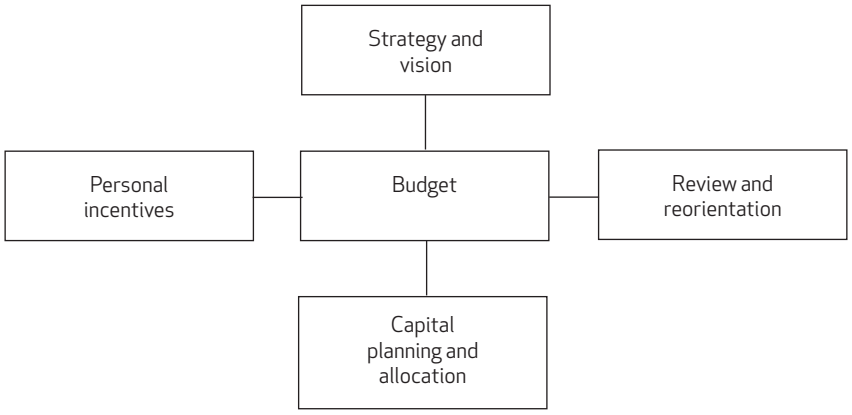


***Figure 4**: Balance scorecard as a management control system (Kaplan & Norton, 2001, p.33)*

Strategic management system

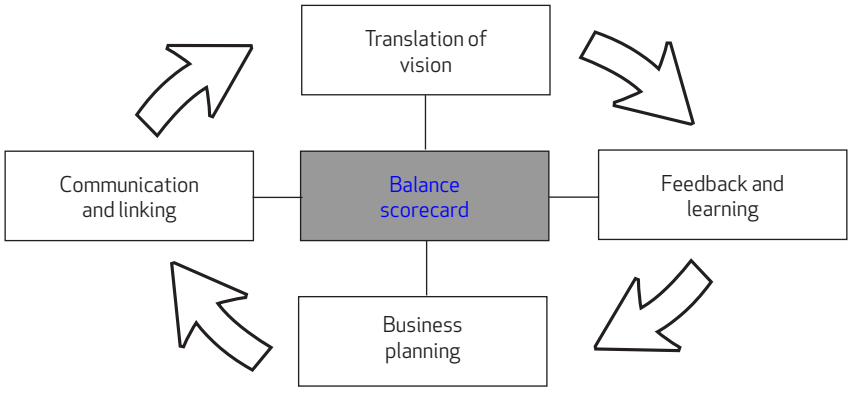
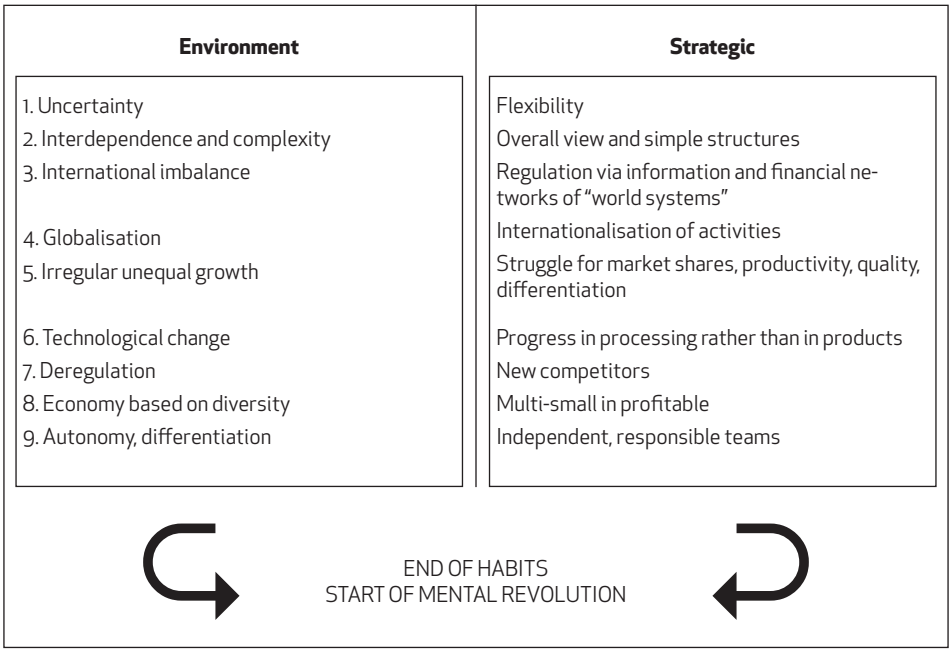


***Figure 5**: Balanced scorecard as a strategic management system (Kaplan & Norton, 2001, p.33)*

The process of incorporating financial indicators into strategic systems allows us to set a clear management direction for a company. Creating financial measurement systems should not be an end in itself, but a path towards generating policies and strategies that facilitate progress for shareholders. Therefore, it seems, all the relevant elements, should be focused, not only on the generation of useful measurement tools, but on designing real business strategies that provide a clear perspective of the company's competitiveness and, as a result, generate real value for shareholders.

Additionally, following the above idea we should consider strategic flexibility, i.e., a firm's capacity to adapt to changes in its environment (Codet, 2001). (This statement assumes the firm makes a permanent effort in technological, commercial and economic planning.) However, we know that flexibility is not sufficient and remaining competitive requires performance in terms of the price and quality of products or services. Of course, performance must be constantly renewed through innovation. It soon becomes obvious that change involves a multitude of possible strategic consequences within a company's environment.

Uncertainly in the environment not only requires flexibility but also reinforces the need for vision and projects, even if only to determine where a company stands in terms of its objective.



Therefore, (Teece, 2010, p.172) "the new environment and strategic flexibility amplify the need to consider not only how to address customer needs more astutely, but also how to capture value by providing new products and services". Without a well-developed business model, innovators will fail to either - or to capture - value from their innovations. In essence, a business model embodies nothing less than a business's organisational and financial architecture. (Figure 6)

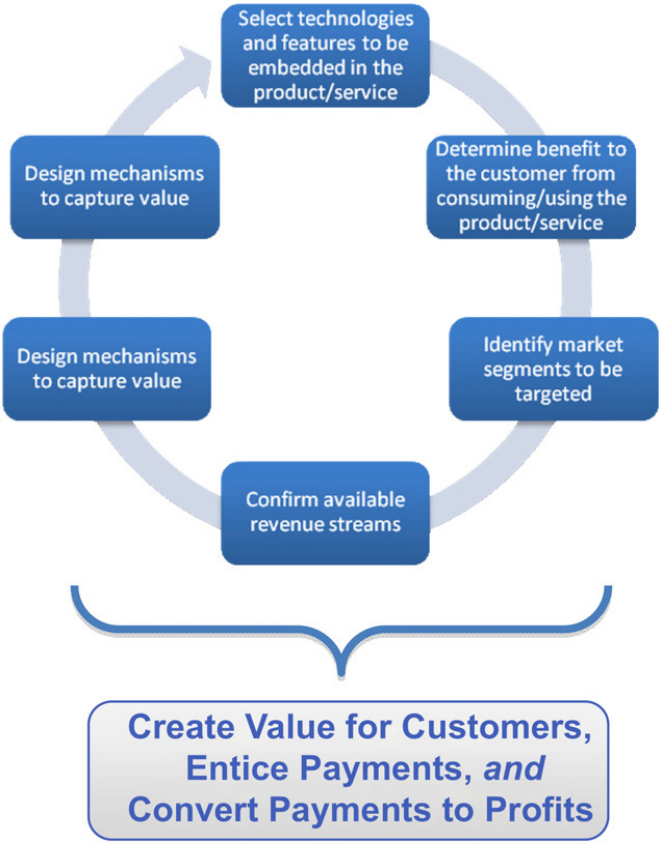


***Figure 6**: Design mechanisms to capture value (Teece, 2010, p. 173)*

On the other hand, the most important aspect for strategy is innovation. A review of (Tidd & Bessant, 2013) 342 research papers, published between 1992 and 2010, on the strategic management of innovation identified some major themes in the literature:

- Principal intended and emergent initiatives. The means measures and activities by which firms aim to produce performance improvements, including "acquisitions" and "diversification", which are typically

characterised by substantial deliberate planning, but also include means such as "learning", which tend to exhibit a strong emergent component.
- Internal organisation adopted, such as "practices", "structure", "process", organisation" and "behaviour".
- Senior managers and ownership: governance, "CEO", "top", "directors", "boards", "agency" and "ownership".
- Utilisation of resources- such as "capability", "knowledge", "assets" and "financial".
- Performance enhancement. Innovation outcomes such as "growth", "returns", "performance", and "advantage".

Finally, strategic management (Ward, 2011) is normally regarded as an integrated management approach drawing together all the individual elements involved in planning, implementing and controlling a business strategy. Thus it clearly requires an understanding of the organisation's long-term goals and objectives. There must also be a comprehensive analysis of the environment in which the business is, and will be, operating. This analysis must include all the organisation's internal operations and resources and, equally importantly, must cover the external aspects of its environment. This includes competitors, suppliers, customers, the economy, and governmental changes, in addition to legal and other regulatory changes.

This need to include, and indeed concentrate on, the many factors that are external to the organisation is a major element separating strategic management accounting from other, more traditional, areas. These have all tended to focus almost exclusively on the internal operations of the organisation and only incorporate its specific transactions with the outside world.

The combination of "where the organisation is "and where it wants to go" normally identifies the need for a series of actions to bridge the gap between the two, or even merely maintain the same position if the external environment is changing adversely.

SWOT of Spanish Economy 2011 (Financial and Economic Crisis)

STRENGTHS	WEAKNESESSES
➢ Labour, financial and welfare reforms to survive the welfare state ➢ Important international companies (Telefonica, Repsol, FCC) ➢ Good value for employees=> employability ➢ Good performance in tourists sectors ➢ Everybody in society is aware of the real economic problem	➢ High level of debts (government, family and business) (4x the GDP) ➢ Difficult to borrow money in the market ➢ Many administrative obstacles ➢ Council workers without new challenges ➢ Lower productive rate ➢ High unemployment rate (around 25%) ➢ High inflation rate (around 3%) ➢ High youth unemployment (58%)

THREATS:	OPPORTUNITIES
➢ Increased financial rate ➢ Economy strongly linked to the European Union, therefore it depends on this for recovery ➢ A lot of public demonstrations (citizens do not like the current situation).	➢ Probable political change in 2012 ➢ Increased petrol price an energy in Western Europe. Good movement for innovation ➢ Decreased labour costs (around 20% in two years) ➢ Financial reform can give a good result in a short time ➢ Our conviction that Spanish people have a good performance to achieve a good result in a short time

2. Conclusions

This paper presents a review of the strategy management concept and the different approaches to this idea. Our understanding of it is as an information-gathering and decision-making process, supported by the management functions of planning, organisation, motivation and control. Furthermore, the evolution of companies and their environment makes it necessary to update the idea with new innovation techniques.

We have also analysed strategic management techniques including Value Chain, Porter's five forces, modified Balanced Scorecard, and, most importantly, SWOT, which should be updated with 21st century parameters. We have applied this technique to the financial and economic crisis in Spain from the year 2011.

Finally, strategy should include flexibility, and consider not only how to address customer needs more astutely, but also how to capture value by providing products and services.

However, the process should maintain also follow and maintain the essence of the process illustrated below (Figure 8).

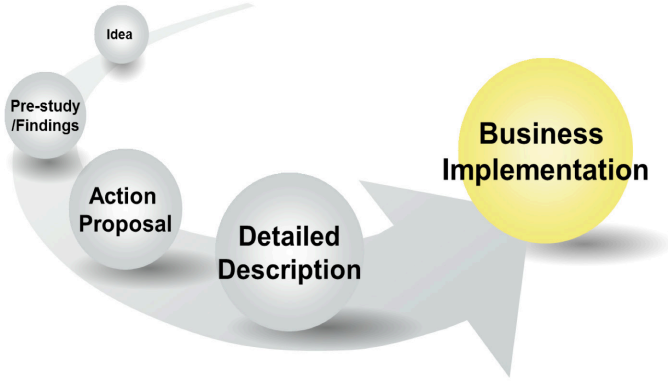


***Figure 8**: Strategic sequence (Proprietary work, 2016)*

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Health

Person-centered approach and rehabilitation.

Case of power struggle between paradigms: Medical vs Rogerian

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Abstract

The objectives of this article are as follows: 1) to present selected, crucial concepts of Rogerian person-centered, non-directive psychological approach; 2) to indicate and discuss some of its possible limitations regarding the process of rehabilitation; 3) to reflect on key differences and contradictions between medical and Rogerian paradigms; and to attempt at seeing these dynamics from various perspectives, including the power struggle between different scientific paradigms.

At first, Rogerian main ideas regarding the therapeutic communication appear simple, if not simplistic. In spite of their wide recognition, practical applications are often obstructed for various reasons; one of them is the difference between today's hegemonic bio-medical paradigm and person-centered axioms. These models appear to be juxtaposed in some crucial aspects. Medical regime imposes a diagnosis, an accurate treatment plan and a predictable outcome; short-term

interventions are favored, whereas health professionals are in charge of others in the multidisciplinary teams. Rogers perceives such model as counter-therapeutic in the psychological help. He emphasizes the symmetrical relationships, shared responsibilities and free choices. A wider introduction of the person-centered approach could be beneficial not only for the patients; still, practical application is slowed or blocked by specific psychosocial dynamics such as tensions, power struggles and complex controlling maneuvers.

Keywords: ***Rogerian approach, bio-medical paradigm, rehabilitation, psychotherapy, power struggle***

Methodological note

Regarding methodology, this paper is an outcome of an analysis of various scientific sources, books, articles and WebPages. The goal of the analysis is to fulfill the following objectives (as mentioned in abstract): 1) to present selected, crucial concepts of Rogerian person-centered, non-directive psychological approach; 2) to indicate and discuss some of its possible limitations regarding the process of rehabilitation 3) to reflect on key differences and contradictions between medical and Rogerian paradigms; to attempt at seeing these dynamics from various perspectives including the power struggle between different scientific paradigms.

Furthermore, the author uses his own professional experience in the field of physiotherapy, clinical psychology and psychotherapy as a relevant component of the exploration.

Introduction

Carl Ransom Rogers is classified as one of the most influential psychologists and psychotherapists of the 20th century. He published sixteen books and many articles that were translated to over sixty languages, his research work and theoretical concepts have stood the test of time (See & Kamnetz, 2004). Ideas that he generated over the years are still inspiring both theorists and practitioners working within the field of helping professions. However, it is worth to remind that Rogerian influences have reached far beyond the above-mentioned domains. At the same time, his writings at the beginning of his professional career were often perceived as controversial or even rebellious. They labeled him anti-psychiatrist and there is some truth in such statements. For example, Rogers tends to oppose the use of medical paradigm in the field of psychotherapy. In his opinion, the traditional medical diagnostic investigations turn often into counter-therapeutic actions. One of his basic assumptions is that facilitative conditions of empathy, positive regard and genuineness are necessary and sufficient conditions for therapy; for

many scientists, practitioners and others such statements were unacceptable and seen as a serious menace. The images of experts possessing special and difficult to acquire skills were threatened as it appeared that those prominent therapeutic factors were too simple to be so influential. These factors were not spectacular, not much seemed to happen during sessions following a person-centered paradigm. Superficially and misleadingly, therapists appeared to be rather "passive"; there were no impressive interpretations, no sage advises or stunning actions. Yet subtle relational qualities often remain invisible to the observers and they are difficult to measure. This style of interaction could be viewed as opposing psychodrama or hypnotic "psycho-surgery" conducted by impressive, quick and sometimes overwhelmingly directive therapists. However, in spite of the strong voices of the opponents, shortly before his death, Rogers's life work was acknowledged with the Nobel Peace Prize nomination.

Domain of rehabilitation is developing fast and gaining significance. It is based mainly on the bio-medical model (Banaszak & Florkowski, 2010; Conrad, 1992). Specialists are usually medically trained or placed in subordinate position to medics. On the one hand, Rogers worked for years in collaboration with psychiatry department; on the other hand, he developed an alternative health care paradigm opposing medical algorithms. His approach is helpful in various medical and non-medical contexts and it reached the status of psychological school of thinking. Yet, at the same time, there are multiple incompatibilities or even oppositions in the person-centered approach and medical model, these areas of tensions, power struggles and complex controlling maneuvers will be reviewed in this article.

1. The review of selected Rogerian concepts

Rogers kept changing and revising his concepts, remained elastic and open for new ideas as well as cautious of dogmatic stagnation. He perceived humans as beings created with the potential for goodness. What is necessary to develop and grow are good enough – mainly relational in nature – conditions. According to him, we all live essentially in our own personal and subjective worlds. Subjective processes are immanent even in the operations perceived commonly as objective, such as sciences and especially mathematics, because they are the outcomes of a subjective purpose and choice (Banaszak & Florkowski, 2014; Kirschenbaum & Henderson, 1989; Rogers, 1980; Rogers, 1993; Rogers & Stevens, 1994; See & Kamnetz, 2004). In his view, what intends to meet the criteria of objectivity is entangled with subjectivity.

In the process of therapy, unique, personal and intimate world is explored; emotional expression is encouraged and corrective emotional experience seems possible. The desirable end results of therapeutic engagement are (although it may sound a bit grandiloquent) self-actualization, creativity, personal development and growth leading to fully lived personhood. A person-centered approach is also useful

in a "simple" supportive work, assistance in decision-making, which requires more in-depth self-exploration as well as in multiple another circumstances.

Rogers assumes that human beings have a tendency toward actualization, but it can develop only in a favorable, loving and permissive environment, which creates an opportunity for the person to reach his or her full potential. Actualizing a human being becomes increasingly complex, congruent, and self-regulated and moves away from control toward autonomy. Self-actualization refers to the actualizing moves manifested in the "self", understood as a subsystem differentiated within the whole person. Actualization can be disturbed by unfavorable environmental circumstances, but the trend will exist in spite thereof. In the case of positive changes, actualization will be unblocked as any opportunity shows up. Humans share this tendency with other species, but there are some distinctive features. One of them is the possibility to use self-awareness in the process of self-actualization, It gives the opportunity to follow free choices and makes people's actualization unique. It has also a fundamental impact on therapy, although both therapist and client have to learn to trust this essential tendency (Bozarth & Brodley, 1991).

In Rogers's approach, there is an emphasis on the experience of feelings. In general, in some domains of the Western culture (and not only), the use of emotions is severely limited, especially the ones which are negative in nature. For instance, educational systems tend to focus on the rational, cognitive effectiveness and neglect the emotional aspects. A good illustration thereof seems to be the admiration for people equipped with a high Intelligence Quotient (IQ). However, an emphasis on the intellectual efficiency and an omission of the affect often lead to lessened aliveness, boredom and disengagement, whereas best learning can only happen when the emotional involvement is activated**.** From this perspective, even an adult scientist is reminiscent of a playing child, engaged in the emotionally charged exploration of the surrounding world. Laboratory or real world scientific investigations resemble the behavior of a youngster on the playground. They trigger a variety of emotions: from anger and frustration to enthusiasm and joy. It has to be emphasized that the full motivation, holistic engagement in any aspect of life is hampered without released and utilized affect (Banaszak & Florkowski, 2014; Kirschenbaum & Henderson, 1989; Rogers, 1980; Rogers, 1993; Rogers & Stevens 1994; See & Kamnetz 2004).

In his books and papers, Rogers uses as synonymous terms: awareness, symbolization and consciousness. Awareness is defined as a symbolic representation of some portion of experience – the used symbols do not have to be verbal, they may have a differentiated nature. The above-mentioned representation may vary in the degree of explicitness, beginning with the sharpness and vividness and ending with the state of dimness or vagueness. States of awareness resemble the effect of figure and ground; at times, something is seen as a vague background and then it is transformed into a foreground figure. In properly working therapeutic engage-

ment, the change in focus may occur, some relevant figures may become the elements of background and vice versa (Banaszak & Florkowski, 2014; Kirschenbaum & Henderson, 1989; Rogers, 1980; Rogers, 1993; Rogers & Stevens, 1994; See & Kamnetz 2004).

Rogers uses the concept of the self, understood as an organized consistent gestalt, which is available to awareness but does not have to be in awareness. One cannot be aware of "everything" since it would lead to overload, exhaustion and confusion. As it was mentioned earlier, the state of awareness and self-awareness fluctuates and certain focus of awareness is time-limited. Self is a composition of perceptions of characteristics building "I" or "me". It also consists of the relationships between "I" or "me" and the others. There is a distinction between the real self and the ideal self – the latter consists of the features which an individual would like to possess. The ideal self is connected to the system of the most highly regarded values and personality features, whereas the real self consists of the genuine, true constellation of characteristics. In some cases, a drastic discrepancy between the real and the ideal self may occur as it happens in case of narcissistic personality disorder. In most severe cases of this disturbance, one loses the access to the real self and lives the life via the false ideal self. The experience of one's realness is jeopardized and the false self is carefully nurtured, mistakenly perceived as real and projected (sometimes very efficiently) on the social environment. Rogers indicates that the access to the real self is crucial in achieving mental well-being. Spontaneous experience of the self and its expression during the encounters with others, opens the opportunity to drop the facades on both sides of an interaction. Only when the falseness disappears, the facades are dropped, the real encounter between human beings is possible and existentially significant connection may take place. When the false self is ever present, the facade remains solid and overdeveloped and thus the real being constituting another person cannot be encountered; the only possibility is to meet with carefully developed and sustained image. Ideally, in the process of therapy, when all states of self are explored, the self-awareness of one's falseness may give an opportunity to discover and learn to live with the realness within the self. During the therapy, severe painful swings between selves may be observed. These moments are usually challenging for both the therapist and the client. Because the self is perceived as gestalt, a minor change of a small part may generate the alteration of the whole pattern. Rogers emphasizes significance of the consistency between the self and the experience. In some cases, the experiences which do not fit with the self and appear incompatible are denied – they are not allowed to become part of the self-awareness. This lack of consistency and synchrony is called incongruence. The state of internal incongruence, blockage between the self and the experience, results in external incongruence, namely incongruent persons bring their incongruence into relationships with other people. In such cases, others often perceive such person as lacking in authenticity, as false, stiff, rigid or manipulative. Large amount

of experience is excluded on the intrapersonal and interpersonal level. The aim of therapy is to reverse this adverse process, i.e. to bring the person back in touch with the real self and to create an environment which allows to learn and live with it as well as act on it (Banaszak & Florkowski, 2014; Kirschenbaum & Henderson, 1989; Rogers, 1980; Rogers, 1993; Rogers & Stevens, 1994; See & Kamnetz, 2004).

However, this process is usually anxiety provoking, since it is not easy to realize the incongruence between the concept of the self and the total organismic experience. From this perspective, being incongruent paradoxically provides a sense of stability and safety in spite of certain suppressions and its consequences. Self-exploration leading toward the detection of self-deception can trigger high-level anxiety and it does not have to happen exclusively as a part of psychotherapy. Such a discovery may be a spontaneous result of various life circumstances, especially those deeply challenging; self-concept can be restructured under the severe pressure of relational crisis and another radical change, for example as a part of emigration and adaptation or adjustment to severe dysfunction and disability. The defense mechanisms – set to maintain the current structure of the self when an organism faces the threat – often work against the change. They can be very powerful and may lead to drastic perceptual distortions of the experience reflected in the awareness. As long as the defenses succeed, the incongruence between the experience and the real self is reduced and the anxiety is kept under control. For example, someone may effectively deny homosexual predispositions to himself or herself. The defense mechanisms may distort the perceptions of sexually attractive, yet consciously rejected, potential partners; the desire may be displaced with anger, aggression, aversion and rejection. It is not easy to realize that the real self wishes for the union with consciously despised object of desire. Therapist has to be very sage and be cautious so as not to push for premature dismantling of safe defense mechanisms, which have been efficiently working for an extended period of time. Ideally, as the process of psychological adjustment progresses, one can reach complete congruence of the self and the experience. When this state is achieved, a person may enter the optimal level of functioning. As it is indicated above, this ideal situation exists only theoretically as total congruence is an illusion; in reality only approximation is possible. Available congruence allows the organismic valuing to become a part of daily experience. It means that someone is connected with the real self and that the whole information provided by the organism can be used without limitations and distortions (Rogers, 1989).

According to Peter S. Fernald (2003), a person-centered approach could be named body-centered since there is a lot of emphasis put on the unobstructed flow of bodily sensations and ongoing organismic valuing as the major "navigational system" of a healthy self-actualizing human being. In the process of therapy, all relevant changes – *moments of movement* – are reflected in the body and they would remain insignificant without such reflection (Fernald, 2003). A person who is in

touch with his or her own body as a whole may experience every sensation generated by soma and psyche. He or she is receptive to every feeling flowing through all organismic channels as well as capable of empathy, and can use his or her whole bodily experience to sense the mental states of another human being.

The ability to empathize is perceived by Rogers as crucial in building deeper connections with fellow humans. It is necessary in therapy, but it is also of paramount importance in good enough parenting (Leckman et al., 2002; Winnicott, 1991), friendly support and any other interpersonal communication reaching beyond formality and superficiality. Therapists of different theoretical orientations agree that empathy is placed on the top of the list of most relevant therapeutic factors. Empathy can be detected very early, during initial sessions and high level of its presence is the single best predictor of positive therapeutic outcome. Brilliance and diagnostic skills, as well as academic achievements, do not have to be correlated with the degree in which the therapist is able to create empathetic climate. In fact, they often remain in opposition since diagnostic process is based on use of specific clusters and judgments, while pure empathy is preconception-free, is not compatible with formally constructed, fixed categories. Empathizing requires elasticity, openness and tolerance. It is not possible to be judgmental and empathic simultaneously. Hence Rogers places emphasis on the ability to remain non-judgmental. Rogers (1975) wrote that "true empathy is always free of any evaluative or diagnostic quality" (p. 10).

Empathy should be accompanied by other attitudinal qualities, for example the unconditional positive regard, i.e. acceptance of a person on unconditional basis, which is not a reward for fulfilling someone else's expectations. In opposition to unconditional positive regard, Rogers places conditions of worth. Under such conditions, individuals have to conform if they wish to obtain love from significant others and to do so they have to live according to the expectations of the others. In Rogers's perspective, real love equals non-possessiveness and tolerance (Banaszak & Florkowski, 2014; Kirschenbaum & Henderson, 1989; Rogers, 1980; Rogers, 1993; Rogers & Stevens, 1994; See & Kamnetz, 2004).

Rogers analyzes in-depth the process of therapy and eventual personality changes that may occur as its result. We would like to give here only a few hints of what is supposed to happen when psychotherapy works effectively. It is definitely necessary for two people to be in contact, therapist must be able to establish a good rapport with a client. Relational qualities are in the center of the therapeutic process and the relationship itself is the most relevant agent of support, insight and potential change (Thorne, 1995). Client entering the therapy is supposed to be – and often is – in the state of incongruence, vulnerability and anxiousness. On the other hand, the therapist is expected to bring the state of congruency into therapeutic encounter; he or she should be able to be congruent during sessions. There are some limitations inevitable as the total congruence expressed inappropriately with the violation of

dignity and defense mechanisms could be destructive. *Primum non nocere* remains a relevant guideline and whatever the therapist does cannot be damaging to the client.[1] The appropriateness of the therapy setting sets limits for congruence as well as other therapy components.

The therapist must be able to experience unconditional positive regard toward the client and an empathic understanding of client's internal frame of reference. It is worth to mention that if unconditional positive regard is missing or the therapist realizes that it is impossible on his or her side to present congruently such attitude, the only ethical decision is to refer the client to another psychotherapist (Thorne, 1995). Otherwise, the therapy in Rogers's opinion (Rogers, 1994) cannot be useful; on the contrary, it can be harmful. The therapist must be able to bring the indicated qualities into an encounter in such way that a client could sense them. He or she must be able to detect the unconditional positive regard and empathic understanding on the part of the therapist; otherwise, the process will turn into a fiasco.

Unconditional positive regard counterpoises the conditions of worth leading to conditional positive regard, which takes place when acceptance, support and affection are offered only if certain expectations are fulfilled (Fernald, 2003). However, it is worth noting that even relatively open, tolerant and loving parents may – under certain circumstance – withdraw Rogerian attitudinal qualities, as it is to difficult to accept certain choices made by their child. Yet, the therapist cannot fail regarding this relevant axiom.

Toward the end of a therapeutic process, a client should experience less physiological and psychological tension and be able to cope better with future tensions and frustrations. In the case of an effective therapy, the defensiveness is decreased, client's behavior is more independent and emotionally mature. Positive outcome of therapy is associated with openness, assertiveness, more direct communication and self-expression as well as a sense of being a real self, also in relationships with the others (Thorne, 1995). Paradoxically, such changes may be surprising and dif-

1 At times, it is very difficult not to come across difficulties regarding this basic assumption. Firstly, therapists are ordinary humans and often make mistakes in both personal and professional life. Secondly, therapeutic processes can take various, difficult to control courses at certain points of therapy and may reach the level exceeding the competences of a psychotherapist. Thirdly, self-explorations at certain moments are immanently painful or at least unpleasant. Such situations can be easily evaluated as harmful. Obviously, the examples indicated above do not exhaust the number of options. Reader may easily think that such comments are based on common sense and not anchored in the scientific evidence. These comments are specifically placed in the footnote as they are rooted in to two main sources: professional experience of the author as a clinical psychologist and psychotherapist, and psychology. On the one hand, they are part of personal experience; on the other, they are rooted in theory. It is difficult to make clear distinction between the personal and the professional, especially when the frame of reference is marked by Rogers's theory. He often emphasizes that person-centered therapy belongs to both domains – professional role and, at the same time, unique and deeply personal experience. The boundaries are sometimes difficult to maintain (May, 1973; Rogers, 1993).

ficult to accept. Additionally, it is difficult to judge to what extend those changes are the outcomes of the therapeutic intervention or are simply associated with growth and maturation – obviously, they can also result from an overlap of both factors (Banaszak & Florkowski, 2014; Kirschenbaum & Henderson, 1989; Rogers, 1908; Rogers, 1993; Rogers & Stevens, 1994; See & Kamnetz 2004).

2. Challenging contexts

According to John See and Brian Kamnetz (2004), facilitative conditions are relevant in the rehabilitation setting, however, they are not sufficient for ensuring positive rehabilitation outcomes. The therapist or counselor engaged in rehabilitation should be empathic, respectful and congruent, but he or she is also expected to be "technically proficient". The balance between Rogerian communicational components and other interventional style depends *inter alia* on the stage of the rehabilitation process. The above-mentioned authors describe three successive stages of the rehabilitation process. The first, initial stage is focused on the diagnostic workup; the emphasis is placed on establishing the rapport, therapeutic alliance, exploration of feelings and hope installation. At this stage, the presence of classic Rogerian facilitative conditions is of paramount importance as they are supposed to create the relational background for the engagement in rehabilitation. Furthermore, good rapport appears to be crucial. The second stage – based on common sense and logical deduction – accentuates analysis leading to the integration of information gained during the diagnostic stage.. According to See and Kamnetz (2004), facilitative conditions are not as relevant as previously, however, they are still responsible for the relational atmosphere, which allows the anxiety and worries to be expressed. Such cathartic opportunities continue playing a significant role.

Finally, the third stage requires taking actions, i.e. rehabilitation plans have to be implemented. If the adjustment takes the right course, a client takes a new job or training program. At this stage, the action-orientation supported by therapeutic approaches using behavioral strategies and rational interventions focused mainly on the challenges of the reality seem to be most relevant. But again, facing reality may evoke high level of anxiety, which can be handled with the Rogerian approach. Sometimes, empathic listening is more than enough to lower the anxiousness of a distressed individual (See & Kamnetz, 2004).

See and Kamnetz enlist limitations of classical person-centered approach in the rehabilitation settings. Rogers focuses mainly on the self-actualization and work aimed at "fine tuning" of an individual. Rehabilitation requires also work on very specific, daily-life tasks, the challenges of reality have to be addressed. Non-directive approach is not primarily concerned with a diagnosis; on multiple occasions, the use of a diagnosis is criticized and indicated as counter-therapeutic. Yet, rehabilitation is strongly affiliated with medicine, which accentuates accurate

diagnosis and treatment plans – medical approach imposes the use of diagnosis and diagnostic tools.[2]

Rogers tries to free psychology and psychotherapy from the influence of medical paradigms, yet he does not succeed, or at least not on the level of highly structured health care, affiliated with hospitals and insurance companies. On the other hand, independent private practitioners have the opportunity to make more free choices in terms of the therapeutic model. Still, when they need to refer a patient to another specialist, they have to use diagnostic clusters (Rogers, 1989).

Rogers opposes giving advice, he rather wishes to reinforce independence and free choices (Rogers, 1989; Rogers, 1993). In the process of rehabilitation, direct advice, suggestion, and information are required – a patient needs to be connected with specific agencies and services, as well as has to be informed about available options and opportunities. In general, classical Rogerian paradigm is not much concerned with the environment And the accent is placed on the individual work and on the handling of intra-psychic dynamics. Specialists involved in the rehabilitation, including counselors, have to be in touch with the environment, as well as build, maintain and coordinate multiple professional connections. They cannot functions in alienation, as they have to cooperate with the community resources, families and schools (See & Kemnetz, 2004).

Rogerian approach appears suitable for work with anxious and verbal clients. The most effective work can be performed with the highly functioning and insightful individuals, who are able to verbalize mental subtleties, name emotions and describe their thinking patterns (Rogers 1989; Rogers, 1993). Not all people engaged in rehabilitation meet such criteria – in extreme cases, due to organic brain damage, speech is severely disturbed or aphasia occurs. It could be added that the person-centered approach is suitable in cases, in which someone's reality testing is sound, whereas the above mentioned organic brain damage may also result in the impairment of this complex mental function.

Non-directive, person centered approach is also process-oriented (Rogers, 1989; Rogers, 1993; Rogers, 1994), hence rehabilitation counselors are accountable for the end results. In general, all professions dependent on the medical model are concerned with the end results. The notion of the outcome-based treatment is popular, accurately predicted outcome justifies treatment on every level, beginning on the financial and ending on the mental. From such perspective, Rogerian approach appears to be a luxury aimed at a relatively small, exclusive population. It calls for personality restructuring in the service of better adjustment and self-realization,

2 The consequences of the medical paradigm are vast. For example, this style of thinking has had decisive impact on the insurance companies. Patients do not get paid for an extended psychotherapy. Therapeutic intervention has to be quick, it should resemble a surgical intervention. It has to be done fast and effectively. Additionally, the insurance does not cover the costs if a diagnosis is not made. Willingly or not, even non-medical procedures have to at least resemble the medical ones because it is *sine qua non* condition of the refunding system (Thorne, 1995).

while not every person involved in the rehabilitation has to implement personality tuning. However, it may be disputable as an adjustment to a disability may require serious changes in the mental functioning, including the structure of personality.

In Rogerian approach, behavioral changes are in the background, whereas primary areas of concern are the scripts of thinking and related layers of emotions. Modifications of actions are welcomed but could be named as "side effects" of the therapeutic process. Rehabilitation, on the other hand, is focused on the modifications of behavior and the client needs to acquire specific skills necessary for the adjustment to highly specific changes. However, it seems worth to remind once again that Rogers never opposes a client to proceed with the very "down to earth" actions and if such need will transpire during sessions, specific behavioral modifications may be introduced. The focus of the therapy may shift at any time from "talking" to "doing" or any other needed technique. If client's preference is to work on certain issues in a very practical style, for example with the use of homework etc., it can certainly happen (Witty, 2007). Rogers always encourages to follow the genuine needs of the client. See and Kamnetz (2004) indicate that the disability may cause changes in the hierarchy of needs (. Difficult circumstances and loses of functions pose a severe threat to the mental functioning and the sense of security is often impaired or lost, whereas insecurity and extremely high level of anxiety push self-realization out of the "here and now" equation. In acute situations, defense mechanisms have to work tirelessly to regain the sense of security and the need to work on self-actualization may not appear during the session at all. Mental systems can go through the phase of an overload, which requires mainly psychological work of a supportive nature. However, it turns us back to the person-centered approach, as it is very suitable and efficient in providing support.

At least at the first stage of the rehabilitation, another Rogerian principle – namely aiming for autonomy – may also lose relevance. In certain circumstances, a given person can almost totally give up autonomy, as well as severe regression and infantilization may take place. Depending on the individual case, permission and acceptance of dependency may happen to be the most appropriate adaptive or

survival strategy.[3] Some inaccurate perceptions, distortions may be addressed via confrontation. As indicated by See and Kamnitz (2004), the non-directive approach is generally perceived as non-confrontational. The avoidance of confrontation appears to be naturally associated with the non-directive style of therapy. It is correct that Rogers uses such techniques cautiously, but in the essence it is not about non-confronting but about confronting in a specific style. Rogers emphasizes that not only therapy and counseling depend on non-threatening conversational style, but also any open, constructive and facilitating creativity and reflectivity interpersonal communication. There is a place for challenging and confronting, yet it has to be done in a way which is not triggering defensive reactions. Person-centered confrontation – however contradictory it sounds – exchanges potentially destructive criticism or direct pressures for the sensitive exposition of contradictions in emotions and cognitions. It appears to be an obvious and simple style of intervening, however, in practice it can be extremely difficult to refrain from criticism and forceful attempts of redirecting someone.[4]

The therapist can undergo an unconscious conversion into "the rapist", as in the process of the therapy, there is an opportunity to abuse a client in various forms, to impose and force thinking and acting in the way that is confirming the therapist

3 I would like to refer to my therapeutic case as an illustration of such situation. Due to a spinal injury and tetraplegia, a middle age man was experiencing severe adjustment difficulties. At the beginning of our sessions, he was medically stabilized, whereas mentally he was in the state of havoc. His personal world collapsed. There was no mental space for planning the future and the sense of despair appeared unbearable; The sense of loss was overwhelming and the suicidal ideations were prominent and ever present. Drastic twist happened on the dependence - independence continuum. Taken by surprise, against his wishes, this man fell into total institutionalized dependence. He needed assistance in every aspect of his daily functioning, beginning on feeding, through mobility, ending on defecation. As an adult man, he became a baby again. Experienced crisis influenced every aspect of his functioning. He lost financial and professional independence, the sense of identity fell apart including the sexual dimension. During our sessions, he reported repeatedly on the episodes of humiliation experienced during daily cleaning procedures. He would lie naked on the bed when young nurses would wash his body, including genitals. They would insert catheters and make enemas while he felt helpless and exposed. Earlier, being naked in the presence of women (he had a wife and a young lover) meant sexual involvement; now, young attractive nurses looked at him not like at a man, but at a sexless, impotent creature.
Subjectively and objectively, he was trapped in the total dependence. At this stage of rehabilitation, there was no alternative. There was no other option than to accept the death would be inevitable without the help of fellow humans. Dependence, like on the early stage of life, is adaptable and potentially can become a safe base for the next developmental stages. The process of rehabilitation resembles in some aspects the earlier stages of human life with the necessary progress and adaptations.

4 Researches show that therapists tend to be non-directive on a declarative level; nevertheless; in practice they often refer to easily visible as well as skillfully camouflaged directive pressures. Such actions often remain beyond awareness of both the therapist and the client (Rogers, 1989; Rogers, 1993; Rogers 1994).

convictions and providing him or her various gratifications (Masson, 1989). Such state of affairs is certainly an antithesis of the person-centered principles.

There are numerous difficulties in the application of the person-centered approach in the rehabilitation settings. An interesting account is provided by the physiotherapists from New Zealand who work with neurological patients. Suzie Mudge, Caroline Stretton and Nicola Kayes (2014) use co-autoethnographical method to research the obstacles in the application of the person-centered physiotherapy. They analyze the causes of conflicting responses and encountered discomfort on every operational level when Rogers's approach is introduced. Researchers look at the program aiming at the improvement of the walking skills in the neurological patients. They focus on the components of the mentioned program which deals with the collaborative manner of both goal setting and action planning with the explicit identification and management of barriers. Emphasis is also put on the shared expertise and openness to patients' preferences. They observe that although the approach is acceptable for the patients, it causes discomfort to the physiotherapists.

Goal setting is indicated as the first problematic realm. Mudge, Stretton and Kayes claim that "as clinicians we have experienced discomfort with goal setting, particularly when we have perceived patients and their goals to be 'unrealistic'" (2014, pp. 6-7). It is very difficult for a physiotherapist to handle their own feelings, when they hear someone hoping for impossible to achieve. They cope with such circumstances with the use of corrective information, yet such a direct intervention shifts interactions from the emotional level to the rational one. Therapist feel uncomfortable when they anticipate that a patient will not be able to achieve the goals and will be disappointed so they are very cautious so as not to set false hopes. Owing to the conducted research, they have changed attitudes toward this dilemmatic issue and they adopt a point of view that unachievable hope may motivate and empower as well as lead to the new meanings. Such permissive attitude requires possession of skills qualified as emotional work. It is worth to add that hope installation is a dilemmatic matter. Loss of hope can be detrimental for the treatment and the unrealistic hopes can have similar impact from the long term perspective.

Physio-centric background makes it difficult to apply the person-centered approach. Physiotherapy presents the mechanistic perception of a human body, accentuating sequences of procedures rather than holistic encounter. Dominant paternalistic attitudes assume that a physiotherapist plans and provides treatment, whereas a patient has to obey. For an average therapist, it is not easy to swap

paradigms and move from the physio-centric to the "person-centric".[5] Researchers summarize these difficulties as follows:

> Person-centered practice poses a number of challenges for our professions. Physiotherapists often lack capabilities to collaborate and share power and knowledge, which results in a lack of readiness and confidence to recognize shared expertise of patients and take on a broader view of functioning which is needed before patient-centered care can move beyond its current nominal adoption. This change of relationship from one of the experts, all knowing, physically focused physiotherapist to a relationship of greater collaboration and connection will require a range of more advance communication skills, for which most physiotherapists are ill-equipped (Mudge & Stretton & Kayes, 2014, p. 14).

Additionally, as indicated by the quoted authors, patients are used to come across paternalistic attitudes, thus they are not acquainted with alternative styles, as the health care systems present totalitarian features. Hospitals, including the psychiatric ones, have a hierarchical paramilitary structure, which is strongly bureaucratic and favors social distances between the staff members and the patients, who are placed at the bottom of the power ladder. It resembles the position of an inmate in the penitentiary system (Banaszak & Florkowski, 2010; Goffman, 1961; Weinstein, 1982). Opposite tendency shows up yet in its extreme form it is tainted with a demanding attitude and legal charges. Balanced cooperation remains a rare occurrence.

Difficult application of person-centered ideas in the medical domain is related to power and control. Ideas disseminated by Rogers remain rebellious and threatening to the medical establishment (Thorne, 1995). Technical advancement, progressive specialization, sky high costs of the medical care are paired with depersonalization and dehumanization of the health agencies. Person-centered ideas undermine colossal structure by pointing out its weaknesses, Achilles' heel. Medicalization giant wants not only to survive, but also to grow even bigger and stronger so it has to exterminate the opposition in order to secure its own prosperous future. It seems that its hegemonic position is not endangered now and in spite of mushrooming alternative medicine, the risk of extinction seems higher in the case of humanistic discourses. It is a very unfortunate situation. Technical advancements of the modern

5 Looking from personal experience and the perspective of a qualified physiotherapist, I support findings of the presented researchers. As a student, I quickly realized that physiotherapists have a unique opportunity to establish close, personal relationships with their patients. They spend with them a lot of time, often on a regular basis. They often proceed with routinized operations and such circumstances create a lot of "conversational space". It is easy to begin a conversation which can evolve into a significant exchange of thoughts and emotions. At the same time, we are educated in the total obedience to the bio-medical model. Psycho-social perspective is marginal; a qualified physiotherapist has no psychotherapeutic competences at all. Thinking style is dominated by the medical model.

medicine are amazing; medical interventions save lives; pharmacological, physical and surgical treatments give a chance for normal living to those who would have been previously condemned to the inconceivable suffering and death. Paradoxically, the more lives it can save, the more dehumanized it gets. Doubtlessly, best health care practice has to combine the technical advancements with the person-centered, humanistic qualities.

3. Conclusions

Good relationship with a patient or a client plays a relevant role in a variety of helping professions.[6] Rehabilitation requires a changing degree of help and assistance provided by the specialists. A significant percentage of specialists are skilled technicians and operators who have chronic difficulties in establishing and maintaining an empathic supportive relationship. This problem is often evident and described in the literature, as well as commonly present in daily experiences, as patients feel unheard, misinformed and not treated in the respectful way (Conrad, 1992). They suffer in the state of silent despair in the hospital waiting rooms and perceive the personnel engagements as distant, cold, at times even arrogant, lacking in the sensitive listening and empathic understanding. Such difficulties lead to the flow of negative evaluations and complaints on the low quality care (Banaszak & Florkowski, 2014; Conrad, 1992).

There are numerous reasons for such state of affairs. One of them is the deficit in the communicational skills, which paramount core is of Rogerian nature. Rehabilitation process is very specific, it is usually a set of long-term treatments that requires a team of specialists to be involved. There are series of encounters, often giving a chance to establish close working alliance. Developed relationships may evolve into close, even intimate ones, as specialists involved in the laborious process of the rehabilitation are often mentally and directly physically in close touch with the patients. It may seem trivial, but such close personal contact gives an excellent opportunity to establish supportive, therapeutic relations. People undergoing rehabilitation experience a lot of stress, frustration and they often long for a simple friendly chat or opportunity to express their concerns and fears; they are desperate to

6 Rogers makes a distinction between a patient and a client. In his point of view, the role of a patient fits well into the traditional medical model. A patient is diagnosed and treated. He or she is largely dependent on the diagnosis and the treatment plan offered by a physician and other medical staff. Persuasion is often used as an expert is supposed to be more knowledgeable and to know better what is good for the patient. A client does not equal patient. A client is not expected to take the role of a subordinate who follows the orders. He or she may not suffer from any medical condition, and even if she or he does, the subjective personal perceptions are equally relevant as the one experienced by the expert. The final responsibility for the decisions and actions are discussed, reviewed and not imposed by the "superior" expert. Rogers argues that especially in the case of the mental difficulties, the client-centered approach is more suitable and effective than the expert-centered. Furthermore, patients should more often be seen and treated as clients in general (Rogers & Stevens, 1994).

be heard and understood. Physiotherapists often spend with a certain person more time than other specialists. Doctors, nursing staff, or laboratory workers usually make short contacts of more superficial nature, while the physiotherapists have a unique opportunity to create close relationship, at times closer than counselors or psychotherapists. They may encounter emotionally charged expressions that require their ability to contain such moments. In the case of the lack of psychological therapeutic skills, they are unable to provide the necessary support and they may struggle to cope with their own feelings of discomfort, tension and confusion, which can easily turn into – consciously or unconsciously caused – negative reaction and, instead of giving a chance for improvement, worsen the situation (Hammell, 2007).

These briefly mentioned issues suggest that Rogerian skills are, on the one hand, neglected by the educational institutions providing training for helping specialists. On the other hand, they remain crucial and the accent should be placed on their training and implementation. As the mentioned authors indicate, non-directive person-centered approach may not be sufficient in the complex process of rehabilitation It may need to be combined, supplemented or even at times exchanged for another type of intervention. Therefore, one has to remain open-minded, flexible and adaptable. However, Rogerian attitudinal qualities appear as solid fundaments, on which other interventional styles and types of approaches can rest and draw upon. Without such strong relational base, any level of intervention will be incomplete and insufficient.

The discussed approach also corresponds with the rehabilitation due to its intense bodily focus. Rogers strongly encouraged attentiveness toward all messages emitted by the body (Rogers, 1989; Rogers, 1993). The more we become our bodies, the better and fuller life is.[7] Changes, traumas, dysfunctions, disfigurations, disabilities – they are all deeply engraved in the every cell of a complex structure. Our soma evolves from birth to the death and Rogerian approach effortlessly and spontaneously embraces every aspect to a living body, beginning on joy, through boredom, ending on pain, suffering, despair and dying.

Intense bodily focus may equal close connection to the human existentiality. Existential concerns rise easily toward "the mental surface" of the self-awareness at times of paramount changes, threats, losses and other hardships. These experiences are unavoidable when illness, damage or dysfunction overthrow daily routine and the faced challenges trigger the in-depth, significant and possibly ultimate reflections (Frankl, 1970; May, 1973; Rogers, 1993. It could be stated that the person-centered approach cannot be non-existential, as existential concerns constitute the essence of reflectivity, which seems to be a unique quality marking our kind. Disease and tribulation may lead to the existential anxiety and illumination. *Boundary situations* – such as the loss of the loved one, the collapse of the self-concept, the loss

7 Understood as reaching for congruence, using organismic valuing process, removing obstacles on the way to the organismic self, becoming living wholeness (Rogers, 1989).

of the sense of meaningfulness – may turn into an opportunity to get in touch with the authentic self (Stumm, 2008). All areas of existential inquiries could be activated at all stages of illness and rehabilitation and, at least potentially, they can match well with this approach for a variety of reasons. For example, the radical phenomenological stance means avoidance of any preconceptions and full concentration on the unique inner experiencing (Stumm, 2008). It encourages free choices, which are inevitably clipped with anxiety, but also creates an opportunity to break out of the existential isolation. Finally, the signaled above issues confirm Rogers's humanistic-existential affiliation.

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Estrogen–androgen imbalance as a defect of the development and function of the male reproductive system

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Abstract

It is now known that not only androgens, but also estrogens, are involved in the regulation of spermatogenesis, spermatozoa differentiation, and normal fertility in males. Estrogens are formed from androgens in a reaction catalyzed by cytochrome P450 aromatase (P450arom). Estrogens exert their cellular effects via estrogen receptors (ERs) distributed throughout the male gonads and genital tract. ERs can also interact with endocrine-disrupting chemicals (EDCs). EDCs are identified for their ability to perturb the homeostasis of the endocrine system and hormonal balance. EDCs have agonistic or antagonistic interactions with hormone receptors that change the synthesis, transport, and metabolism of endogenous hormones.

The aim of this article is to present the current knowledge on the influence of the estrogen–androgen imbalance on/in the male reproductive system, and data obtained in the Department of Histology and Embryology in Pomeranian

Medical University in Szczecin. Studies were performed on/in adult male Wistar rats treated with substances producing hormonal imbalance: soya isoflavones, letrozole, finasteride, lead.

Endocrine-disrupting chemicals have agonistic or antagonistic interaction with hormone receptors, altering the synthesis, transport, and metabolism of endogenous hormones. A disturbed balance in sex hormone biosynthesis can provoke morphological and functional changes in the male reproductive system.

Keywords: ***Male reproductive system, estrogens, androgens, endocrine-disrupting chemicals***

Introduction

The reproductive male function in humans is regulated by a number of hormones and paracrine factors. The development of the male reproductive system is also influenced by specific hormones, such as testosterone (T), dihydrotestosterone (DHT), and anti-Müllerian hormone (AMH). Testis cell development is dependent on the local action of hormones produced by differentiating gonads, and in fetuses it is dependent on the differentiation and development of Leydig and Sertoli cells, which are responsible for the proper development of the male reproductive system. In the last decades there has been an increase of the incidence of reproductive disorders, suggesting that environmental factors, rather than genetic defects are the most likely causes (Svechnikov *et al*., 2014).

Although androgens are the most important hormones in the normal development of the male reproductive system, the important role played by estrogen in the development and function of the testicles in adults is now recognized (Hess *et al*., 1997). The balance between androgens and estrogens may be important in maintaining normal spermatogenesis (Zhang *et al*., 2010). Exposure to endocrine-disrupting chemicals (EDCs) which have estrogenic (xenoestrogenic) or antiandrogenic activity during fetal and neonatal development is associated with numerous disturbances of the male reproductive system, such as cryptorchidism, hypospadias, impaired fertility, and incidences of testicular cancer (Zhang *et al*., 2014).

The aim of the paper was to present the current knowledge on the influence of the estrogen–androgen imbalance on male reproductive system, and data obtained in Department of Histology and Embryology in Pomeranian Medical University in Szczecin.

1. Materials and methods

Studies in Department of Histology and Embryology were performed on adult male Wistar rats treated with substances producing hormonal imbalance in following experimental schema:

1. The animals in the experimental group received finasteride, an inhibitor of 5α-red2 (per os; 5 mg/kg body weight/day; Proscar®, MSD Sweden) for 56 days (the total duration of spermatogenesis), what produced decrease of DHT and increase T levels.

2. The rats in the experimental group received per os letrozole (Femara®; Novartis Pharma, Germany) — non-steroidal inhibitor of cytochrome P450 aromatase (P450arom) at a dose of 1 mg/kg b.w./day for six months (the total duration of three spermatogenesis). The levels of circulating and intratesticular estradiol were significantly decreased (43% and 48%, respectively).

3. In the experimental group, adult male Wistar rats were intoxicated with 1% lead acetate (PbAc) administered in drinking water for nine months, a period five times longer than the duration of one spermatogenesis. No significant differences were observed in steroid hormones level.

4. The rats of the experimental group received *per os* soya isoflavones (genistein and daidzein) (Meno Stop - HASCO Lek, Poland or SoyaMeno - Terpol, Poland) prenatally, neonatally and next postnatally up to the sexual maturity, at a dosage of 20 mg/kg body weight/day, to produce the increased level of circulating estradiol.

2. The role of androgens in the male reproductive system

Androgens produced by Leydig cells in the testis and by the adrenal glands play a pivotal role in the development and function of the adult male reproductive system. Decreased levels of androgens or their improper interaction with androgen receptors (ARs) may impair both male development and reproductive function.

The male reproductive system starts to develop around the seventh week of prenatal life, when primordial germ cells repopulate the primordia of the gonads. The key to sexual dimorphism is the Y chromosome, which contains the testis-determining gene called SRY (sex-determining region on Y) on its short arm (Parker *et al.,* 1999). The expression of the SRY gene determines the development of the undifferentiated gonads into the fetal testis, which produces testosterone and anti-Müllerian hormone (AMH). AMH causes the regression of the Müllerian ducts, while testosterone causes differentiation of the Wolffian ducts into epididymis, vas deferens, and seminal vesicles. Testosterone may be converted by the enzyme 5-alpha reductase into dihydrotestosterone (DHT), which causes the development of the prostate and external genitalia (the penis and the scrotum). However, both testosterone and DHT are needed for penile growth. A deficiency of 5-alpha reductase is one cause of pseudohermaphroditism; at birth, individuals with this condition have clitoral-like phallus, a bifid scrotum, urogenital sinus, and the testes were present in the inguinal canals or labial-scrotal folds (Peterson et al., 1977).

Testosterone is produced by the Leydig cells. There are two populations of Leydig cells - the fetal and postnatal. The early stages of androgen production in prenatal life are probably gonadotropin independent, because pituitary Luteinizing Hor-

mone (LH) production occurs later in prenatal life. Fetal Leydig cells are the most abundant just before birth; thus, directly after birth, the serum level of testosterone reaches adult concentrations over several months and mascularizes the hypothalamus. Thereafter, and until puberty, androgen production decreases dramatically, which prevents virilization in young individuals. Postnatal (adult) Leydig cells are a distinct population from the fetal Leydig cells (Benton *et a*l., 1995). Although the postnatal Leydig cells start to differentiate in the second postnatal week, their mitotic activity is initially tempered by the inhibitory action of the Müllerian inhibiting hormone and estradiol. Moreover, the expression of Leydig-cell specific markers, steroidogenic enzymes, and LH and androgen receptors is lower than at more differentiated stages (Wu X *et al.,* 2007).

At puberty, testosterone is needed for the maintenance of spermatogenesis and for the inhibition of germ-cell apoptosis (Singh *et al*., 1995). The intratesticular testosterone level in the rete testis and the seminiferous tubule fluid is 50 to 100 times greater than the circulating level. The main influence of testosterone on spermatogenesis is through the interaction of testosterone with androgen receptors (AR) in Sertoli cells, which mediate androgen action to the intimately associated germ cells. Chemical signals, biological factors, and molecules induced by androgen can be transported back and forth between germ cells and Sertoli cells through specialized cell junctions and cytoplasmic bridges (Fawcett *et al*., 1961). AR expression levels are different in adult Sertoli cells depending on the stages of the seminiferous epithelium. During stages VI to VIII, AR levels increase dramatically (Lyon *et al*., 1975). Testosterone also helps to maintain the integrity of the blood–testis barrier (BTB) and enhance the endocytosis of integral membrane proteins at the BTB (e.g., occluding and N-cadherin); however, these proteins are rapidly recycled back to the surface of the Sertoli cell (Yan *et al*., 2008).

Many animal studies reveal that epididymal function is also influenced by androgens (Robaire *et al*., 2006). Testosterone is required for the development of the epididymis from the Wolffian ducts; however, the function of the epididymis in adulthood is dependent on DHT, and steroid 5α-reductase activity is a key regulator of androgen action in this organ (Robaire *et al.,* 2006). Without androgens, the epididymis gradually loses its ability to maintain the process of sperm maturation (Cooper *et al.,* 1996).

Testosterone binds with androgen receptors (AR) located in the cytoplasm and the nucleus of target cells, which results in DNA activation and the transcription of particular proteins. The AR gene is located on the X chromosome (Xq 11-12) and consists of eight exons (Dohle *et al.,* 2003). Defects or mutations of the AR gene lead to androgen insensitivity syndromes (AIS) and cause a range of phenotypic abnormalities of male sexual development, which may lead to low virilization or testicular feminization. Individuals with a 46, XY karyotype and with complete androgen insensitivity (CAIS) exhibit female external genitalia, normal breast en-

largement, a blind-ending vagina, and intra-abdominal testes. Less severe mutations of the AR gene may lead to subtle undervirilization or infertility in individuals with male phenotypes (McPhaul *et al.*, 2002; Quigley *et al.*, 1995).

Male infertility may be also caused by hypogonadism, which is due to testicular insufficiency, androgen resistance, or failure of the hypothalamic–pituitary endocrine system. Hypogonadotropic hypogonadism is responsible for 3.4% of male infertility (Pierik *et al.*, 2002). The suppression of spermatogenesis may be caused by acute or chronic diseases that affect gonadal function directly or by inhibiting GnRH and gonadotrophins, which results in low levels of intratesticular and circulating testosterone. Moreover, severe undernutrition and metabolic deficiencies also have negative effects on testicular endocrine function (Dohle *et al.*, 2003).

The treatment of adult rats with finasteride resulted in the changes of morphology in the testis that included the sloughing of premature germ cells into the seminiferous tubules lumen, the formation of giant cells, altered the expression of various types of proteins (Trybek *et al.*, 2005) (fig. 1). The morphology of epididymal

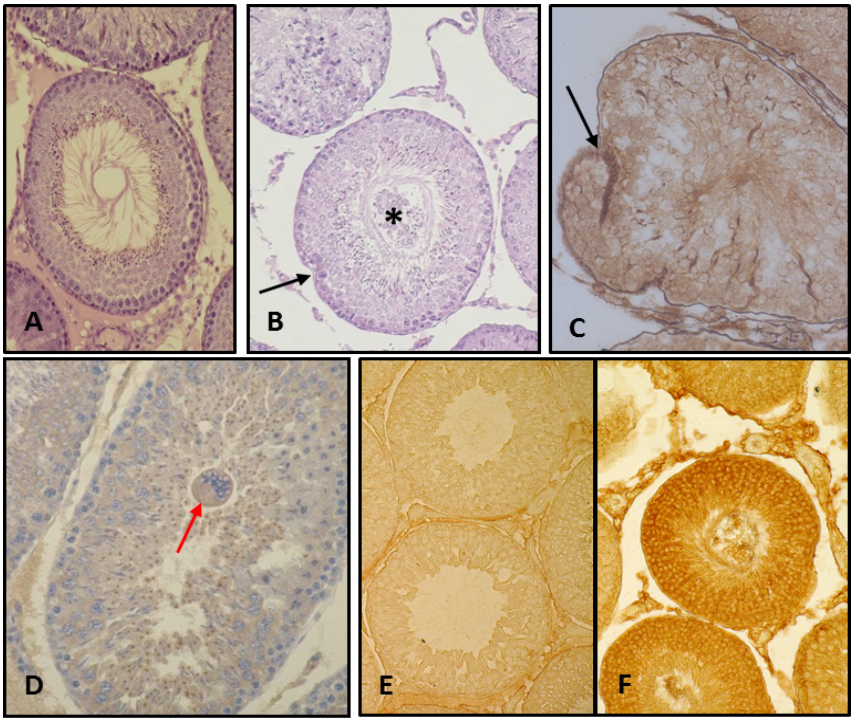

***Figure 1**: Cross-sections of seminiferous tubules in: control rats - A (H-E), E (immunoexpression of Bclx); rats exposed to soya isoflavones - B (H-E); rats receiving letrozole – C (silver impregnation), D (immunoexpression of TRPV1); F (immunoexpression of Bclx). All generations of the germ cells are present in the seminiferous epithelium of control rats. Black arrows show invaginations of the seminiferous tubules; red arrow shows giant cells; black asteriks shows sloughed immature germ cells.*

epithelium in the experimental rats was not changed. However, the immunoexpression of antioxidant enzymes, receptor proteins and junctional protein was changed (Trybek *et al.*, 2005) (fig. 1F).

3. The role of estrogens in the male reproductive system

Estrogens have long been considered female-specific hormones. In the 1990s, new discoveries in the male reproductive system revealed that estrogens not only play important functions in the male reproductive system but also estrogens, together with androgens, are essential for normal fertility in males. Evidence for this was provided by the discovery of aromatase P450 and estrogen receptors in testicular cells (Nitta *et al.,* 1993; Carreau *et al.*, 2011). Indeed, the androgen–estrogen balance is essential for normal sexual development and reproduction in mammals.

Aromatase P450 is an enzymatic complex responsible for the conversion of androgens into estrogens. P450arom is localized in the endoplasmic reticulum of different tissues including placenta, brain, adipose tissue, bones, and gonads. Aromatase expression is detected in Sertoli cells, Leydig cells, spermatocytes, spermatids, spermatozoa and epithelial cells of efferent ductules in the head of the epididymis (Carreau *et al.*, 2008).

Estrogens are steroid hormones that can easily cross the phospholipid bilayer of the plasma membrane. The most potent estrogen produced in the body is 17β-estradiol (E2), while estrone and estriol are much weaker but have high affinity to estrogen receptors (ERs). Two types of nuclear estrogen receptors (ERα and ERβ) are encoded by two different genes located on different chromosomes (Carreau & Hess, 2010). ERα and ERβ are widely distributed in the cells of male reproductive system. In the testes, reports of ERα and ERβ expression vary not only between species, but also between individuals. ERβ is more abundant than ERα in the male reproductive system. In male fetuses, ERβ is expressed in germ and Sertoli cells in the seminiferous epithelium and in the epididymis (Takeyama *et al.,* 2001). In adult males, ERβ is present in spermatogonia, spermatocytes, and round spermatids (Makinen *et al.,* 2001). ERα and ERβ are classical steroid receptors, but estrogen signaling is also possible through the transmembrane G protein-coupled receptor GPR30 (Prossnitz *et al.,* 2008).

The crucial role of estrogen for reproduction has been shown by studies with mice with knockout estrogen receptor alpha (ERαKO), estrogen receptor beta (ERβKO), and P450 aromatase (ARKO) genes. Lack of ERα impairs the development of the epithelium of the ductuli efferentes and inhibits reabsorption of the testicular fluid (Hess *et al.,* 1997). Moreover, ERαKO mice are sterile and the spermatozoa in the caudal part of epididymis are characterized by very low motility (Mahato *et al.,* 2001). ERβKO mice are sterile, although histological defects of the testis and epididymis are not seen and sperm motility seems to be normal (Antal

et al., 2008). This may be caused by the fact that ERβ regulates germ cell development (Delbes *et al* ., 2004).

Surprisingly, ARKO mice, in which the natural estrogen ligand was removed, at the age of 12–14 weeks were fertile and morphology of the testis and spermatogenesis appeared to be normal, but in older animals (18 months old) the process of spermatogenesis was disturbed and the structure of the seminiferous tubules was improper. Testis weight was reduced after 1 year of postnatal life, while degeneration of round spermatids appeared early on, between 12 to 14 weeks. Moreover, ARKO mice are characterized by hypotrophy and hyperplasia of Leydig cells (Carreau & Hess, 2010; Haverfield *et al*., 2011).

The process of spermatogenesis is controlled by hormones (androgens and estrogens) and insufficient amounts of these can lead to many complications, even to infertility; excesses of these hormones may also have deleterious effects. Animal experiments have shown that excessively high levels of estrogen caused by overexpression of aromatase lead to estrogen–androgen imbalance, Leydig cell hyperplasia, dysmorphic seminiferous tubules, and disrupted spermatogenesis (Li *et al.,* 2001).

All the previously mentioned data indicate the significant physiological function of estrogens in male fertility. The influence of estrogens on the hypothalamic–pituitary–testis feedback loop and their effect on Leydig cell function through ERα in these testosterone-producing cells have been well established (O'Donnel *et al.,* 2001). Experiments on transgenic animals have revealed that the impact of estrogens on spermatogenesis include regulation of germ cell proliferation, differentiation, survival, and spermatid maturation (Carreau & Hess, 2010). Estrogens are also involved in the regulation of apoptosis, including the number of Sertoli cells during development. Germ cell apoptosis is a normal and physiological process in which the number of germ cells is regulated and damaged cells are removed through programmed cell death (Chimento *et al.,* 2010).

The letrozole treatment induced estrogen deficiency caused statistically significant decreases of both intratesticular and serum levels of estradiol, and morphological changes in the seminiferous epithelium and in the interstitial tissue of the testes. Those histomorphological changes in rat testes were similar to that observed in the testis aging processes, such as the sloughing of premature germ cells, the vacuolization of the seminiferous epithelium, the formation of giant cells (fig. 1D), shallow and deep invaginations of basement membrane (fig. 1C), as well as lipofuscin accumulation in Leydig cells.

4. Endocrine-disrupting chemicals and their impact on males

In the last few decades, there has been evidence that the function of the male reproductive system is deteriorating in both humans and animals, and that this may be caused by exposure to environmental endocrine-disrupting compounds (EDCs). EDCs, which are also referred to as xenohormones, are exogenous substances or

compounds that cause negative health effects in the body by disrupting endocrine functions. Exposure to EDCs affects different aspects of human health and reproductive development during prenatal and early postnatal life (Egbowon *et al*., 2011; Bergman *et al.,* 2012). EDCs may impair testosterone secretion, block hormonal action, change the metabolism, or activate estrogen or androgen receptors (Rhind *et al*., 2002). The exposure of experimental animals to high doses of exogenous estrogens leads to many disturbances, such as male feminization, decreased sperm count and quality, and decreased size of the testis (Akingbemi, 2005).

EDCs constitute a heterogeneous group of anthropogenic compounds present in industry (dioxins, lead), agriculture (organochlorine pesticides), pharmaceutical agents (diethylstilbestrol), and food. The largest group of xenoestrogens found in food are the phytoestrogens (Cederoth *et al.,* 2009), which are also called "dietary estrogens"; these are naturally occurring nonsteroidal plant compounds. There are several groups of phytoestrogens including coumestans (coumestrol), lignans (enterolacton, enterodiol), stilbens (resveratrol), and isoflavones (genistein, daidzein).

Phytoestrogens have the ability to cause estrogenic or antiestrogenic effects because of their structural similarity with estradiol (17-β-estradiol). Genistein and daidzein, which are isoflavones, occur predominantly in soybeans and soy-based infant formulas. Isoflavones are converted in gastrointestinal tract: daidzein can be metabolized to equol and O-desmethylangolensin (O-DMA) by intestinal bacteria; these metabolites are absorbed, enter the circulation, and are excreted in urine (Cederoth *et al.,* 2010). Equol binds more easily with ERs than daidzein. Studies have revealed that only 30–50% of people are capable of producing equol from daidzein while 80–90% of people are able to produce O-DMA from daidzein (Kelly *et al.,* 1995).

Children and newborns are more sensitive to environmental toxins than are adults. They may be exposed to such chemicals not only during postnatal life, but also during prenatal life. Toxic substances may cross the placental barrier and be transported into the fetus or may be transferred during lactation to the plasma of newborns (Doerge, 2011). Thus it is very dangerous, as metabolic pathways in infants are immature and so they metabolize, detoxify, and eliminate toxins in a different way than adults do. Sometimes the effects from the prenatal or neonatal periods are not seen for many years. EDCs have high lipid solubility, so they accumulate in the adipose tissue and their long-term effects may thus be visible even many years later (Unuvar *et al* ., 2012).

There are many reports of the influence of the EDCs on the male reproductive system. A correlation has been found between maternal serum concentration of PCB (polychlorinated biphenyl), DDT (dichlorodiphenyltrichloroethane), and DDE (primary DDT metabolite) and incidences of hypospadias and cryptorchidism (undescended testicles) in infants born to these mothers (Pierik *et al.,* 2004). Boys exposed to intrauterine PCB and PCDF are characterized by reduced serum

testosterone levels together with an increase in serum FSH and estradiol levels during puberty (Hsu *et al*., 2005). Other studies have demonstrated that prenatal, perinatal and adult exposure to a plastic component, BPA, causes developmental genitourinary anomalies, decreased epididymal weight, decreased daily sperm production, and increased prostate weight in experimental animals (Nagel *et al.,* 1997).

Intoxication of adult rats with small doses of lead did not produced changes in testis morphology. Electron-microscopic studies revealed electron-dense inclusions contained lead in macrophages of testicular interstitial tissue (Wenda-Różewicka *et al*., 1996). The lead-loaded inclusions were also found in the cytoplasm of epididymal epithelium, in smaller amount in smooth muscle cells of epididymal wall and in the epididymal lumen (Piasecka *et al*., 1995).

Rats exposed to soya isoflavones during the prenatal period, lactation, youth, and sexual maturity were characterized by a significant reduction in testosterone level, sloughing of the premature germ cells into the lumen of the seminiferous tubules (fig. 1B), decreased diameter of the seminiferous tubules, and decreased thickness of the layers occupied by c-Kit-R-positive spermatogonia (Misiakiewicz *et al.,* 2013).

5. Conclusion

Studies in recent decades indicate that male reproduction has been deteriorating (Si *et al.,* 2015). The androgen–estrogen ratio is essential for the physiological function of the testis and other male reproductive organs. Lower circulating levels of testosterone can be found in a large percentage of infertile men. Estrogens are responsible for the proper function of Leydig cells, germ cells, and the epithelium of the efferent ductules. Estrogen receptors are abundant through the male reproductive tract. It is now known that there are many substances in daily life, known as endocrine-disrupting chemicals (EDCs), which can disturb endocrine functions. Many EDCs are xenoestrogens, which can bind to the estrogen receptor and decrease the level of endogenous estrogens. EDCs have agonistic or antagonistic interaction with hormone receptors, altering the synthesis, transport, and metabolism of endogenous hormones (Svechnikow *et al.,* 2014). A disturbed balance in sex hormone biosynthesis can provoke morphological and functional changes, not only in germ cells, but also in the somatic cells of the male reproductive system.

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Mathematics

A procedure to check the mathematical skills of students in Secondary School

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Abstract

This paper shows a detailed study on learning mathematics in Secondary School, and comparing the mathematical performances. More specifically, numerical and spatial reasoning issues are handled which are essential when solving mathematical problems. The methodology that we carry out is based on tests of mathematical skills (named 'test group') and comparing the results with national data regarding this subject (named 'validation group'), the results being analyzed statistically.

We have obtained that our groups have a 'numerical reasoning' factor 2.3% lower than the national statistics, and 1.5% lower than this national averaged data for 'space turns' factor.

They are somewhat lower but not alarming values. At the same time, concerning the 'numerical problems' and '2D figures reasoning' factors, the score for our students is slightly higher than the national average data.

On the whole, we have detected a general lack of ability to represent figures and perform turns in 3D, recommending a deep review of 2D concepts; teachers should incorporate contents related to spatial geometry little by little, after ensuring that students have a good knowledge of 2D issues. Besides these analyses, we also indicate innovative strategies based on the use of software and e-learning.

Keywords: ***Numerical and spatial problems, e-learning, mathematical problems, methodologies for teaching and training, innovation quality***

1. Introduction

Mathematics has traditionally been a rather arduous and complex subject for a large part of students (Bieda et al., 2014; Bakker, 2014). It has always required to implement innovative strategies and methodologies to make the process of learning easier and, at the same time, it is necessary that students pay attention to professors, not losing the interest and the motivation (van Oers, 2010; Jha et al. 2007; Kort et al., 2001) to study an extremely useful and practical subject in our society (Bakker, 2014; Posner & Raichle, 1994; Campbell & Clark, 1992).

Whatever the aspects influencing the process of learning mathematics are (Gerstner and Bogner, 2009; Zack and Reid, 2003), we need to carry out experimental studies (Alexander and Golja, 2007; Cattell, 1890) that allow us to know what aspects are particularly complex when learning maths, and in turn these studies help us to implement solutions to reduce them, either relying on e-learning tools for example (Sun et al. 2008), or with the use of specific mathematical software (Cuicas Avila et al., 2007). Likewise, the results of the studies should be analyzed and validated statistically with reliable data which come from prestigious agencies and organisms, being them typically obtained from tests or examination processes (Bonett & Price, 2002; Cattell, 1890; Peró-Cebollero & Guàrdia-Olmos, 2013).

Fortunately, nowadays, ICT (Information and Communication Technology) industry and information science offer a multitude of mathematical tools (for the calculation, reasoning problems , graphic representation (Boonen et al., 2014; Pitta-Pantazi & Christou, 2010; Gorgorió 1998), etc., (Albalooshi & Alkhalifa, 2002; Cuicas Avila et al., 2007), which facilitate the students to understand the concepts, and likewise allow them to deepen into more advanced contents (Sampson et al., 2002). That is one of the reasons why every teacher or professor should not being kept away from what we call 'Innovation in Education', and they should be actively involved in the search of the best ways for the acquisition of skills by students.

Therefore, the goal of our study is based on the aforementioned issues, that is to say, performing an experimental analysis in some Secondary School classes for our students, and comparing the results with data provided by Spanish national agencies of quality in Education. More specifically, we address two aspects which are classified as the most complex by the students, and they often require a greater mental activity when solving problems, we are referring to: 'Numerical Reasoning' (NR) and 'Spatial Reasoning' (SR) problems. The results presented in this paper are highly clarifiers as they allow us to check and confirm the trend or bias in the results of acquisition of skills when compared with mixed group classes. At the same time, we have to stress the competitive advantage of using software tools when understanding and solving mathematical problems.

2. Motivation for selecting this subject. Context of study

Teachers who have worked for years at Secondary School where this study is performed, have been observing and detecting problems and difficulties when students have to solve mathematical problems in which they simply have to "think". It is detected that students seek and require a series of structured steps (or broken guides) of how to solve a problem, and they avoid applying their own reasoning and logical deduction skills, which is a major setback in subjects like mathematics.

Learning mathematics involves both the development of Numerical Reasoning (NR), which historically has got a great importance in education, and Spatial Reasoning (SR), (Clements and Battista, 1992), the latter with less weight in the academic curriculums but also essential for troubleshooting (Tartre, 1990).

The aim of this paper is to analyze, through a test of skills, the development of these two factors (NR, & SR) in a 2nd course of Secondary Education (at the age of 14 years old). After analyzing these factors a plan, for improving the areas deemed necessary, will be proposed.

2.1 Context

The context in which the project is developed is a private school, located in a residential area of Madrid. The socio-economic status of families is medium-high. In this school, an integral education is offered (both human, scientific, cultural, religious and sporting aspects are taught), hence it comprises all aspects of the person, in a climate of freedom and personal responsibility.

The pillars on which the educational project is based is: a differentiated, comprehensive and personalized education. It seeks to personalize the education to students, treating each student according to their own particular needs and characteristics. The learning model followed is based on three bases: learning to think, learning to work, and learning to know and appreciate the reality.

The groups under study at this center, and in this course, have the characteristics put forward in table 1.

Group A	Group B
It is a group of 31 girls. They sit at individual tables. There is a student with Attention Deficit Disorder (ADD), but with no hyperactivity or dyslexia (HD), so her behavior does not alter the normal rhythm of the class.	This group has 29 girls. Like the group A, they are placed in individual tables. This group is conditioned because six of its students have Attention Deficit Disorder (ADD) and two of them have also hyperactivity.

***Table 1**: Characteristics of the classes under study*

3. Methodology

According to experts, if you want to know the cognitive map which is more related to the teaching and learning of mathematics, it is necessary to analyze: a) the numerical aptitude, b) the logical ability, both inductive and deductive, and c) the spatial ability (Arrieta, 2003; Clements & Battista, 1992).

These capabilities (Bishop 1980) can be evaluated by performing a test of skills. Therefore we analyze the results obtained by all students of 2nd course of Secondary School in a test of skills, studying the above aspects related to mathematics learning (Cattell, 1890; Donabedian, 1980).

We have conducted intelligence tests that encompass many aspects of knowledge (Tartre, 1990) and personality of the students (Reise & Waller 1990). It has been applied to the entire second course of Secondary School, in the second quarter of the academic year. Although the tests consisted of several aspects that could be interesting, we focus strictly on the two blocks referring to a) the numerical and b) spatial factor, comprising two of the main areas of study of mathematics. In the analyses, the results of the students who have ADD or ADHD are also shown.

Finally, a plan for improving the teaching of this subject is introduced, emphasizing aspects whose results have been more negative and how to get better results.

3.1 Procedure for collecting data: Aptitude Tests

In 2nd course of Secondary School (SS), we selected the aptitude tests proposed by a prestigious Spanish Institute of Educational Sciences (*Instituto Calasanz de Ciencias de la Educación* – ICCE). The Institute is a center of teaching and learning resources at the service of the educational community; it collaborates in the cultivation, improvement and development of Pedagogy (Kort et al., 2001) and Educational Sciences. In order to address emerging educational needs, it is up to date in topics related to research at SS, the Institute is also specialized in psychopedagogical services; furthermore, it is at the forefront of new technologies applied to the educational field, and gives the possibility of acquiring a deep educational training for teachers and youth (Swanson & Williams 2014; Albalooshi & Alkhalifa 2002; Frank et al., 2002).

Aptitude tests are carefully constructed, hence a good result cannot be attributed to chance. A very low mark can be attributed to various causes unrelated to the characteristics studied in the own test, and it may require some additional test using a single and personalized examination.

These tests are not intended as an instrument whose purpose is to predict school success. It is rather to show the current status of the students, and these results do not imply any future development or progress.

The blocks under study are: 1) the numerical block which refers to the arithmetic content, numbers, operations and algebra, and 2) the spatial block related to the visualization or graphic representation (Hegarty & Kozhevnikov, 1999; Pitta-Pantazi & Christou, 2010) of functions, curves and objects (Bishop, 1989; Battista, 1990). According to experts, the visualization (Van Garderen & Montague, 2003) can be described as the ability, the process and the product of creation, interpretation, use and thought on portraits, pictures, or diagrams in our minds, on paper, or with technological tools, with the main purpose of representing and communicating information, previously unknown, and to perform or develop advanced insights (Godino et al., 2012).

The fundamental aspects that are valued in these tests are reflected in table 2: the Numerical factor (McCloskey & Macaruso, 1995) and the Spatial factor (Bishop, 1980).

Issues under consideration	Definition
Numerical Factor (NF)	It indicates the ability to cope with numbers and resolve mathematical operations and problems. A high score may indicate ease of learning in the area of Mathematics.
Spatial Factor (SF)	It is the ability to understand logical sequences of figurative content, based on geometric shapes and to handle objects mentally, imagining a structure from a plan or design in 2D (two dimensions).

***Table 2**: Issues that are examined for the numeric and spatial factors*

The students took four tests, two for each group mentioned in table 2; that is to say, they conducted the next tests: i) numerical problems (NP), ii) numerical reasoning (NR), iii) reasoning with figures (RF), and, finally, iv) spatial turns (ST).

3.2. Examples of tests

An example of question of each type of test is indicated below:

- NUMERICAL FACTORS:

a) Numerical problems: they measure the speed of calculation and arithmetic skills in solving numericalverbal problems (not with pictures or graphs).

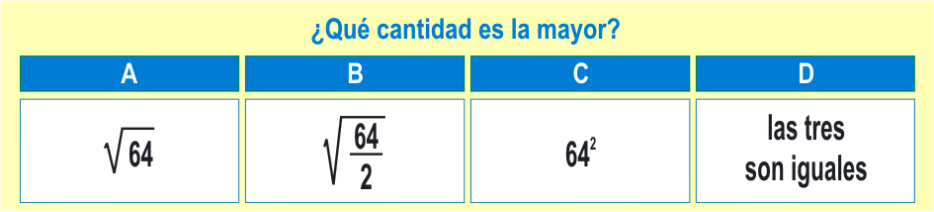

***Figure 1**: Example of question for numerical problems*

b) Numerical reasoning: they measure the aptitude to determine logical regularities or implications in a sequence of numbers.

***Figure 2**: Example of question for numerical reasoning*

- SPATIAL FACTORS:

c) Reasoning with figures: they measure the ability to discover the logic with which series of geometric pictures are organized.

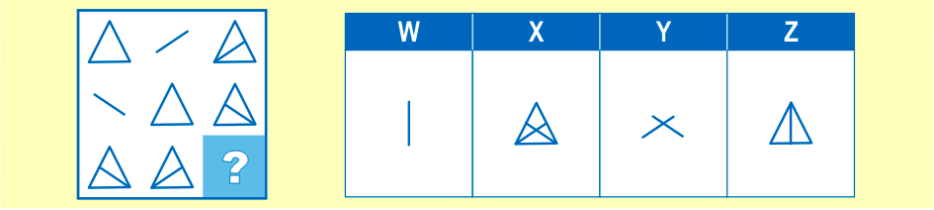

***Figure 3**: Example of question for reasoning with figures*

d) Spatial turns: they measure the ability to determine the equality of figures performing some turns to them, or completing a surface which has been removed.

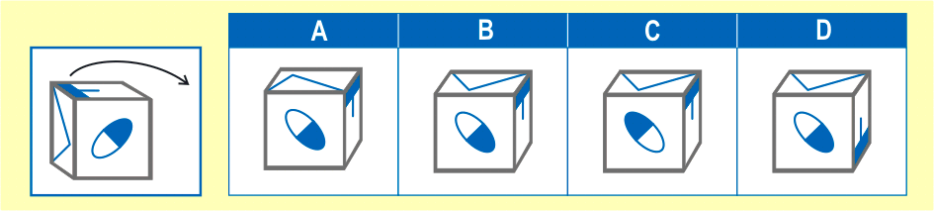

***Figure 4**: Example of question for spatial turns*

Each test consisted of thirty questions. The score for each question was a point if they are correct and not rated for incorrect answer. Thus, the assessment of each test is about thirty points. Therefore, it follows that the maximum score that a student can get is thirty points.

4. Interpretation and analysis of the results

4.1 Analysis of results from our students

First, we carry out a comparative analysis of the results in the groups A and B. To perform this analysis, we use the table of results directly coming from the tests that the students conducted.

Table 3 shows the results of each test performed by the student. Basically, it summarizes the average and standard deviation of each group and for each type of test (Walpole et al., 2007).

Second course of SS	NR (0/30)	NP (0/30)	ST (0/30)	RF (0/30)
Mean value. Group A	15,90	17,45	16,87	20,97
Mean value. Group B	16,21	17,00	16,71	22,04
Standard deviation. Group A	4,50	4,32	4,12	4,39
Standard deviation. Group B	4,65	4,22	4,56	4,65
Group A				
Percentil 10	10,00	12,00	13,00	15,00
Percentil 90	21,00	22,00	22,00	26,00
Group B				
Percentil 10	9,70	11,70	11,00	16,70
Percentil 90	21,40	22,40	21,80	27,40

***Table 3**: Statistics of the results for Group A and B. Mean, standard deviation, and percentile values. NR, NP, ST and RF are: numerical reasoning, numerical problems, spatial turns, and reasoning with figures respectively*

The average or mean value, which comes from adding all the values and dividing by the number of elements (students in our case), indicates a value of reference in terms of middle class. We must stress that the maximum score is thirty, hence, an average value of about fifteen reflects that there must be students in that class who are below and above fifteen points. The most worrying cases are those who are below the average value, which means that their skills should be improved.

The standard deviation measures the variation data in absolute terms. It is defined as the average distance of the data to the arithmetic mean.

In general, the percentiles can be defined as follows: the 100kth percentile is a data value such that approximately 100k% of the observations are at or below this value and approximately 100(1-k) % of them are above it. When calculating the 90th percentile of our sample, we get the value such that the 90% of the students' marks are below the value that we provide. It allows us to obtain additional information about the results of the students. In table 3, we have shown the 10 and 90 % percentiles because they are very representative of the data and can provide us with relevant information for our analysis. In particular, the 10% percentile (for Numerical Reasoning) gives us an idea that there are students with scores really low, below 10 points; the 90% percentile also shows that there students who excel the rest, with higher values (above 21 points for the four factors expressed in table 3). The latter values are much closer to the maximum score of 30 points in each of these tests.

Making a graphical comparison of results between the two groups, we obtain figure 5.

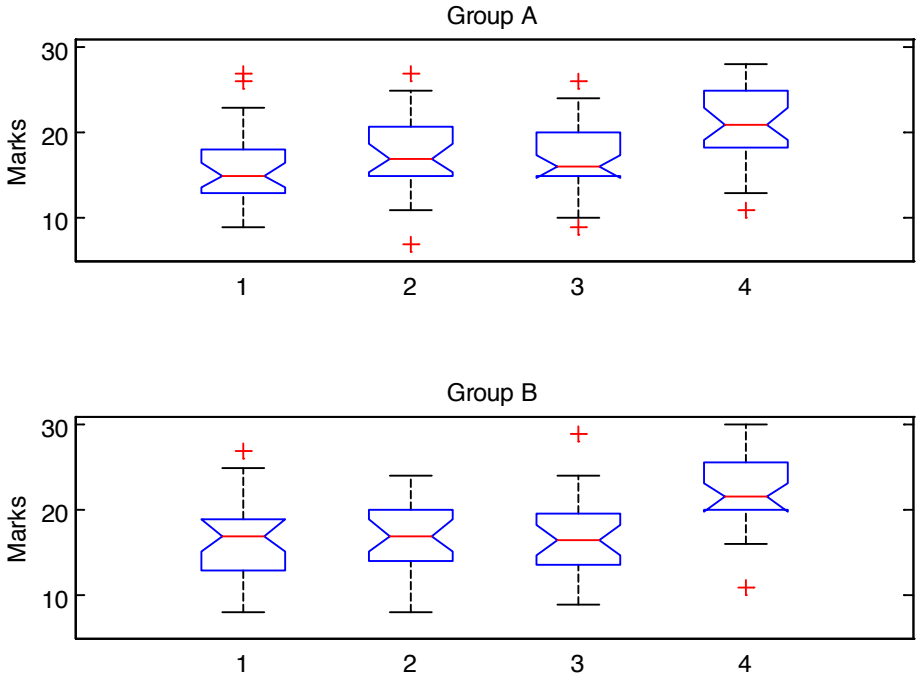

***Figure 5**: Box-plot with the results for the two groups under study. (1) Numerical reasoning, (2) Numerical problems (3) Spatial turns, (4) Reasoning with figures*

In the 'box-plot' graph, figure 5, the median value is the central mark, the 25th and 75th percentiles are corresponded with the edges of the box. In the same way, the whiskers extend to the most extreme data points not considered outliers, and the outliers are plotted individually.

- **Results for the spatial factors (SF), related to (3) y (4) in figure 5**

The results obtained in the test for 'Reasoning with Figures' clearly are outstanding if we compare them with the other kind of tests. The average of the two groups is above 20, and, in the case of group B, it becomes above 22 points out of 30, which is a very positive result.

However it contrasts with the low result obtained in the test of 'Spatial Turns', where in both cases, the average value is below 17 points (see also table 3). Although both concepts refer to the Space Factors, the difference between the two tests is that whereas in the RF test we work in two dimensions, i.e. in the plane; in the ST test we work in three dimensions. Hence, this justifies that the results can be so different in one type of test or another.

Consequently, it is interesting to note that the result in ST is much lower than in RF, the latter being a very positive result; therefore their aptitudes concerning RF are really excellent (as we also discuss in next sections in this paper).

If we try to analyze the results coming from the percentiles, we draw similar conclusions; in RF tests, the 90% (P10) of the class, in both cases, is above 15 points. We must stress that in group B, this value is 16.7 (slightly higher than for group A), this result probably means that group B, at some point, may have had greater stimulation in this regard.

We also want to highlight a positive aspect regarding RF: in group B, there are 10% of students who get more than 27.4 points out of 30 score.

By contrast, in the case of ST, 50% of the students for both groups have obtained scores below 17 points. And only 10% approximately of the students have a value greater than 22 points out of 30.

• **Results for the numerical factors (NF), related to (1) and (2) in figure 5**

In this case both classes are pretty equal, without showing big changes between both groups. In the Numerical Reasoning tests, the results, roughly speaking, are lower than the results for ST and RF tests, that is to say, lower than the two tests linked to Spatial Factors.

The mean value for Group A is 15.9 points out of 30. 10% of the class has achieved results below 10 points out of 30. Only 10% of the students scored more than 21 points. In the case of Group B, the mean value is a little better, 16.21 points. 10% of the students is scoring less than 9.7 points, which is really worrying, although the mean value is acceptable. Comparing the results of the Numerical Problems tests, we see that except some minor differences, both groups are evenly matched. The mean values, for both groups, are above 17 points, exceeding the group A to group B at half point. Standard deviations are very similar, not reflecting large asymmetries in the composition of classes.

If we analyze figure 5, and we try to distinguish between SF and NF as groups of two components (adding, on the one hand, RF and ST, and, on the other hand, NR and NP) we can guess that, roughly speaking, mean value for SF is above the NF's, mainly due to the large contribution that RF makes on SF. It is simply a consequence of the aforementioned figure.

• **SEN students (Special Education Needs)**

Taking into account the high incidence of students with ADD, it is mandatory to carry out an analysis, albeit brief, of the results coming from these kinds of students. However, we recognize that due to the complexity of these cases, in case we wanted to propose some educational modifications, it would probably be necessary, and more suitable to perform individualized studies of each student.

	NR (0/30)	NP (0/30)	ST (0/30)	RF (0/30)
Mean values. SEN students	13,86	16,43	16,00	20,86
Mean values. ADD plus dyslexia students	12,50	9,50	12,00	14,50

***Table 4**: Mean values obtained for SEN students (distinguishing between SEN and ADD plus dyslexia). NR, NP, ST and RF are: numerical reasoning, numerical problems, spatial turns, and reasoning with figures respectively.*

Table 4 shows the mean values for the different tests under study and having selected exclusively ADD or SEN students. Although the number of students with these characteristics is not very large, they form the 12 % of the students, so it is appropriated to refer to them and formulate some considerations concerning the results of the tests.

We have differentiated between the average or mean values for SEN students (in which we encompass all the pathologies) and the students with ADD and dyslexia (being the latter a specific case of study due to the relevance of the attention deficit when learning and understanding new concepts).

As we might expect, the results for this group of SEN students (see table 4) are below the counterparts for the overall students considered in table 3. We obtain lower values for the four type of tests, however, it is particularly striking for NR test, where the average value is more than two points below the average of the overall course, and the score fails at 14 points (13.86), being below the 15 points which would mean an acceptable mark. In the rest of the aspects evaluated (NP, RF and ST tests), the performances are below the global class, but the differences are not as noticeable as in NR.

However, the results of the students who have ADDs + Dyslexia force us to reflect on the great difficulties that these kinds of students have for learning mathematics. As we can see in table 4 all results are well below the average for the global class, and none of the factors discussed reaches 15 points. Nevertheless, the RF factor is still the highest value of the four factors discussed but, even so, it does not reach 15 points. The result obtained in NP is really poor, below 10 points.

It seems clear that for SEN students (considering the whole range of special needs), learning mathematics is a very difficult challenge and it would be necessary to adopt new measures, concerning the educational programs, which allow them to work with mathematics at an affordable level for them; thus they could make progress and, at the same time, they would enhance their motivation for mathematics. Some tools that we describe in Section 7 give us some possibilities to improve these skills for this group of people.

4.2. Comparison of results with statistics from a prestigious organism

The ICCE Institute has made this kind of tests in many schools of different characteristics, including public, private and charter schools in Spain, from different regions and with different socio-economic levels. This allows it to have a large database from which we can calculate averaged referenced levels that are useful to perform comparisons, as we do in this section.

		Institute database	Our course	Group A	Group B
NR (0-30 points)	Number of students	2796	59	31	28
	Mean value	16,73	16,05	15,9	16,21
	Standard deviation	5,68	4,54	4,5	4,65
NP (0-30 points)	Number of students	2795	59	31	28
	Mean value	16,76	17,24	17,45	17
	Standard deviation	5,06	4,24	4,32	4,22
RF (0-30 points)	Number of students	2799	59	31	28
	Mean value	20,49	21,47	20,97	22,04
	Standard deviation	4,96	4,5	4,39	4,65
ST (0-30 points)	Number of students	2797	59	31	28
	Mean value	17,24	16,8	16,87	16,71
	Standard deviation	4,88	4,3	4,12	4,56

***Table 5**: Main statistics of the groups under study and the validation group (from the Institute of reference). NR, NP, ST and RF are: numerical reasoning, numerical problems, spatial turns, and reasoning with figures respectively*

Table 5 shows the mean and standard deviation values for the four factors under study. The maximum mark in each factor is 30 points.

The column 'Institute Database' reflects the total number of students from the reference sample (which we name the 'validation group') and the other two columns allude to our group A and B; the statistics we calculate are the mean and standard deviation values. The comparison with the average national reference allows us to compare the results, and to highlight the elements on which an improvement plan will be proposed.

In table 5, we have highlighted in bold the values that are below the reference group (or Validation group). On the one hand, the average values obtained for NR test, especially in group A, have a value lower than the counterpart for the Validation group in more than half a point. The difference, between 'Our course' (arithmetic mean of the two groups, A y B) and the Validation group is 0.68 points out of a possible 30, which means a 2.3 % lower than the national average.

The average obtained from the ST tests is also below the average of the reference, especially in group B. In general, when comparing our course with the national reference sample (or Validation group) we obtain a difference of 0.44 points out of a possible 30, which results in 1.5% below the national average.

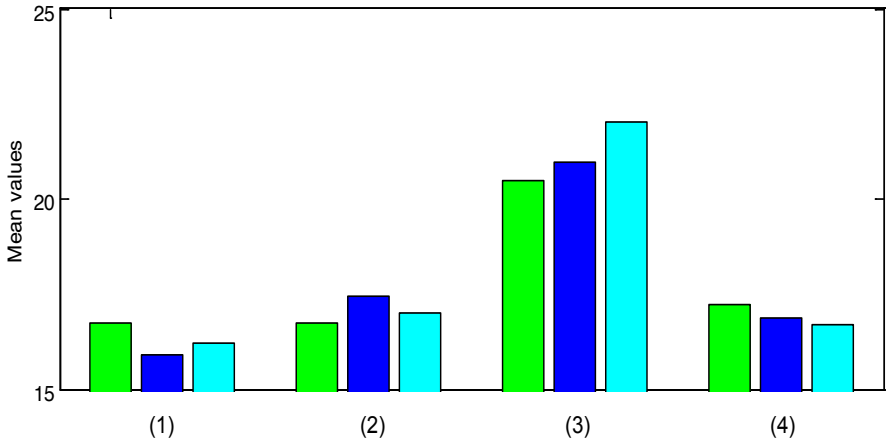

***Figure 6**: Mean values for: (1) NR, (2) NP, (3) RF, and (4) ST. Group A in blue, Group B in cyan, and Validation group in green. NR, NP, RF and ST are: numerical reasoning, numerical problems, reasoning with figures, and spatial turns respectively*

Figure 6 shows the different mean values for the different tests, plotting the results for groups A, B and the Validation group. It is a visual form to represent the mean values of the table 5, being a more visual form.

It should be noted that the good results achieved in RF tests (related to 2D shapes) are reflected in table 5 as well, since both classes are above the average of reference in this factor. It is interesting to stress that, although the reference mean was obtained with data coming from mixed classes (male and female students), and from schools with different characteristics, it does not seem that our results are below the corresponding results for mixed classes.

5. Discussion and use of Information and Communication Technologies (ICTs) and e-learning for an improvement plan for visualization

We provide the reader with possible actions which involve an improvement in the learning of mathematics.

5.1 Theoretical context about visualization

It is necessary to highlight and promote the use of Geometry from a practical and intuitive point of view.

We must note that the test results of RF tests, in which operations are conducted in 2D, (Clements and Battista 1992) were very positive, therefore it seems necessary to focus on the development of 3D spatial reasoning (Lackovic et al. 2015).

Some experts argue that we must learn to use creative visualization as a tool for understanding.

Mathematical visualization is the process of forming mental images, (Torres and Climent 2010), with pencil and paper or with the aid of technology, and using such images to discover and understand the mathematical concepts. Others try to find out the level of understanding of students about building 3D models, as a visual strategy, used in the process of solving problems. Then, it is necessary to highlight and promote the use of Geometry from a practical and intuitive point of view (Kaput 1987; Tartre 1990).

Nowadays, the evolution experienced by the software offers us new ways of teaching, learning and working with mathematics, providing us with lots of learning opportunities (Guedez Maryianela 2005). We have also to highlight the potential of ICTs both to achieve the interaction of students with learning situations (allowing them to build 'knowledge'), and to have a broader vision of mathematical contents (letting students go further when dealing with new contents).

The computer-tools allow teachers to make use of a more constructivist methodology to work with in math classes, promoting an active and creative participation of the student (Albalooshi and Alkhalifa 2002; Cuicas Avila et al. 2007).

Thanks to the potential uses of the software, we can get a more active, a more personal, and sometimes also a group communication with students, where each student can evolve according to their cognitive abilities, and the results of these activities can also be used as a part of the examination process. There is no point using a software that has nothing to do with the curriculum of the subject under study, so it is very important to carry out a good selection.

5.2 Contents related to the visualization. An example of progressive methodology to be used

Improving spatial visualization in 3D is determined in part by the knowledge of plane geometry (Clements and Battista 1992). Therefore, in these educational stages, firstly, it should be reviewed the plane geometry contents (2D), whose knowledge will be needed to perform operations in 3D. Secondly, and little by little, contents in 3D will be introduced. Consequently, we can distinguish two steps:

- **Step 1) Introduce concepts related to plane geometry**

1. Reference elements in the spatial location:
    - Cartesian coordinate system (numeric or alphanumeric)
    - Conventional system of orientation by the cardinal points.
    - Geographical coordinates: Latitude and Longitude. Axis system of geographical coordinates.

- Polar coordinate system.

2. About proportions. Reference element about the size of objects when passing from the real world to a representation of them.
   - Measures length.
   - Numerical scale.
   - Graphic scale.
3. Models of representation of reality: plans and sketches
   - Interpretation of drawings and maps.
   - Representation in 2D of an environment
   - Plants and elevations of an object.
   - Sections.

• **Step 2) Introduce concepts related to spatial geometry**. These activities are intended to be able to perform mental or physical operations that allow the students to understand and interpret visual models. At the same time they must be able to represent a visual image from the in symbolic information received.

The introduction to the spatial geometry (in 3D) must be made easily, starting with the construction of polyhedra in cardboard or paper. Later, we can enter more complex objects and work with models or modeling figures.

1. Introduction to the dihedral system.
2. Study of plans and elevations.
3. Making plans and construction of polyhedral figures on paper.
4. Making axonometric perspectives.
5. Introduction to representing conic projection.
6. Making models in different materials.
7. Modeling figures.

6. Conclusions

This paper has shown that it is necessary to use the appropriate academic tools for evaluating the student skills, thus we are able to draw conclusive results that help us to identify the aspects which are more complex, and at the same time, to design new strategies and methods to improve, as far as possible, the understanding process (specially for contents which involve high difficulty and effort).

In particular, we have focused on the study of mathematical problems related to spatial and numerical factors, at Secondary School. We have used standard tests for assessing their skills.

First, the results that we have obtained show that in the case under study, the numerical factor marks (which encompass both the numerical problems, NP, and the numerical reasoning problems, NR) are very close to the reference group values (or Validation group, VG, whose data come from a prestigious national organism); more specifically, our statistics concerning NP are above the average values for VG, and concerning NR, they are somewhat lower than in VG.

We have analyzed two classes, groups A and B. We have also checked that for students with ADD (Attention Deficit Disorder) and dyslexia the results of the tests are worse, and consequently we extract from this that these students have special difficulties to learn mathematical contents. The results obtained by this group of students, with special needs, require a deep reflection on the difficulty for learning mathematical contents, and it demands to teachers an ongoing effort to adopt measures to facilitate the learning process and thus being easier achieving goals.

Second, concerning the spatial factor marks (which encompass both the Reasoning with Figures, RF, and the Spatial Turns, ST), we highlight the positive results we have obtained by our classes in RF tests which indicate a good development of spatial ability in two dimensions (2D). They are really positive marks whether we evaluate them with the highest possible score (30 points), or we compare them with the values from the reference sample, VG, being the results of our students above the average for the validation group. It is also true that, among the results from the VG, the highest score for students (at national level) is obtained precisely in RF, so we are in line with the national statistics.

However, it seems important to note that against these positive data, the results obtained in ST tests are low and are below the national reference values. This indicates that the spatial ability of the students is rightly developed in 2D operations, while three-dimensional (3D) visualization must be clearly improved.

In comparison with the national statistics (our Validation group), it shows that it is a widespread problem, and the marks for ST are typically lower than for RF tests.

In general we could draw a deficit about contents related to the spatial geometry in academic curricula; hence it should be recommendable to assess the possibility to increase them. We suggest starting with theoretical contents about visualization and little by little increasing the difficulty of them, first studying plane geometry (in 2 Dimensions) and then studying spatial geometry (3 Dimensions).

Acknowledgment

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Mechanical and Electrical Engineering

Introduction to soft matter

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Abstract

The Soft Matter belongs to a material class that has a complex mechanical and thermodynamics behavior. It does not belong to the conventional fluid or solids category, for instance, polymers, colloids, surfactants and liquid crystals. The behavioral investigation of those materials is very important, since they have been used in several areas, such as, in industrial technology, in medicine, in biomechanics, in microelectronics and even in our day by day lives. For this reason, this work aims to give an introductory viewpoint of those materials and specifically do a research on a polymer called Ionic Polymer Metal Composite (IPMC). The IPMC is an electroactive polymer saturated with an electrolytic solvent and composed of two surfaces of metallic electrodes. This work is part of a doctorate thesis that is still in progress. Its methodology will be the development of a theoretical mathematical model by the use of formal continuum mechanics, which shows the IPMC behavior under the effect of electricity, chemistry and mechanics.

Keywords: ***Soft matter, electroactive polymer, IPMC, continuum mechanics.***

Introduction

The macro area of this paper is to introduce materials called Soft Matter, which belong to a material class that have a complex mechanical and thermodynamics behavior, and thus they cannot be classified into the conventional fluid or solid category. Some examples of those materials are polymers, colloids, surface activating agents (surfactants) and liquid crystals (DOI, 2013).

Studying the behavioral investigation of those materials is very important, since they have been used in several areas, such as, in automobile, aeronautics and naval industries, with the replacement of conventional materials by polymers and polymeric gels; in medicine and biomechanics, with artificial muscles and prosthesis; in dispersion technology, with colloids and surfactant; in computing, in telephony and in optical devices, with liquid crystals screens; in electronics, with the microelectromechanical systems (MEMS), with the cell phones chips and the cantilever (DOI, 2013).

For the electroactive polymer, there is an Ionic Polymer-Metal Composite (IPMC) that can be considered a smart material. The IPMC consists of an ionic polymer sandwich and the most common ones are nafion or teflon, covered with metallic electrodes, usually platinum or gold. The polymer is saturated with an electrolytic solvent in a way that a difference in the electric tension between the electrodes causes a deformation in its structure, that is, it works as an actuator (SHAHINPOOR, 2013). (SHAHINPOOR, 2013)

Nowadays, there have been a lot of studies investigating the behavior of IPMC and to enlarge its applications. JO et. al. (2013), analysed recent progresses of IPMC and they have given a general view of several kinds of ionic polymer membranes, besides doing a controlling project for practical applications. Another research concerning electroactive polymer was done by WALLMERSPERGER et al. (2004), in which they studied an increase of polymeric gels volume when it suffers an electrical stimulation and is inserted into a chemical solution. This phenomenon can be seen in the contraction and relaxation of electrical-chemical-mechanical actuator or in artificial muscles.

In another study, NARDINOCCHI et al. (2011) observed the behavior of IPMC for small deformations when it suffered electrical and chemical stimulations. The methodology used was a mathematical model with electrical, chemical and mechanical terms.

Thus, this work aims to show the macro area of Soft Matter material and specifically do a research on IPMC.

1. Soft Matter

The Soft Matter belongs to a material class that has a complex mechanical and thermodynamics behavior. It does not belong to the conventional fluid (Thermoscience) or solids (Solid Mechanics) categories. It is not a unique type, but a material

class with a great variety such as polymers, colloids, surfactants, liquid crystals and so on. This material class is presented in simple and complex situations in everyday life. In daily life, it is used plastic, rubber, textiles, optical devices, laptops, cell phones, etc. In industrial areas, in biomechanics, in medicine, there are the actuators, the prosthesis and the artificial muscles (DOI, 2013), (SHAHINPOOR, 2013).

Polymers

The polymers (poly = many, mers = parts) are formed by a sequence of long chain molecules, known as macromolecules (macro = big / large) composed of millions and even dozens of millions of individual elements called monomers (mono = one). In that macromolecule the monomers are ordered one after the other (MICHAELI et al., 1992). Picture 1 shows a monomer and a polymer.

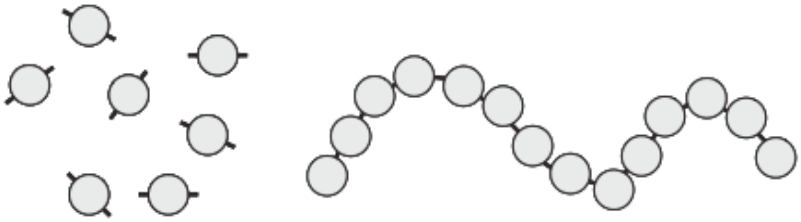

Figure 1 *– (a) monomer and (b) polymer (Source: DOI, 2013).*

The polymers are present in people's routine and in modern technology. The qualities of that material are so varied that they can often replace traditional engineering materials, for instance metal and wood (DOI, 2013).

Depending on the chemical structure of monomers, the polymeric materials can be soft or hard. The polymers may be divided into three big groups: the thermoplastic, the thermosets and the elastomers (MICHAELI et al., 1992).

In figure 2, it can be seen several examples of polymers in day by day life.

Figure 2*: Day by day products made by polymers*

Colloids

The colloids are small solid particles or droplets of liquid scattered into other kinds of fluids. The diameter of a colloidal particle is very small, measuring between 1nm to 1μm. The colloids are part of daily life, for instance in colored water which is a colloidal solution of solid particles known as pigments scattered into water (DOI, 2013). There are other examples of colloids in everyday life: in hygiene products (soap, shampoo, toothpaste, shaving cream, etc.), in nutrition (milk, butter, gelatin, just to name a few). Another example is the addition of vinegar to milk. The milk becomes viscous and has its fluidity reduced (DOI, 2013). In figure 3, there are materials that use colloids.

***Figure 3**: Examples of colloids in everyday life products.*

Surfactants

They are materials which can be dissolved in oil and cannot usually be dissolved in water. However, the Surface Activating Agents (surfactants) can be dissolved in water and in oil (DOI, 2013).

(a) (b)

***Figure 4**: Surfactants: (a) hydrophilic part and (b) oleophilic part.*

The micelles' forms can be: spherical, cylindrical or lamellar. The spherical micelles can have dozens of molecules, the cylindrical and lamellar micelles can have millions or even billions of molecules (DOI, 2013).

Liquid Crystals

The condensed states of matter are usually classified as crystalline (ordered molecules) or liquid (disordered molecules). The Liquid Crystals are materials

which have states of matter between solid and liquid, that is, a semi-disordered state. These materials have characteristics of both solid and liquid states (DOI, 2013). The liquid crystals are present in day by day life, such as in displays, screens, notebooks, cellphones, among others (figure 5).

***Figure 5**: The liquid crystals products in day by day life.*

What do those materials have in common?

The molecules of polymers have millions of atoms and the colloids' particles also have billions of atoms, whereas the molecules of surfactants and liquid crystals are not as big as the ones of polymers and colloids. However, they form an ordered structure and can move in groups as if they were a unit: the micelles (DOI, 2013).

The fact that Soft Matter is consisted of a group of molecules that move, it gives two important characteristics to that material (DOI, 2013): (1) Big deformations and non-linear answer and (2) slow answer and a non-dynamic equilibrium.

The active polymers

An active polymer is a system which acts through electro, pH, temperature, chemical, and mechanical stimulations, etc. In other words, the polymer changes form, deforms and works as an actuator.

The polymers that change forms as a consequence of electricity can be classified into two groups, and each one has advantages and disadvantages over the other, as it can be seen in the table 1 below:

Electronics	Ionic bond
Dielectric	Ionic polymer gels (IPG)
Graphene Elastomers	Ionic Polymer Metal Composite (IPMC)
Viscoelastic Elastomers	Conductive polymer (CP)
Ferroelectric Polymers	Carbon Nanotubes (CNT)
Liquid Crystals Elastomer	Solid Polymer Electrolyte (SPE)

***Table 1**: Active polymers.*

The electroactive polymers are stimulated to work by an electric field. They need high voltage compared to ionic electroactive polymers, but on the other hand they can react quickly and generate considerable mechanical forces. They do not need a protection cover and need a very low electric current to be in certain position.

The ionic electroactive polymers work based on electrochemistry and on the mobility or diffusion of charged ions. They can work directly turned on electric batteries once the material already has some deformation. The ionic electroactive polymers need to be in water.

2. IPMC

This work deals with the Ionic Polymer Metal Composite (IPMC) which can also be classified as a Smart Material (SHAHINPOOR, 2013). The IPMC is a polymer metal composite that consists of a hydrated ionomeric membrane that is sandwiched between noble metal electrodes.

The most common standard IPMC found in the market is made of nafion or teflon to be used in the polymer and is covered with metallic electrodes, usually platinum or gold. During the manufacturing process of IPMC, the electrodes need to be adhered to the surface between the metal and the polymer so that the electrochemistry can occur and the electrode electrical resistance can be minimized and, thus, do not lose adhesion to the surface when wet. Some of the IPMC characteristics are softness and flexibility, and it is activated by an electric field of low magnitude (Shahinpoor, 2013).

Some applications using the IPMC can be seen in several situations, such as artificial muscles, robot actuators, robotic arms, prosthesis, robots moving inside an aquarium (artificial fish and others which use the IPMC deformation as propulsion), biological robots and even micro motors made of polymers (propane fuel burn in chamber). A few of these examples are shown in figure 6 below.

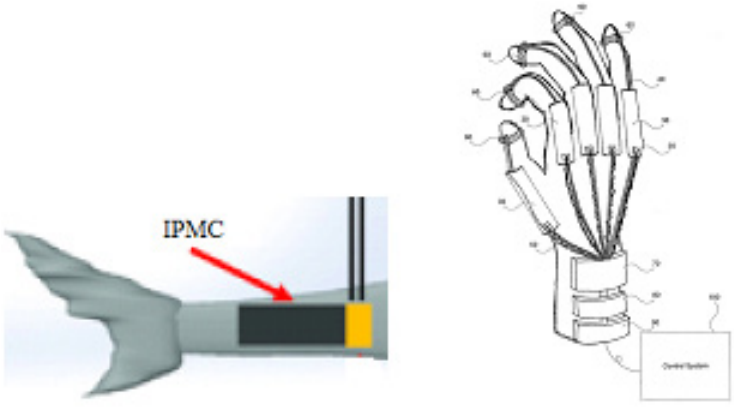

Figure 6 *– Some examples of applications using IPMC.*

The IPMC operation consists of ions movements divided into cations (positive and mobile charge) and anions (negative and fixed charges). When an electric field is applied to IPMC and it is wet, the free cations move inside the permeable polymer together with the water molecules. In figure 7, the IPMC operation is represented when an electric tension is applied to it.

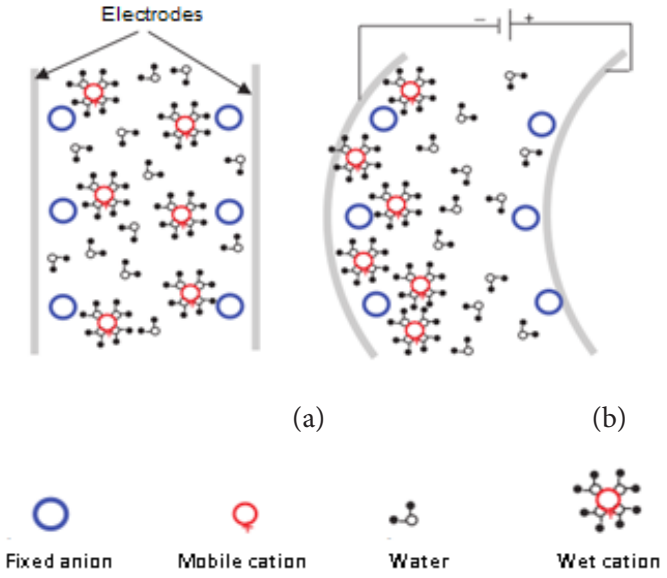

***Figure 7**: IPMC operation when applied an electric field. (a) before the electric field and (b) after the electric field and water (Source: Shahinpoor, 2013).*

3. Conclusion

The aim of this paper was to present an introduction view of the Soft Matter materials and also of the electroactive polymer called IPMC. This paper is part of a study of a doctorate thesis which is in progress. The current stage of that study is in the IPMC mathematical modeling.

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The resonance phenomenon: condition, consequences, practical applications

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Abstract

The resonance phenomenon may often occur in the reactive circuites that contain both inductors and capacitors and may have harmful consequences.

For this reason, in order to avoid the unwanted effects, the user should understand very well the behavior of the reactive circuits under sinusoidal steady state and the resonance phenomenon (condition and consequences).

This paper presents an analysis of one of the simplest circuits in which the resonance may occur (the RLC series circuit), under sinusoidal steady state, the resonance condition and its consequences.

There are also briefly described two LabView applications used in the analysis of the RLC series circuits under sinusoidal steady state in order to avoid the harmfull effects. On the other hand, the article enumerates and presents some useful applications of the resonance phenomenon.

Keywords: ***sinusoidal steady state, resonance phenomenon, resonance condition, resonance consequences, applications of the resonance phenomenon***

1. The RLC series circuit in sinusoidal steady state

1.1. The current

Let us consider the circuit shown in figure 1, consisting of a resistor having the resistance *R*, an inductor of inductance *L* and a capacitor of capacitance *C*, connected in series (*RLC* series circuit) and supplied from a source of sinusoidal voltage with the pulsatance ω (it is assumed that the resistance *R* includes the own resistances of the inductor and capacitor).

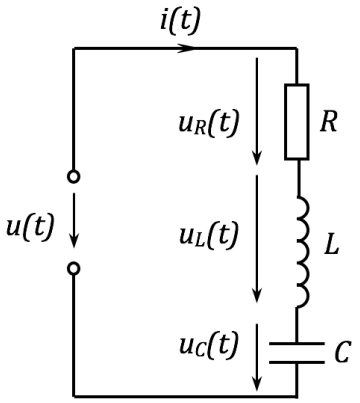

***Figure 1**: RLC series*

If the circuit is linear (all its components are linear – for a sinusoidal current the voltage will be also sinusoidal and viceversa), considering a property of the linear circuits, if the suplying voltage is sinusoidal

$$u(t) = U_{max}\ \sin(\omega t + \gamma_u) = \sqrt{2}U \sin(\omega t + \gamma_u) \quad (1)$$

the circuit (and, of course, each of its components in part) will be crossed by a sinusoidal current,

$$i(t) = I_{max}\ \sin(\omega t + \gamma_i) = \sqrt{2}I \sin(\omega t + \gamma_i) \quad (2)$$

where, in the expressions (1) and (2):

- *u(t)* and *i(t)* are the instantaneous values for the two electrical signals (the suppying voltage and current);
- $U_{max} = \sqrt{2}U$ and $I_{max} = \sqrt{2}I$ are the voltage/current amplitudes (their maximum values), with *U* and *I* their r.m.s. (root mean square) values;
- $\omega = 2\pi f$ (with f – frequency) is the pulsatance;
- $\omega t + \gamma_u$ and $\omega t + \gamma_i$ are called phases (the voltage phase and the current phase);
- γ_u and γ_i are the initial phases (the voltage phase and respectively the current phase obtained for the initial time $t = 0$).

The sinusoidal current produces the sinusoidal voltages $u_R(t)$, $u_L(t)$, $u_C(t)$ on the three circuit components. These voltages are given by the characteristic equations (functioning equations) for the linear resistor, inductor and capacitor.

$$u_R(t) = R \cdot i(t) \quad (3) \qquad u_L(t) = L \cdot \frac{di(t)}{dt} \quad (4) \qquad u_C(t) = \frac{1}{C}\int i(t)\,dt \quad (5)$$

Based on the Kirchhoff's second theorem (the voltages theorem), at any moment, the applied voltage is equal to the sum of the voltages on the three components.

$$u(t) = u_R(t) + u_L(t) + u_C(t) \quad (6)$$

or, considering the dependence on current for the voltages on each component (the equations (3), (4), (5)), the next integro-derivative equation is obtained:

$$u(t) = R \cdot i(t) + L \cdot \frac{di(t)}{dt} + \frac{1}{C}\int i(t)\,dt \quad (7)$$

*

In the equation (7) we consider the current as unknown and we intend, in the following, to solve this equation to find the sinusoidal current.

Solving the equation (7) is relatively difficult, requiring an uncomfortable computing, so that the equation is solved indirectly through one of the known methods: for example, through the **geometrical representation** or **analytical representation** (with complex sizes/numbers).

In the **geometrical representation**, to each sinusoidal signal (variable)

$$v(t) = V_{max}\sin(\omega t + \gamma_v) = \sqrt{2}V\sin(\omega t + \gamma_v) \quad (8)$$

we can associate a phasor that has the length equal to its r.m.s. value V and the angle with the horizontal reference, considered positive in the trigonometrical direction, equal to its initial phase γ_v (figure 2) and viceversa, to any phasor we can associate a sinusoidal signal that has the r.m.s. value equal to the phasor's length and the initial phase equal to the angle between the phasor and the horizontal reference, considered positive in the trigonometrical direction.

$$v(t) = \sqrt{2}V\sin(\omega t + \gamma_v) \quad \leftrightarrow \quad \vec{V} = V\langle\gamma_v \quad (9)$$

In the **analytical representation**, to each sinusoidal signal (size)

$$v(t) = V_{max}\sin(\omega t + \gamma_v) = \sqrt{2}V\sin(\omega t + \gamma_v)$$

we can associate a complex number, that is a point drawn in the complex/imaginary plan, of which position is given by a positioning phasor that has the length equal to the r.m.s. value V and the angle with the horizontal/real axis, considered positive in the trigonometrical direction, equal to the initial phase γ_v (figure 3) and viceversa (to any complex number, represented in the complex/imaginary plan by a positioning phasor, we can associate a sinusoidal signal that has the r.m.s. value equal to the phasor's length and the initial phase equal to the angle between the phasor and the horizontal/real axis, considered positive in the trigonometrical direction).

$$v(t) = \sqrt{2}V\sin(\omega t + \gamma_v) \;\leftrightarrow\; \underline{V} = \underbrace{V \cdot \underbrace{e^{j\gamma_v}}_{\cos\gamma_v + j\sin\gamma_v}}_{\text{exponential writing of } \underline{V}} = \square$$

$$= \underbrace{V(\cos\gamma_v + j\sin\gamma_v)}_{\text{trigonometrical writting of } \underline{V}} = \underbrace{\underbrace{V\cos\gamma_v}_{=\mathrm{Re}(\underline{V})}}_{\text{real part of } \underline{V}} + j\underbrace{\underbrace{V\sin\gamma_v}_{=\mathrm{Im}(\underline{V})}}_{\text{imaginary part of } \underline{V}} = \underbrace{\mathrm{Re}(\underline{V})}_{=a} + j\underbrace{\mathrm{Im}(\underline{V})}_{=b} = \square$$

$$= a + jb \qquad (10)$$

where j is the imaginary unit with the property (we used this notation, and not i used in mathematics, to avoid the confusion with the current *i*):

$$j^2 = -1 \quad \text{and} \quad \frac{1}{j} = -j$$

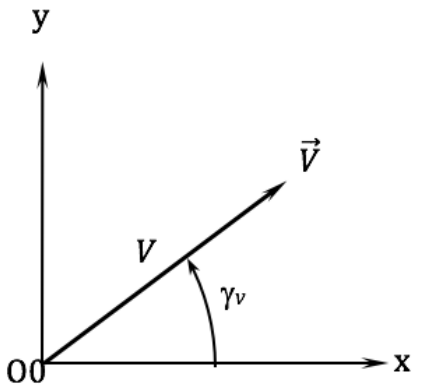

***Figure 2**: Geometrical representation of a sinusoidal variable*

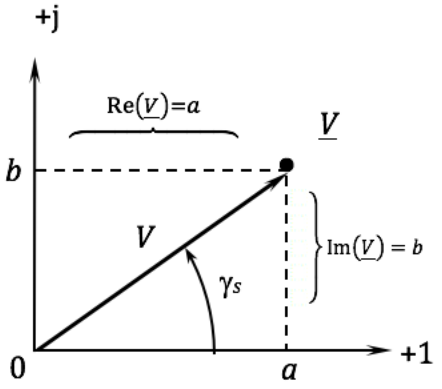

***Figure 3**: Analytical representation of a sinusoidal variable*

*

Replacing the expression (2) of the current, the equation (7) becomes:

$$u(t) = \sqrt{2}RI\sin(\omega t + \gamma_i) + \sqrt{2}\omega LI\sin\left(\omega t + \gamma_i + \frac{\pi}{2}\right) + \sqrt{2}\frac{I}{\omega C}\sin\left(\omega t + \gamma_i - \frac{\pi}{2}\right) \quad (11)$$

The corresponding phasorial equation is:

$$\vec{U} = \vec{U}_R + \vec{U}_L + \vec{U}_C \quad (12)$$

where the phasors representing the voltages on the circuit components are written as:

$$\vec{U}_R = RI\langle 0 \quad (13) \qquad \vec{U}_L = \omega LI\left\langle +\frac{\pi}{2} \quad (14) \qquad \vec{U}_C = \frac{I}{\omega C}\left\langle -\frac{\pi}{2} \quad (15)\right.\right.$$

For **geometrical solving**, the unknown sinusoidal current is considered as phase origin (because it is common to the three circuit elements) and its corresponding phasor will be drawn horizontally.

The phasor diagram is shown in figure 4.

- if $\omega L > \frac{1}{\omega C}$ – the inductive reactance is preponderant ($X_L > |X_C|$) – the

phase shift between the voltage across the circuit and the current is positive $\varphi > 0$ (the current is shifted with φ radians after the voltage), the circuit having an inductive nature/behaviour (figure 4.a);

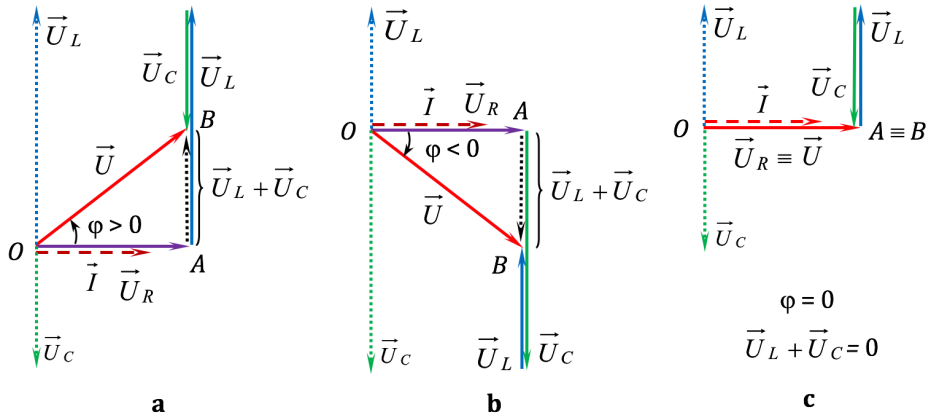

Figure 4: Phasor diagram

- if $\omega L < \frac{1}{\omega C}$ – the capacitive reactance is preponderant ($X_L < |X_C|$) – the

phase shift between the voltage across the circuit and the current is negative $\varphi < 0$ (the current is shifted with φ radians before the voltage), the circuit having a capacitive nature/behaviour (figure 4.b);

- if $\omega L = \frac{1}{\omega C}$ – the inductive reactance and the absolute value of the capacitive reactance are equal $\left(X_L = |X_C|, \text{where } X_C = -\frac{1}{\omega C} \text{ is the capacitive reactance}\right)$

– the phase shift between the voltage across the circuit and the current is null $\varphi = 0$ (the current is in phase with the voltage), the circuit having a resistive nature/behaviour (figure 4.c).

Therefore, the angle φ may be positive or negative as the inductive reactance is greater than or less than the capacitive reactance.

From the *OAB* triangle follows that:

$$U = \sqrt{U_R^2 + (U_L - U_C)^2} = \sqrt{(R \cdot I)^2 + \left(\omega L \cdot I - \frac{1}{\omega C} \cdot I\right)^2} =$$

$$= \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} \cdot I = \sqrt{R^2 + (X_L + X_C)^2} \cdot I = \sqrt{R^2 + X^2} \cdot I = Z \cdot I \quad (16)$$

where Z is the circuit's **impedance**, that can be written using one of the following expresions:

$$Z = \sqrt{R^2 + X^2} = \sqrt{R^2 + (X_L + X_C)^2} = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} \quad (17)$$

In the impedance's expression, we denoted as $X = X_L + X_C = \omega L - \frac{1}{\omega C}$ the total (equivalent) reactance of the circuit.

The **r.m.s. current** (egual to the length of the phasor $\bar{I}$ is deduced from the above equations.

$$I = \frac{U}{Z} = \frac{U}{\sqrt{R^2 + X^2}} = \frac{U}{\sqrt{R^2 + (X_L + X_C)^2}} = \frac{U}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}} \quad (18)$$

The equation (18) is the Ohm's theorem in alternative current written for an *RLC* series circuit.

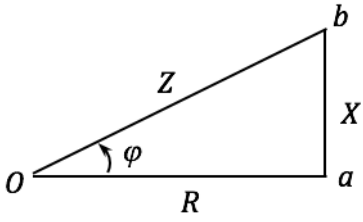

***Figure 5**: The impedance triangle*

The phase shift between voltage and current is deduced from the same triangle (ΔOAB), or from the impedance triangle (figure 5) obtained by dividing the sides of the first triangle by the r.m.s. current I (the representation was drawn for the first case of the inductive circuits):

$$\varphi = \operatorname{atan}\frac{X}{R} = \operatorname{atan}\frac{X_L + X_C}{R} = \operatorname{atan}\frac{\omega L - \frac{1}{\omega C}}{R} \quad (19)$$

Therefore, the **initial phase of the current** will be:

(22)

$$\gamma_i = \gamma_u - \varphi = \gamma_u - \operatorname{atan}\frac{X}{R} = \gamma_u - \operatorname{atan}\frac{X_L + X_C}{R} = \gamma_u - \operatorname{atan}\frac{\omega L - \frac{1}{\omega C}}{R} \quad (20)$$

From the equations (18) and (20) and using the rule of phasorial representation we obtain the phasor corresponding to the current:

$$\vec{I} = I\langle\gamma_i = \frac{U}{Z}\langle\gamma_u - \varphi = \frac{U}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}\left\langle\gamma_u - \operatorname{atan}\frac{\omega L - \frac{1}{\omega C}}{R}\right. \quad (21)$$

Therefore, using the rule of inverse representation (phasor to instantaneous value), the instantaneous current will have the expression:

$$i(t) = \sqrt{2}I\sin(\omega t + \gamma_i) = \sqrt{2}\frac{U}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}\sin\left(\omega t + \gamma_u - \operatorname{atan}\frac{\omega L - \frac{1}{\omega C}}{R}\right) \quad (22)$$

The variation curves of the sinusoidal signals $i(t)$ and $u(t)$ are shown in figure 6.

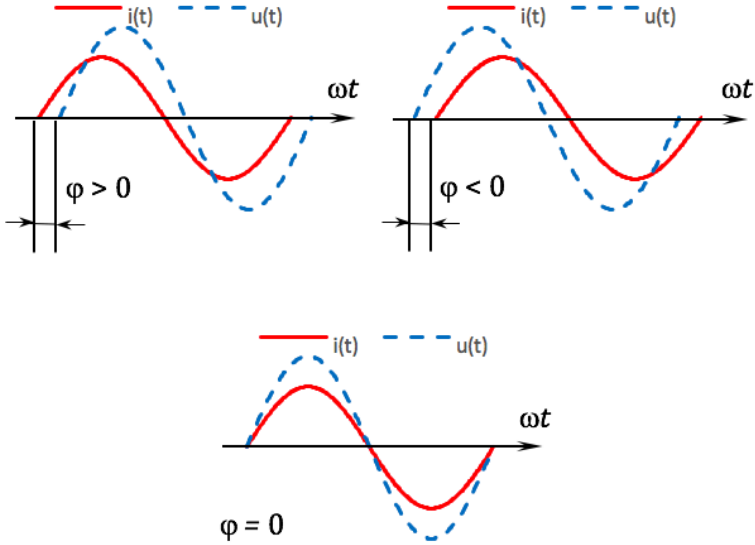

Figure 6: *The variation curves of i(t) and u(t)*

*

Using the **analytical representation**, starting from the equation (11), considering the rule for transforming a sinusoidal size into a complex number (10) and that

$$e^{j\left(\omega t \pm \frac{\pi}{2}\right)} = e^{j\omega t} \cdot e^{\pm j\frac{\pi}{2}} = e^{j\omega t} \cdot \left(\cos\frac{\pi}{2} \pm j \sin\frac{\pi}{2}\right) = e^{j\omega t} \cdot (0 \pm j \cdot 1) = \pm j \cdot e^{j\omega t} \quad (23)$$

we will obtain the **complex supplying voltage**:

$$\underline{U} = R \cdot \underline{I} + j\omega L \cdot \underline{I} + \frac{1}{j\omega C} \cdot \underline{I} = R \cdot \underline{I} + j\omega L \cdot \underline{I} - j\frac{1}{\omega C} \cdot \underline{I} =$$

$$= \left[R + j\left(\omega L - \frac{1}{\omega C}\right)\right] \cdot \underline{I} = [R + j(X_L + X_C)] \cdot \underline{I} = (R + jX) \cdot \underline{I} = \underline{Z} \cdot \underline{I} \quad (24)$$

where

$$\underline{Z} = R + j\left(\omega L - \frac{1}{\omega C}\right) = R + j(X_L + X_C) = R + jX \quad (25)$$

$\underline{Z}$ being called **complex impedance**, written algebraically.

The complex impedance can be written exponentially as:

$$\underline{Z} = |Z| \cdot e^{j \cdot \arg(\underline{Z})} = \sqrt{\mathrm{Im}(\underline{Z})^2 + \mathrm{Re}(\underline{Z})^2} \cdot e^{j \cdot \mathrm{atan}\frac{\mathrm{Im}(\underline{Z})}{\mathrm{Re}(\underline{Z})}} = \sqrt{R^2 + X^2} \cdot e^{j \cdot \mathrm{atan}\frac{X}{R}} =$$

$$= \sqrt{R^2 + (X_L + X_C)^2} \cdot e^{j \cdot \mathrm{atan}\frac{X_L + X_C}{R}} = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} \cdot e^{j \cdot \mathrm{atan}\frac{\omega L - \frac{1}{\omega C}}{R}} = Z \cdot e^{j \cdot \varphi} \quad (26)$$

with the modulus

$$Z = |Z| = \sqrt{\mathrm{Im}(\underline{Z})^2 + \mathrm{Re}(\underline{Z})^2} = \sqrt{R^2 + X^2} = \sqrt{R^2 + (X_L + X_C)^2} = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} \quad (27)$$

and the argument

$$\varphi = \arg(\underline{Z}) = \mathrm{atan}\frac{\mathrm{Im}(\underline{Z})}{\mathrm{Re}(\underline{Z})} = \mathrm{atan}\frac{X}{R} = \mathrm{atan}\frac{X_L + X_C}{R} = \mathrm{atan}\frac{\omega L - \frac{1}{\omega C}}{R} \quad (28)$$

The **complex current** will be:

$$\underline{I} = \frac{\underline{U}}{\underline{Z}} = \frac{U \cdot e^{j\gamma_u}}{Z \cdot e^{j\varphi}} = \frac{U}{Z} \cdot e^{j(\gamma_u - \varphi)} = I \cdot e^{j\gamma_i} \quad (29)$$

where

$$I = \frac{U}{Z} = \frac{U}{\sqrt{R^2 + X^2}} = \frac{U}{\sqrt{R^2 + (X_L + X_C)^2}} = \frac{U}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}} \quad (30)$$

is the **r.m.s. current** and

$$\gamma_i = \gamma_u - \varphi = \gamma_u - \operatorname{atan}\frac{X}{R} = \gamma_u - \operatorname{atan}\frac{X_L + X_C}{R} = \gamma_u - \operatorname{atan}\frac{\omega L - \frac{1}{\omega C}}{R} \quad (31)$$

is the **initial phase of current**.

The rule of transforming the complex current into instantaneous current is, in this case:

$i(t) = \mathrm{Im}(\sqrt{2}\, e^{j\omega t} \cdot \underline{I})$ (32)

But, because

$\sqrt{2}\, e^{j\omega t} \cdot \underline{I} = \sqrt{2}\, e^{j\omega t} \cdot I e^{j\gamma i} = \sqrt{2}\, I \cdot e^{j(\omega t + \gamma i)} = \sqrt{2}\, I[\cos(\omega t + \gamma_i) + j\sin(\omega t + \gamma_i)]$, the instantaneous current will have the same expression as the previous one:

$$i(t) = \mathrm{Im}\left(\sqrt{2}e^{j\omega t} \cdot \underline{I}\right) = \sqrt{2} I \sin(\omega t + \gamma_i) =$$

$$= \sqrt{2}\frac{U}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}} \sin\left(\omega t + \gamma_u - \operatorname{atan}\frac{\omega L - \frac{1}{\omega C}}{R}\right) \quad (33)$$

From the above it is noted that, regardless the method of solving the circuit, we get the same result. The graphic-analytical method of solving, based on the geometrical representation, is more laborious but has the advantage that it allows the comparison of r.m.s. values and phases for different terms of the equation, while the method of symbolical representation as complex numbers has the advantage of a quick solving.

1.2. The voltages

Using the equations (3), (4), (5) for the voltages on the circuit components, the rule (10) for writing the complex number corresponding to them, the three voltages written as complex numbers and as instantaneous values are:

- on the resistor:

$$\underline{U}_R = \underline{Z}_R \underline{I} = R\underline{I} = RIe^{j\gamma i} \quad (34)$$

with

$$U_R = RI = R\frac{U}{Z} \quad (35) \qquad \gamma_{u_R} = \gamma_i = \gamma_u - \varphi \quad (36)$$

$$u_R(t) = \sqrt{2}\frac{R}{Z}U \cdot sin(\omega t + \gamma_u - \varphi) = \sqrt{2}\frac{R}{\sqrt{R^2 + X^2}}U \cdot sin\left(\omega t + \gamma_u - arctan\frac{X}{R}\right) =$$

$$= \sqrt{2}\frac{R}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}U \cdot sin\left(\omega t + \gamma_u - arctan\frac{\omega L - \frac{1}{\omega C}}{R}\right) \quad (37)$$

- on the inductor:

$$\underline{U_L} = \underline{Z_L}\underline{I} = \mathrm{j}\omega L\underline{I} = \omega L I \mathrm{e}^{\mathrm{j}\left(\gamma_i + \frac{\pi}{2}\right)} \quad (38)$$

with

$$U_L = \omega L I = X_L \frac{U}{Z} \quad (39) \qquad \gamma_{u_L} = \gamma_i + \frac{\pi}{2} = \gamma_u - \varphi + \frac{\pi}{2} \quad (40)$$

$$u_L(t) = \sqrt{2}\frac{X_L}{Z} U \cdot sin\left(\omega t + \gamma_u - \varphi + \frac{\pi}{2}\right) = \square$$

$$= \sqrt{2}\frac{X_L}{\sqrt{R^2 + X^2}} U \cdot sin\left(\omega t + \gamma_u - arctan\frac{X}{R} + \frac{\pi}{2}\right) = \square$$

$$= \sqrt{2}\frac{\omega L}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}} U \cdot sin\left(\omega t + \gamma_u - arctan\frac{\omega L - \frac{1}{\omega C}}{R} + \frac{\pi}{2}\right) \quad (41)$$

- on the capacitor:

$$\underline{U_C} = \frac{\underline{I}}{\mathrm{j}\omega C} = \frac{I}{\omega C}\mathrm{e}^{\mathrm{j}\left(\gamma_i - \frac{\pi}{2}\right)} \quad (42)$$

with

$$U_C = \frac{I}{\omega C} = |X_C|\frac{U}{Z} \quad (43) \qquad \gamma_{u_C} = \gamma_i - \frac{\pi}{2} = \gamma_u - \varphi - \frac{\pi}{2} \quad (44)$$

$$u_C(t) = \sqrt{2}\frac{X_C}{Z} U \cdot sin\left(\omega t + \gamma_u - \varphi - \frac{\pi}{2}\right) = \square$$

$$= \sqrt{2}\frac{X_C}{\sqrt{R^2 + X^2}} U \cdot sin\left(\omega t + \gamma_u - arctan\frac{X}{R} - \frac{\pi}{2}\right) = \square$$

$$= \sqrt{2}\frac{\frac{1}{\omega C}}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}} U \cdot sin\left(\omega t + \gamma_u - arctan\frac{\omega L - \frac{1}{\omega C}}{R} - \frac{\pi}{2}\right) \quad (45)$$

1.3. The powers

1.3.1. The real power

The **real power** corresponding to the *RLC* series circuit has the expression:

$$P = \underbrace{U}_{=ZI} I\cos\varphi = ZI^2\cos\varphi = \underbrace{Z\cos\varphi}_{=R} I^2 = RI^2 \geq 0 \quad (46)$$

and is positive or, at limit, zero, regardless of the phase shift φ, which means that, generally, the *RLC* series circuit consumes real power.

The size cos φ is called **power factor**.

1.3.2. The reactive power

The **reactive power** is defined by:

$$Q = \underbrace{U}_{=ZI} I \sin\varphi = ZI^2 \sin\varphi = \underbrace{Z \sin\varphi}_{=X} I^2 = XI^2 = (X_L + X_C)I^2 = \left(\omega L - \frac{1}{\omega C}\right) I^2 \quad (47)$$

and is:

- positive for inductive circuit
- negative for capacitive circuit
- zero – the circuit behaves like a resitive circuit although it contains reactive elements (we can say that it has resistive character/behaviour).

1.3.3. The complex apparent power and the apparent power

The **complex apparent power** is written as:

$$\underline{S} = P + \mathrm{j}Q = \underbrace{U}_{=ZI} I \cos\varphi + \mathrm{j} \underbrace{U}_{=ZI} I \sin\varphi = \underbrace{ZI^2 \cos\varphi}_{=RI^2} + \mathrm{j} \underbrace{ZI^2 \sin\varphi}_{=XI^2} = \square$$

$$= RI^2 + \mathrm{j}XI^2 = \underbrace{(R + \mathrm{j}X)}_{\underline{Z}} I^2 = \underline{Z}I^2 \quad (48)$$

and has the modulus, called **apparent power**, given by the equation:

$$S = |\underline{S}| = \sqrt{P^2 + Q^2} = \sqrt{(RI^2)^2 + (XI^2)^2} = \sqrt{R^2 + X^2} \cdot I^2 = ZI^2 \quad (49)$$

The complex apparent power can be:

- real, when the reactive power in null
- pure imaginary, for the pure reactive circuits (when R = 0), having the imaginary
  - positive, for the inductive circuits
  - negative, for the capacitive circuits

2. The resonance phenomenon in RLC series circuits under sinusoidal steady state

2.1. The resonance condition

Usualy, the energy sources that supply the circuits provide them with both real power (required for different uses), and reactive power (corresponding to the variation of the stored electromagnetical energy into the electrical and magnetical fields of the reactive elements – inductors, capacitors). In particular cases it is possible that, while in some of these energy fields the energy is stored (the energy increases), in other fields the energy decreases by an equal amount, the electrical and magnetical fields providing energy to each other, so that the exchange of energy between the source and the energy fields from circuit is zero at any time and, accordingly, **the reactive power supplied by the source is** also **zero**. Although the circuit contains

reactive elements, it absorbs only real power from the source. In this case we say that a **resonance phenomena** occurs in the circuit.

For the *RLC* series circuit, the resonance condition is:

$$Q = 0 \rightarrow UIsin\varphi = 0 \rightarrow \varphi = 0 \rightarrow arctan\frac{X}{R} = 0 \rightarrow X = 0 \rightarrow \omega L - \frac{1}{\omega C} = 0 \quad (50)$$

This condition can be obtained:

- by varying the supplying pulsatance ω (the frequency f) and keeping constant the inductance *L* and capacitance *C*:

$$\omega_r = \frac{1}{\sqrt{LC}} \quad (51) \qquad \text{respectively} \qquad f_r = \frac{1}{2\pi\sqrt{LC}} \quad (52)$$

ω_r and f_r being named resonance pulsatance/frequency;

- by varying the inductance *L* and keeping constant the capacitance *C* and the supplying pulsatance ω (the frequency *f*):

$$L_r = \frac{1}{\omega^2 C} \quad (53)$$ *Lr* being named resonance inductance;

- by varying the capacitance *C* and keeping constant the inductance *L* and the supplying pulsatance ω (the frequency *f*):

$$C_r = \frac{1}{\omega^2 L} \quad (54)$$ *Cr* being named resonance capacitance.

In the following let us analyze the consequences of the resonance phenomenon/regime obtained by varying the pulsatance (the frequency).

2.2. Consequences of the resonance phenomenon

Considering the resonance condition, if we replace in the previous expressions the difference $X = X_L + X_C = \omega L - \frac{1}{\omega C}$ with zero or the pulsatance with the resonance pulsatance, the consequences will be:

(50)

- the complex impedance:

$$\underline{Z}_r = R + j\left(\omega_r L - \frac{1}{\omega_r C}\right) = R \text{ (real)} \quad (55)$$

- the impedance:

$$Z_r = \sqrt{R^2 + \left(\omega_r L - \frac{1}{\omega_r C}\right)^2} = R \text{ (min)} \quad (56)$$

- the impedance argument, that is the phase-shift between voltage and current:

$$\varphi_r = \text{atan}\frac{\omega_r L - \frac{1}{\omega_r C}}{R} = 0 \quad (57)$$

- the complex current:

$$\underline{I}_r = \frac{\underline{U}}{\underline{Z}_r} = \frac{U \cdot e^{j\gamma_u}}{Z_r \cdot e^{j\varphi_r}} = \frac{U \cdot e^{j\gamma_u}}{R \cdot e^{j0}} = \frac{U}{R} \cdot e^{j\gamma_u} \quad (58)$$

- the r.m.s. current:

$$I_r = \frac{U}{\sqrt{R^2 + \left(\omega_r L - \frac{1}{\omega_r C}\right)^2}} = \frac{U}{R} = \frac{U}{Z_{\min}} \text{ (max)} \quad (59)$$

The r.m.s. current has the maximum value at resonance and the smaller resistance is the greater r.m.s. current will obtain. This could be harmful, especialy when the current exceeds the maximum allowed values for the resistor and/or inductor. In these cases, the resistor may burn (if it's a coiled resistor, its metallic wire may melt) and/or the electromagnetical forces between the inductor spires may be so high so that the inductor will be deformed.

Knowing this, when handling the variable elements of the RLC circuit, we should take care not to exceed the maximum allowed value for the current, so that to avoid the harmful effects.

- the initial phase of the current: $\gamma_{ir} = \gamma_u - \varphi_r = \gamma_u - 0 = \gamma_u$ (60)
- the instantaneous current:

$$i_r(t) = \sqrt{2} I_r \sin(\omega t + \gamma_{i_r}) = \sqrt{2} \frac{U}{R} \sin(\omega t + \gamma_u) = \frac{u(t)}{R} \quad (61)$$

- the voltage on the ideal resistor: $u_{Rr}(t) = Ri_r(t) = u(t)$ (62)
- the voltage on the inductor: $\underline{U}_{Lr} = j\omega_r L\underline{I}_r$ (63)

$$U_{Lr} = \omega_r L I_r = \frac{\omega_r L}{R} U \quad (64) \qquad \gamma_{u_{Lr}} = \gamma_{i_r} + \frac{\pi}{2} = \gamma_u + \frac{\pi}{2} \quad (65)$$

$$u_{Lr}(t) = \sqrt{2} \frac{\omega_r L}{R} U \cdot \sin\left(\omega t + \gamma_u + \frac{\pi}{2}\right) \quad (66)$$

- the voltage on the ideal capacitor:

$$\underline{U}_{Cr} = \frac{\underline{I}_r}{j\omega_r C} = -j\frac{1}{\omega_r C}\underline{I}_r = -j\omega_r L\underline{I}_r = -\underline{U}_{Lr} \quad (67)$$

$$U_{Cr} = \frac{1}{\omega_r C} I_r = \frac{\omega_r L}{R} U = U_{Lr} \quad (68) \qquad \gamma_{u_{Cr}} = \gamma_u - \varphi_r - \frac{\pi}{2} = \gamma_u - \frac{\pi}{2} \quad (69)$$

$$u_{Cr}(t) = \sqrt{2} \frac{\omega_r L}{R} U \cdot \sin\left(\omega t + \gamma_u - \frac{\pi}{2}\right) \quad (70)$$

- the real power:

$$P_r = RI_r^2 = \mathrm{R}\left(\frac{U}{R}\right)^2 = \frac{U^2}{R} = P_{max} \quad (71)$$

- the reactive power:

$$Q_r = \left(\omega_r L - \frac{1}{\omega_r C}\right) I_r^2 = 0 \quad (72)$$

- the complex apparent power: $\underline{S}_r = P_r + jQ_r = P_r$ (73)
- the apparent power:

$$S_r = \sqrt{P_r^2 + Q_r^2} = P_r \quad (74)$$

In conclusion, under resonance conditions:

- the complex impedance is real, equal to the resistance *R*, and its module (the impedance) has the minimum value, equal to the same resistance *R*;
- the power factor is maximum;
- the current, in phase with the supplying voltage, has the maximum r.m.s. value;
- the voltage on resistor is equal to the supplying voltage;
- the voltages on inductor and capacitor are opposite and have equal r.m.s. values (for this reason the resonance in the *RLC* series circuit is called voltage resonance) and they may overcome the supplying voltage, namely **overvoltages** may occur.

The overvoltages condition (when the voltages on inductor and capacitor are greater than the supplying voltage) is:

$$\frac{\omega_r L}{R} = \frac{1}{\omega_r RC} > 1 \quad (75)$$

But, because under resonance conditions $\omega_r = \frac{1}{\sqrt{LC}}$

it follows that $\frac{1}{R}\sqrt{\frac{L}{C}} > 1$ (76)

If the resonance overvoltages exceed the maximum allowed values, they may cause the inductor damage or the capacitor breakdown.

- under resonance condition the *RLC* series circuit doesn't consume and doesn't supply reactive power.

3. Graphical representations

MathCad representations for the main important sizes regarding the *RLC* circuit and depending on the frequency, inductance and capacitance (the three ways of variation for obtaining the resonance) are given in the figures 7, 8 and 9.

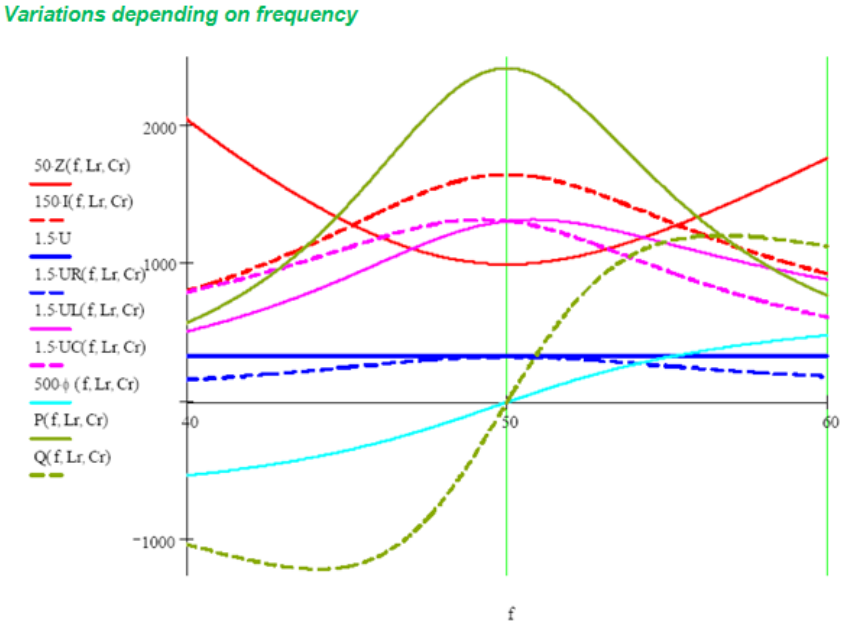

Figure 7: *Variations depending on frequency*
(f variable, L and C constant -)

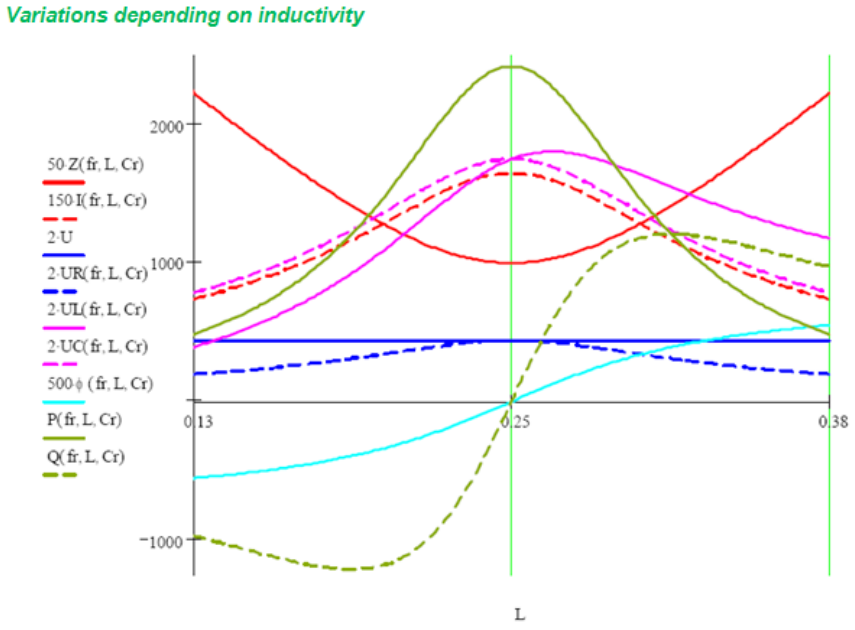

Figure 8: *Variations depending on inductance*
(L variable, C and f constant -)

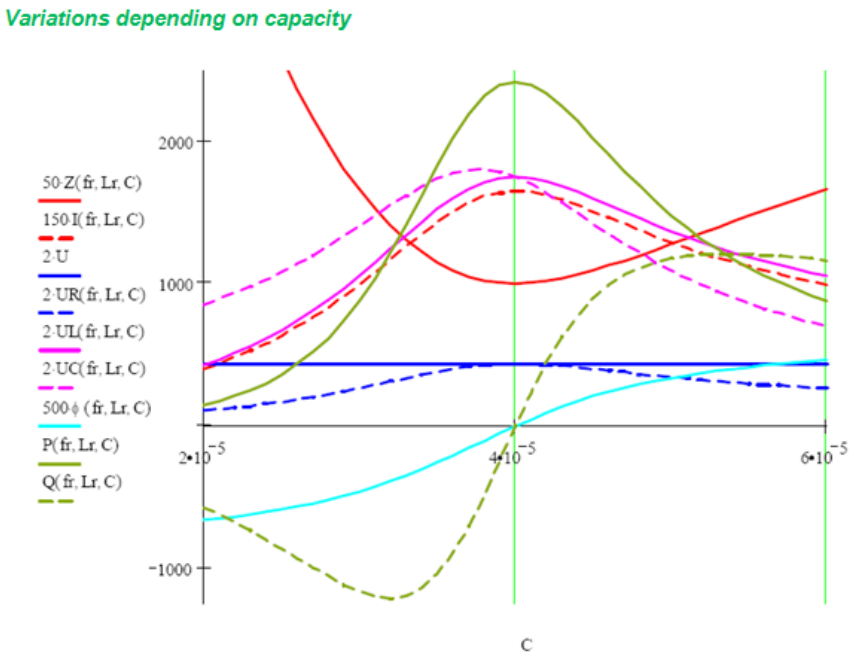

Figure 9: *Variations depending on capacitance*
(C variable, L and f constant - $C_r = 4 \cdot 10^{-5}$ F = 40 **μ***F)*

Analyzing the graphs, we can draw the same conclusions regarding the consequences of the resonance phenomenon.

Besides all these, from the figure 7, 8 and 9, we can notice that:

- when varying the frequency *f*, the maximum values of voltages on inductor and capacitor are obtained after and respectively before the resonance (the two maximum points are places on both sides of the same value of the two voltages, obtained at the resonance frequency)
- when varying the inductance *L*, the maximum value of the voltage on capacitor coincides with the value for resonance and it occurs before the maximum voltage on inductor
- when varying the capacitance *C*, the maximum value of the voltage on inductor coincides with the value for resonance and it occurs after the maximum voltage on capacitor

These observations could be important when handling an *RLC* circuit so that to prevent exceeding the maximum allowed values for current and voltages on inductor and capacitor that cause harmful effects.

If we draw on the previous graphs horizontal lines that represent these maximum allowed values, we can deduce the value ranges for frequency, inductance and capacitance that must be prevented for avoiding the harmful consequences.

A simpler way is to use a simulation soft (for example Labview) for analyzing an *RLC* behavior in different conditions and to deduce the value ranges of the three variable sizes that must be avoided.

With the application shown in figure 10 we can set the maximum allowed values for current and voltages on inductor and capacitor and, when varying a parameter (frequency, inductance, capacitance), we can observe the limits exceeding throught the leds that turn into red.

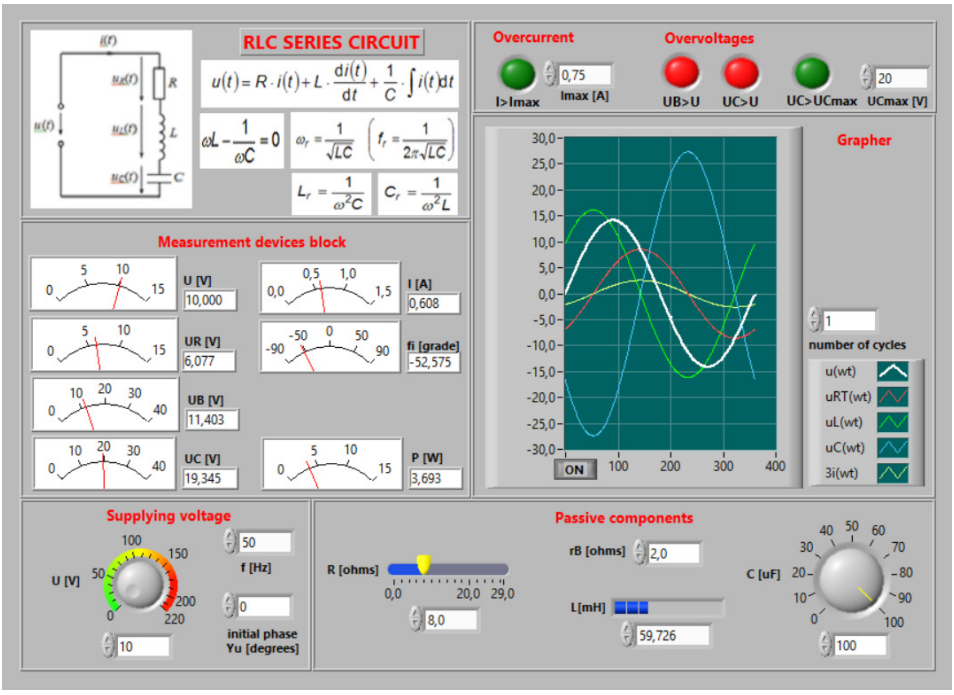

Figure 10: *Labview application for analyzing the RLC series behavior – variant 1*

The application shown in figure 11 draws different curves (that can be set – here U_L and U_C) depending on one variable size (frequency, inductance or capacitance) that can be set (here we vary the frequency *f*, so the graph will draw the U_L and U_C curves depending on the frequency *f*).

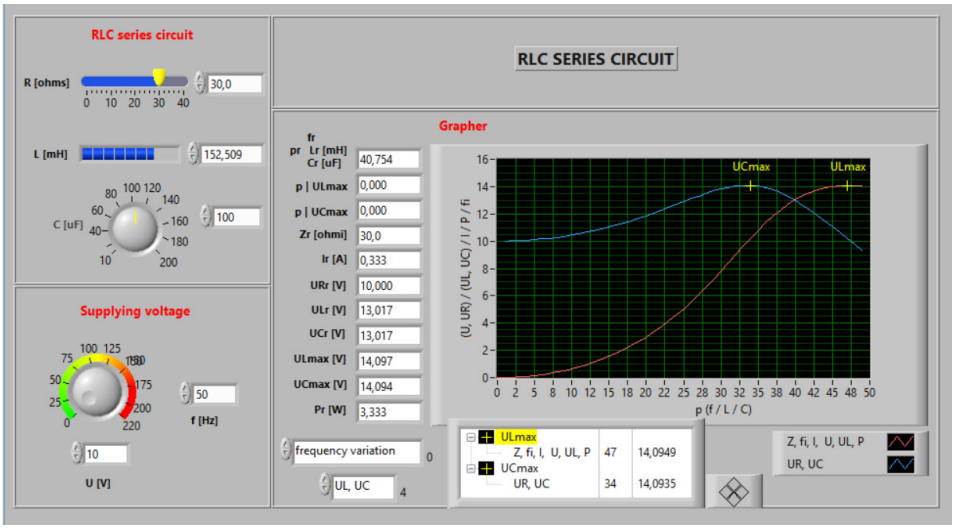

Figure 11: *LabView application for analyzing the RLC series behavior – variant 2*

If we set the frequency variation, the graphs will be drawn for a range of frequency values from 0 to the value set on the control panel (here 50 Hz).

Using these applications, we can highlight the value ranges for the variable sizes (frequency, inductance or capacitance) that must be refrained in order to avoid the harmful effects.

4. The practical importance of resonance phenomena in electrotechnics

4.1. Harmful consequences

As we already deduced, the resonance phenomena may have harmful effects (when they are not foreseeable).

For example, in the RLC series circuits overcurrents may occur through the circuit elements and overvoltages on the reactive elements (inductor and capacitor), especially when the circuit resistance is very low in comparison with the reactances.

Let us see how they may affect the circuit elements:

- A current greater than the maximum allowed for **resistor** can cause its destruction by melting. For example, if it is a coiled resistor, due to the high temperature generated, its metallic wire will melt and interrupt the circuit. On the other hand, the high current and, consequently, the high temperature, may cause the voltage breakdown of the cables insulations or of the insulation between the resistor spires.
- A current greater than the maximum allowed through **inductor** can cause similar effects as for the coiled resistor (the wire melting and the insulation damage). Besides this, because the electromagnetical forces between the inductor spires are

proportional to the second power of the current, these forces may become so high so that the inductor will be deformed.

- If the voltage on **capacitor** exceeds its maximum allowed value, it may cause the disruption of insulation between its plates.

Therefore, in some cases, due to the harmful effects, the resonance should be avoided.

4.2. Useful applications

However, the resonance phenomenon is often used in electrotechnics, with many useful applications.

Among the useful applications are included: Boucherot circuits used in furnaces with resistors, phase shifter circuits, some measurement devices, radio-transceivers and multiple telephony, improving the power factor.

4.2.1. Boucherot circuits

In the circuits of some special equipments it is required that the amperage through a circuit branch to be independent on the branch impedance. Such a condition is needed in the supplying circuits of the electrical furnaces, wherein the current through the heating resistor of the furnace must be independent on the resistance value. These circuits are called Boucherot circuits.

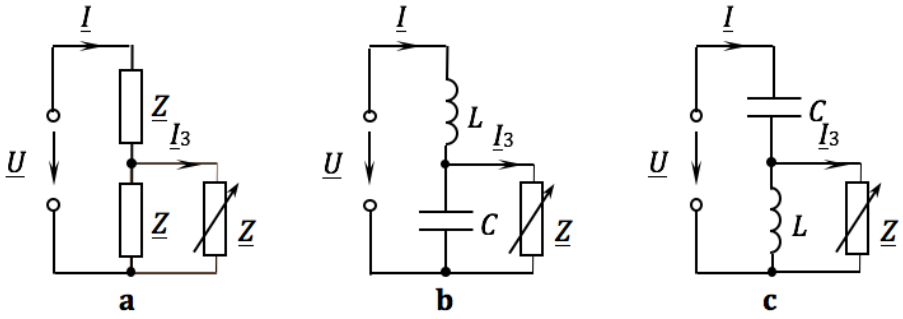

Figure 12: Boucherot circuits

A simple circuit that fulfils this condition consists of three impedances connected in mixed connection as in figure 12.a. The voltage $\underline{U}$ is applied between the circuit terminals, and the current $\underline{I}_3$ must be independent of the impedance $\underline{Z}_3$.

The equivalent complex impedance of the circuit, $\underline{Z}_e$, is:

$$\underline{Z}_e = \underline{Z}_1 + \frac{\underline{Z}_2\underline{Z}_3}{\underline{Z}_2 + \underline{Z}_3} \quad (77)$$

and the current is expressed as:

$$\underline{I} = \frac{\underline{Z}_2 + \underline{Z}_3}{\underline{Z}_1\underline{Z}_2 + \underline{Z}_3(\underline{Z}_1 + \underline{Z}_2)}\underline{U} \quad (78)$$

The current $\underline{I}_3$ is:

$$\underline{I}_3 = \frac{\underline{Z}_2}{\underline{Z}_2 + \underline{Z}_3}\underline{I}_1 = \frac{\underline{Z}_2}{\underline{Z}_1\underline{Z}_2 + \underline{Z}_3(\underline{Z}_1 + \underline{Z}_2)}\underline{U} \quad (79)$$

being independent of the impedance $\underline{Z}_3$ if $\underline{Z}_1 + \underline{Z}_2 = 0$ (80)
namely if the next conditions are fulfilled $R_1 + R_2 = 0$ and $X_1 + X_2 = 0$ (81)

Because the resistances are positive defined, from the first condition follows that $R_1 = R_2 = 0$. The second condition is fulfilled if one of reactances is inductive and the other capacitive: for example, if $\underline{Z}_1 = j\omega L$ and $\underline{Z}_2 = -j\frac{1}{\omega C}$ (figure 12.b) the equation (80) becomes $\omega L - \frac{1}{\omega C} = 0$ (82) that means a resonance condition.

The same condition is fulfilled if $\underline{Z}_1 = -j\frac{1}{\omega C}$ and $\underline{Z}_2 = j\omega L$ (figure 12.c).

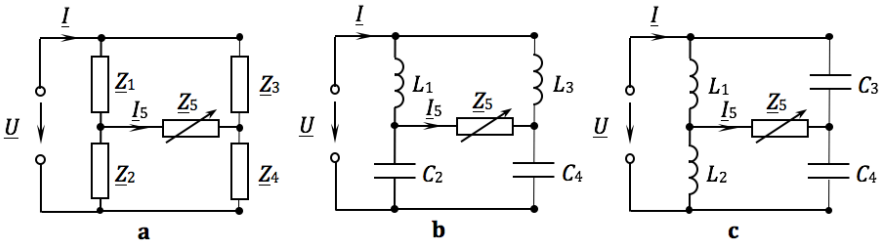

Figure 13: *Boucherot circuits*

In the circuit from figure 13.a, the current $\underline{I}_5$ is independent of the impedance $\underline{Z}_5$ if there are fulfilled the next conditions:

$\underline{Z}_1 + \underline{Z}_2 = 0$ and $\underline{Z}_3 + \underline{Z}_4 = 0$ (83) namely if:

$\underline{Z}_1 = j\omega L_1$, $\underline{Z}_2 = -j\frac{1}{\omega C_2}$ $\left(\text{or } \underline{Z}_1 = -j\frac{1}{\omega C_1},\ \underline{Z}_2 = j\omega L_2\right)$ (84) – figure 13.b

and $\underline{Z}_3 = j\omega L_3$, $\underline{Z}_4 = -j\frac{1}{\omega C_4}$ $\left(\text{or } \underline{Z}_3 = -j\frac{1}{\omega C_3},\ \underline{Z}_4 = j\omega L_4\right)$ (85) – figure 13.c.

4.2.2. Phase shifter circuits

Let us consider the circuit from figure 12.a where

$$\underline{Z}_1 = R_1 + j\omega L_1, \quad \underline{Z}_2 = -j\frac{1}{\omega C_2}, \quad \underline{Z}_3 = R_3 + j\omega L_3 \text{ and } L_1 = L_3 = L \quad (86)$$

It is required to determine the condition that the voltage applied to the circuit to be in quadrature with the current $\underline{I}_3$ for any values of the resistances R_1 and R_3.

The equivalent impedance $\underline{Z}_e$ and the current $\underline{I}$ have the expressions given by the equations (77) and (78). Replacing the current from (78)

$$\underline{I}_1 = \frac{\underline{Z}_2 + \underline{Z}_3}{\underline{Z}_2}\underline{I}_3 \quad (87)$$

and the equation (79) will become

$$\underline{U} = \left(\underline{Z}_1 + \underline{Z}_3 + \frac{\underline{Z}_1\underline{Z}_3}{\underline{Z}_3}\right)\underline{I}_3 \quad (88)$$

Replacing the impedances with their expressions expanded it results

$\underline{U} = [(1 - \omega^2 LC)(R_1 + R_3) + j(2\omega L + \omega R_1 R_3 C_2 - \omega_3 L_2 C_2)] \cdot \underline{I}_3$ (89)

In the equation (89) the voltage $\underline{U}$ and the current $\underline{I}_3$ are in quadrature if

$$1 - \omega^2 LC = 0 \quad (90)$$

namely a resonance condition.

If in the above circuit the coils are replaced with identical capacitors and the capacitor with a coil, a similar circuit is obtained, and the condition that the voltage $\underline{U}$ to be in quadrature with the current $\underline{I}_3$ is similar to the equation (90).

4.2.3 Inductance measuring

The resonance phenomenon is also used in many other practical aims as, for example, in measurement devices for electrical and non-electrical sizes, in automation, just to name a few.

As it noted, within an *RLC* series circuit under resonance condition the current is maximum and the condition is fulfilled. Using these properties, can be achieved industrial devices for quick measurement of resistances, inductances, capacitances (impedances) or frequencies or pulsatances.

For example, a device for inductances measurement consists of a resistor, a calibrated capacitor and an ampermeter. The inductance aimed to be measured is connected in series with this circuit, resulting an *RLC* series circuit. The device must be supplied with a voltage having the frequency for that it was designed/calibrated. Varying continuously the capacitance the circuit is put in resonance condition, that is observed when the current is maximum (a consequence of resonance). From the equation where *w* and *C* are known, the inductance *L* can be deduced. The capacitor can be labeled/calibrated so that the inductance values can be read directly. Other circuits, more complicated, try to reduce or to eliminate the supplying frequency influence. Of course, the measurements done with such devices are less accurate than those obtained by classical laboratory methods.

4.2.4 Radio communications

The high frequency oscillators used in radiotechnics consist mainly of *LC* circuits, operating under resonance condition, that produce oscillations of the voltage or current with the resonance frequency.

In radio communications technique, to each transmitter corresponds a certain high frequency, called carrier frequency. Over the current with the carrier frequency are overlaped oscillations with the frequency of the sounds that must be emitted

(corresponding to words or music), through the process called modulation. Therefore, the transmitter station produces a modulated electromagnetic field, characterized by the carrier frequency, different from a transmitter station to another.

In the radio receiver antenna (which also contains oscillating circuit that can be tuned for the frequency of radio transmitter, by handling, from outside, a variable capacitor, until the circuit parameters satisfy the resonance condition) are induced electromotive voltages by all the transmitter stations. To listen (to select) a certain radio channel, the antenna is introduced into a circuit that (using the variable capacity) is "set" to operate under resonance condition for the carrier frequency of the desired radio channel. This provides the possibility to select (in the radio receiver) a certain radio channel from a large number of channels that exist simultaneously (the electromotive voltages induced by the station with that the tuning is made, generate maximum currents, what makes the audition to be possible; the currents generate by the other electromotive voltages being small, do not disturb the audition).

4.2.5 Multiple telephony

Similarly, in multiple telephony, is used a single two-wire circuit, to make simultaneously multiple calls. As in the radio transmissions, the calls are performed on a certain carrier frequency, different from that of the other posts.

To connect two telephone stations, without disturbing or being disturbed by other calls, it is enough that the connected stations to be tuned with the same carrier frequency, that is performed using also resonant devices called filters.

4.2.6. Power factor improving

The resonance can be used to improve the power factor of the industrial networks which contains inductive and capacitive consumers, considering that, under resonance condition, the phase shift between the supplying voltage and current in zero and the power factor is 1 (the maximum value). The closer to the resonance condition, the higher the power factor.

5. Conclusions

The resonance phenomenon may occur, for example, when varying the frequency, inductance or capacitance into a circuit that contains both inductive and capacitive components, so that the resonance condition is fulfilled.

As we could see, this phenomenon may have both harmfull and useful consequences.

Understanding well the behavior of the circuits in which the resonance may occur, the user can avoid the damages.

A detailed analysis can be done using mathematical formulas but also graphs (drawn in MathCad for example) or simulation software.

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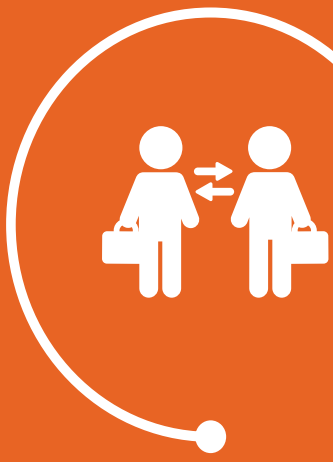

Intensive Programmes
Erasmus+ Mobility of Individuals

The Erasmus+ Project Experiential Education Competence (EXPEDUCOM)

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Abstract

The European Higher Education Area and the Erasmus Intensive Program, among others, enable the mobility of students and the development of interpersonal skills, such as working in diverse and intercultural teams, the ability to negotiate in different languages, decision-making, problem-solving and a pro-active attitude.

In this context, the Expeducom project, financed under Erasmus+ K2, has the main objective of developing and implementing innovative pedagogical practices related to experiential learning, aimed at children between the ages of 3 and 12.

This partnership allowed students from 7 different countries to work, learn and compare perspectives in a pedagogically diverse environment. The project contains four innovative aspects: citizenship, sustainable development, global warming, technologies and healthy lifestyle. Methodological support was provided to foster the development of this approach among trainers and future teachers. A handbook was also developed with guidelines on experiential teaching-learning, as well as with case studies of experiences developed with children. At the end of the project, a study was also performed to analyze the perspectives of the participating students on the impact of the project on their educational action. The data revealed that the Expeducom project had an impact on students' practices, as well as on the development of transversal competences.

Keywords: ***experiential-based learning; preschool; primary school; Erasmus+***

Introduction

Higher Education Institutions (HEIs) are crucial partners in the implementation of the European Union's strategy in the promotion of economic growth and social development. Globalization, international mobility and demographic changes have unequivocally transformed the course of higher education internationally.

Nowadays, internationalization became a strategic goal of European HEI and almost all institutions and countries create offers for international students and reflect on their interaction with the global academic community.

Considering this, the Erasmus+ is an EU program in the fields of education, training, youth and sports for the period 2014-2020, which seeks to respond to these strategies, fundamental to address socio-economic changes.

The internationalization of the European higher education system contributes to the modernization and quality improvement of HEI, paving the way for the effectiveness of the Bologna Process. The Erasmus+ program includes several actions, involving students, teachers and staff. The Transnational Strategic Partnerships is one of these actions, targeting one or more areas of education, training and youth, and promoting innovation, experience and know-how exchange between the different types of organizations involved in these or other relevant areas.

It is recognized that young people studying or receiving training abroad under the Erasmus + program develop not only specific knowledge related to their field of study but also transversal skills necessary for their later studies, which are valued by the employers.

According to the Erasmus Impact Study: Effects of mobility on the skills and employability of students and the internationalization of higher education institutions (Brandenburg, Berghoff, & Taboadela, 2014), graduates with international experience are more successful in the labor market. The possibility of long-term unemployment is 50% lower than those who did not study or obtain training abroad and, five years after graduation, the unemployment rate is 23%. Also, according to the study, more than 90% of the students reported an improvement in their transversal competences, such as knowledge of other countries, their ability to interact and work with people of different cultures, adaptability, language proficiency and communication skills. In addition, 99% of HEIs observed a substantial improvement in the confidence and adaptability of their students.

In the area of teacher training, the openness to other forms of work, other strategies and other cultural, social or ethnic contexts, influence the participants' professional attitude and lifelong learning.

It is in this context that the Experiential Education Competence (EXPEDUCOM) project was designed, supported by the European Union under the Transnational Strategic Partnerships program. It focuses on the development and implementation of educational practices under the experiential based learning methodology, with children from three to twelve years old.

1. Characterization of the Expeducom Intensive Program

Experience-based learning describes a method of teaching by doing, namely it is the process during which young learners obtain knowledge and skills via personal experience. Individuals are involved in a particular activity which they reflect, analyze and that brings higher level of awareness and/or changes in their behavior. The modern world requires to educate young learners so that they are creative, flexible, and able to analyze and think critically. It is common sense that the most predominant tendency in education is to educate young learners this way, so that they can become independent and democratic citizens.

The EXPEDUCOM project was born from the need to meet the requirements of the modern world via the development and implementation of innovative educational practices related to experience-based pedagogical approach, addressed to young learners aged 3-12.

The project outcomes seek strengthening the professional profile of in-service educators as well as students (future teachers) by developing pedagogical guidelines on experiential education, open educational tools, real life cases, offering training for improvement of professional and communicative skills, improving curricula of pre- school, primary and teacher training institutions.

The project comprised four innovative aspects:

(i) Experience-based learning has already been implemented in several contexts. However, new changes in the world and life are coming up soon and make it necessary to introduce new topics into curricula of young learners such as world citizenship, sustainable development, global warming, technologies, healthy lifestyle, among other relevant issues for human life. In this project, the experience is considered as the way to involve young learners in the intellectual work and problem solving that could be understood as relevant for their learning. Young learners are seen as researchers who take a reflexive attitude which involves reasoning and deliberating. This means that young learners are able to make questions and to find answers. For that they must be actively engaged in the selection of the material that can help them to think about the implications and the relationship between the material and the solution they are looking for.

(ii) A relational and holistic approach for learning was also followed, considering that an interdisciplinary integration of the contents is essential, and also because young learners must be understood as a whole, with body, mind, emotions, creativity, history, and social identity. The development of a pedagogy based on experiential and holistic learning considers the young learners' rights and their participative competence. It requires listening, observing, negotiating acting to ensure participation.

(iii) Large scale dissemination of project results, including parents, Erasmus students;
(iv) A wide multicultural context.

1.1 Duration and main activities

The project duration was 2 years, beginning on September 1, 2014 and ending on August 31, 2016.

The project activities directly address: teachers, working in kindergarten (2-6) and primary schools (6-12); students of pre-school and primary education; teacher trainers, researchers at universities providing pre-school and/or primary education; parents or anyone interested in education of young learners aged 3-12.

The main project priority is revising and strengthening the professional profile of teachers already working at kindergartens and primary schools and future teachers.

The main activities include:

(i) a research survey;
(ii) providing a methodological support for project teachers and teacher trainers (lectures and workshops about experiential education);
(iii) writing a handbook of pedagogical guidelines on experiential based learning for educators of young learners;
(iv) Organizing an Intensive Program for students to design cases and test them working with young learners in a kindergarten and primary school.

1.2 Coordinator and partners

Partners were invited considering their competences and the contributions they could bring to the project. The coordinator was Kauno Kolegija/University of Applied Sciences [KK], Lithuania.

The consortium included nine institutions: three non-academic universities from Lithuania, the Netherlands, Latvia, four academic universities from Turkey, Greece, Portugal and Romania (all institutions provide teacher training for pre-school and primary education), a primary school (providing pre-primary and primary education) from Lithuania and a kindergarten (providing pre-school education) from Lithuania. All partners have associated partners' kindergartens and primary schools, functioning together with other educational institutions, social partners, non-profit or profit organization of informal education. Some partner universities have been cooperating in the Erasmus Program and have been working in the project's Intensive Program. Teachers from partner institutions had expertise which was taken into consideration while distributing responsibilities among the Work Packages e.g. Marnix Academie provided didactic support and organized training for teachers, Polytechnic Institute of Bragança hosted a preparatory meeting for students IP, schools and kindergartens disseminated the project results and provided feedback. Moreover, 12 teachers out of 18 had a PhD degree, which guarantees

high quality of research survey and intellectual outputs produced. Geographical variety also brings multicultural value. Eight partners out of nine have experience in international projects.

1.3 The Research Survey

The *International research report on experiential learning approaches* (Alat, Alat, Kamantauskiene, Massari, Miron, Mesquita, Tzakosta, Verheij, & Zirina, 2016), describe a research study, based on a research survey for collecting data, that aims to explore how teachers of young children provide education in their classrooms in the countries participating in the project, namely Greece, Latvia, Lithuania, Portugal, Romania, and Turkey. More specifically, attention was paid to reveal to what degree developmentally appropriate practices were implemented in kindergarten to primary programs.

In the study participated a total of 237 early childhood and primary school teachers from Greece, Latvia, Lithuania, Portugal, Romania, and Turkey. An expanded version of The Instructional Activities Scale with an addition of ten more questions that were developed based on NAEYC's recommendations for developmentally appropriate practices was administered to measure how often developmentally appropriate and inappropriate practices occur in classrooms. Participants were also asked questions about how often they addressed 21th century topics and skills (Alat et al., 2016).

Methodologically, a descriptive analysis of the data was made, showing that it is , reportedly, a common and regular practice for the teachers that participated in the study to offer developmentally appropriate activities including building with blocks, freedom to choose from a variety of learning areas, activities, and projects, experimenting with writing by drawing, copying, and using their own invented spelling, playing with games, puzzles, and construction materials, singing, listening and moving with the music, working with art materials, integration of subjects, inquisitive skills, social skills, plenty of materials to explore and work with, communicating what they have learned, creativity, dialogue among children, given plenty of time, individual interests. Children's work was displayed in the classrooms. Teachers did not have much hesitation on using alternative assessment techniques (Alat et al., 2016).

However, data also showed that some other important elements of developmentally appropriate practices were not as regularly included in teaching even though they are critical in the realization of the main goals of early education. A significant portion of the participants reported missing on those opportunities including hands-on math and science activities, structured gross motor activities, engagement with manipulatives, teaching about people with special needs and adapting materials for children with special needs, parent involvement, providing

experiences to instill care for each other, use of media and technology, and organizing field trips (Alat et al., 2016).

Even though the teachers in the study widely reported that they provided appropriate activities regularly from their answers to the questions about inappropriate practices, it seems that a significant group of teachers also delivered inappropriate activities. There was a significant number of teachers who relied on commercially prepared phonics books. Use of worksheets and flashcards, cut and paste activities, teacher directed whole-class activities, and ability grouping were common practices among the participants. Fortunately, inappropriate disciplinary strategies including separation of children from their friends or putting them in time-out in order to maintain classroom order seemed not to be practice by the majority of the teachers (Alat et al., 2016).

As far as promoting 21th century skills, it appears that teaching about sustainable development, environmental issues, critical thinking, language skills, human rights, care and empathy have become a widespread practice. Care and empathy received the most attention and seemed to be in the majorities' agenda. However, it is unfortunate that in today's ever globalizing world, bearing serious immigration crisis as societies become more and more diverse the participants failed on providing regular experiences to teach children about multiculturalism and intercultural skills. In this globalized economy, with electronic and social media becoming even more widespread and largely accessible, media literacy has become a key skill to be acquired for the generations of the new century. Participants' inattention to cultivating media literacy skills in their students has the potential to interfere with such other important subjects as care and empathy, human rights, and critical thinking.

The findings of this study prove that some major issues in teaching young children still persist in the new millennium. Despite decades of research providing a solid framework for effective pedagogies, there appears to be a broken link between theory and practice. Educational reform does not occur over night. It is essential that both practicing teachers and teacher candidates be given opportunities to gain experience in quality environments where developmentally appropriate practices are endorsed and realized. Teacher educators and administrators should design professional development trainings based on empirical evidence that describes in detail what makes a teacher training program work. Ongoing teacher training, effective mentorship, collaboration between the universities and schools, and easy access to resources could help teachers make the connections between the theory and practice (Alat et al., 2016).

1.4 The Handbook and the Case Studies

The handbook rose from the needs to meet the requirements of the modern world via developing and implementing innovative educational practices related to experience-based pedagogical approach educating young learners aged 3-12. It

constitutes an approach for investigating the theoretical and practical training strategies from the perspective of experiential education. The purpose of the handbook aims to provide theoretical and practical tools useful in early education specialists and primary education by developing practical strategies component, to support the development of educational activities and research to adapt permanently instructive approach to the specific demands of contemporary society. Due to changes at multiple curricular authors develop paradigms for training future teachers and introduce the need for activity planning, implementation and evaluation of training through experiential learning activities, thereby contributing directly to improving interactive teaching strategies. The handbook has three parts, A to C, as follows:

A. Explains the general framework on experiential based learning including the following sections: What is experiential learning? (Concept; Characteristics of experiential based learning; The principles of experiential orientation; Experiential based learning stages; Teacher roles; Children roles; Integration of experiential learning in teaching); Overview of conceptual foundations on the experiential based learning (Instructional models for the experiential learning theory; Dewey's foundations for the experiential based learning; Implications of Vygotsky's ideas on the learning process; Bruner's conceptual contribution to the experiential based learning; The Jean Piaget's perspective; Kolb's experiential learning theory); Citizenship and 21st century education (An overview of 21st century skills education; What kind of citizens are needed in the Netherlands in the 21st century?); Different approaches of experiential education (Reggio Emilia Approach; High Scope Approach; Movement of Modern School, Portugal).

B. Includes the International research report on experiential learning approaches

C. Shows examples of experiential based learning developed in different countries structured as case studies on experiential education in kindergarten and case studies on experiential education in primary school.

The handbook aims to provide the necessary and adequate information regarding experiential learning and teaching and is directed to parents, students and educators of preschool and primary school children. More specifically, the outcomes of the project directly address teachers working in kindergartens and primary schools; students of pre-school and primary education; teacher trainers, researchers at universities providing pre-school and/or primary education; parents or anybody interested in education of children aged 3-12 (Kamantauskiene, 2016).

1.5 The Intensive Program

The intensive program was held in Kaunas, Lithuania from April 3 to April 15, and included activities related to experiential-based learning. Experiential activities were also developed in the scope of natural and social sciences; Literature for Childhood through storytelling and arts; Early English learning through the CLIL

methodology; Project work methodology; The holistic approach and the enabling environments.

A second dimension of the IP relates to the presentation and sharing of case studies, developed in partner countries, in the context of pre-school and primary education. The case studies were presented and discussed in a plenary section. A group reflection was carried out, with the contributions of the teachers and students, that examined the strong aspects and vulnerabilities of the cases studies presented.

The IP also included visits to pre-school and primary schools. Subsequently, transnational groups were formed, in a total of 7 groups. Each group designed a learning experience to be implemented in educational contexts. The teachers supported the projects of the groups. Students have implemented learning experiences. There was also a phase of group sharing and reflection.

The team also had the opportunity to interact with the local culture, participating in study visits to places of interest.

2. Impact of the project on Students

In addition to the students and teachers' satisfaction questionnaires on the project, a Portuguese study was developed, to assess the influence of the Expeducom project on the development of professional skills.

The methodology was based on a quantitative approach, with data collection by online questionnaire and final statistical treatment. The questionnaire, designed to analyze the students' perceptions of the reasons that led them to participate in the project, satisfaction with their participation, the development of transversal and professional competences and the impact of the project in the practices, contained 18 items, structured in 6 dimensions:

1) Sociodemographic characterization of the participant;
2) Reasons for participation in the Expeducom project;
3) Satisfaction with the participation in the project;
4) Development of transversal competences;
5) Development of specific skills;
6) Impact of the project on the professional practices in stage and in the profession.

The questionnaire was distributed to the 27 participating students. The data were analyzed using software R.

The participants were mostly female (93.8%) and the age group from 19 to 22 years old (62.5%), with the remaining 37.5% being between the ages of 23 and 28 years. The majority of the students (81.3%) were attending the bachelor's degree, while the remaining 18.8% were attending a master's degree. All countries were represented.

Students understand that the main reasons that led them to participate in the project was the development of specific skills that help them improve the way they do, immediately followed by the opportunity to develop skills related to mul-

ticulturalism. They also recognize the opportunity to improve the possibility of employability abroad, the development of foreign languages and the development of transversal skills.

Also listed were the development of relational and intellectual skills, specific knowledge and the opportunity to have a curricular internship. The students are, in general, satisfied with the intensive program that integrates Expeducom.

They value the methods used in practical activities, as well as the content and topics of the training units and the structure of the intensive program. They find, however, that the duration was not adequate. Considering the development of professional competences, the students point out that the design of activities that combine content and processes, which promote children's self-discovery and learning, and the creation of stimulating and challenging environments were the most relevant points during their participation.

All students recognized the importance of all the experiences and opportunities to stimulate the learning of the children, making a clear connection with the professional activity.

With regard to transversal competences, students consider that those that were most developed were the possibility of working in an international context, perceiving the culture of other countries, the ability to learn, interpersonal skills, decision making and teamwork. On the other hand, the least valued were the ability to solve problems, the opportunity to interact with experts, the development of critical thinking and the ability to investigate as well as initiative and entrepreneurship. Students identified the impact that the project had on their professional performance, which led them to value the diversity of the children as well as to develop experiential and integrative learning experiences that promoted their participation. They also recognized that there must be positive emotional involvement, and that situations should be created that stimulate reflection and involvement.

3. Conclusions

The internationalization strategy adopted by the European higher education system should continue to support and increase this type of experience, as it introduces learning and valuation factors that would otherwise be inaccessible. We refer to the valorization of multiculturalism and the possibility of working in diversified teams, which contribute to a greater openness and rigor in the learning process of students for active life.

The development of transnational pedagogical projects potentiates the development of different competences. Taking an active role in international working groups encourages a positive view of cultural diversity, teamwork, learning ability, respect for others' opinions and the development of communication skills. With regard to the specific competencies, the participants realised that the project allowed them

to value the diversity of children, to conceive activities that combine processes and contents, as well as contextualized experiential activities.

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