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## Article

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## THE UNIVERSITY ROLE IN DEVELOPING THE HUMAN CAPITAL FOR A SUSTAINABLE BIOECONOMY

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### Abstract

The developments in the bioeconomy area should reflect their usefulness regarding the provision of sustainable solutions for future competitiveness growth by using mainly natural resources. Nowadays the relevance of education, training and research in bioeconomy domain is obvious because these types of solutions which may be generated mainly by educated individuals who contribute to the better specialization of the human capital on this market. The aim of the research is to analyze the influence of universities upon the human capital activating in the bioeconomy sectors throughout the transfer of three types of knowledge: rational, emotional and spiritual. This goal is transposed into practice throughout exploratory quantitative research among students. The data obtained were then processed by factorial analysis in SPSS v.20, resulting in three relevant dimensions describing the phenomenon investigated. These factors manage to capture the facets of human capital in interdependence and interrelation with the dimensions of bioeconomy. The originality of the paper consists in formulating the research assumptions based on the nonlinear principles and components of the new entropic model of the intellectual capital of the organization. The study can be a starting point for designing strategies for increasing the human capital of organizations in various fields as well as of systems in the bioeconomy field.

**Key-words:** bioeconomy, human capital, intellectual capital, university, emotional knowledge, spiritual knowledge, rational knowledge, sustainable development

**JEL Classification:** I25, J24, O34, Q57

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## Introduction

For the European context the progress in the field of bioeconomy has become a priority objective of the European Union's Policy for research, development and innovation being coordinated by the principles of sustainability. Achieving this goal is implicitly aimed at developing biotechnologies that can be used at macroeconomic and global levels so that classical (high-cost) resources are replaced by renewable resources of biological nature (Aguilar et al., 2009; Meyer, 2017; von Braun, 2014). Bioeconomy, as a field of smart specialization, is considered as a viable source of competitive advantage for the European Economic Area, mainly by directing the transfer of scientific knowledge generated inside research centers towards innovative industries for the purpose of manufacturing raw materials and reliable materials, ecologic food, assertive and somatic medical devices, new chemicals, and renewable energy resources (European Commission, 2013; Steffen, et al. 2015; Mustalahti, 2017). Ensuring the transfer of knowledge at an advanced and thorough level will contribute to the exponential growth of the quality of the human resource (Staffas, et al., 2013). The more knowledge-sharing of production and business knowledge management will be more intense, broader and more transparent then the chances for employees to find the best solutions in their work will be greater. Moreover, the undifferentiated and non-discriminatory transfer of knowledge leads to the enhancement of the creativity and innovation potential of each employee and ultimately creates a real added value which is difficult for the organization to measure. From this point of view, the awareness of the importance of the infusion of knowledge and the speed with which the transfer of information is made become indispensable. Consequently, bioeconomy discoveries are launching extensive evolutionary processes that call for a global approach where the knowledge-based economy plays a defining role (Birner, 2018; Lainez et al., 2018).

The intellectual capital of an organization can be successfully operated through appropriate management strategies, these influencing the transformation of the potential intellectual capital (i.e. the available resources) into operational intellectual capital (i.e. results that increase the value of the organization). The benefits of an optimal management of the intellectual capital of an organization are numerous and generate an irreversible evolution on the scale of knowledge towards superior levels (Bejinaru & Iordache, 2011; Bratianu & Bejinaru, 2017).

As the field of bioeconomy is a new and extremely complex one it requires a capital of advanced knowledge on different specialized niches. Connected to this approach we focus to bring forward research figures and solutions mainly related to the area of education and training. We emphasize the overall purpose that we will contribute to building solutions for the improvement of education and training basing on results from our survey.

The reference concept that confers the originality of this research is the entropic model of intellectual capital (Bratianu, 2009) which is based on the theory of organizational knowledge and is developed on the basis of metaphorical thinking. The model functions according to the principle of entropy in a dynamic and nonlinear reference system and consists of independent components that we present as: rational knowledge, emotional knowledge and spiritual knowledge of the employees of an organization.

The originality perspective of the paper is found in the application of a questionnaire developed on the basis of the entropic model of intellectual capital which components we consider to be basic and independent, preserving its intellectual dimension. In this context, we argue that the canonical model of intellectual capital (Stewart, 1997) is outdated in both

the scientific and business spheres and no longer corresponds to the reality faced by business organizations in managing their resources (Bratianu, 2009).

## **1. Literature review**

### **1.1. Perspectives on bioeconomy**

In 2012, the European Union was stating a working definition for the bioeconomy by which the “bioeconomy encompasses the production of renewable biological resources and their conversion into food, bio-based products and bioenergy”. Essentially bioeconomy is interconnected with large fields as: agriculture, forestry, fisheries, food, pulp and paper industries, parts of chemical, biotechnological and energy industries (Dieckhoff et al., 2015, p. 11). In the new vision of the G7 Policy, bioeconomy is embraces both innovation and sustainability in order to support economic growth and employment. The G7 Policy states that bioeconomy must be understood as the knowledge-based production and utilization of biological resources necessary to provide products, processes and services in all sectors of trade and industry within the framework of a sustainable economic system (Dieckhoff et al., 2015). According to the previous perspectives we consider to having presented strong arguments which frame the bioeconomy paradigm in the interdisciplinary area of research, education, training and technology transfer within the academic context of which they belong to (Bratianu, 2007; Hansen and Bjørkhaug, 2017).

Technology transfer and commercialization is another important component which can be greatly intensified by universities and research centers. Innovations such as new patents for products or processes are easier to be transferred to the business sector throughout direct commercialization between the two parties: the universities and the companies (Dabija, Postelnicu & Pop, 2014). ”The greater the stock of patents of a university then there are bigger chances of leveraging them through contracts with businesses and thus to be more effective at seizing their innovations’ potential” (Bejinaru, 2017, p. 591). We mention that ”Ștefan cel Mare” University is in the position of national leader in the field of inventions according to the Romanian universities ranking both for the number of patents awarded and the number of patent applications registered by the higher education institutions at the State Office for Inventions and Trademarks – OSIM for the period 2007-2013. These data are recorded by the Official Intellectual Property Bulletins published by OSIM (2017). ”Ștefan cel Mare” University takes important steps to support entrepreneurship and innovation through projects won in national and international competitions (an exhaustive list of national and international projects run by ”Ștefan cel Mare” University in Suceava can be consulted at <http://www.usv.ro/index.php/ro/17/Proiecte/20/4>).

Besides European Union’s 2030 Strategy on Bioeconomy, there are emerging a series of official documents as real evidence “that regions worldwide are indicating bioeconomy a top priority. It is also largely accepted that bioeconomy is related to smart specialization processes” (Lianu, 2017, p. 23). Debates on this issue call for an understanding of the necessary progress in bioeconomy that may be realized by individuals throughout entrepreneurial innovation. Initiatives of specialization for the field of bioeconomy may be developed by clusters which due to their cross-sectoral configuration facilitate the collaboration between related industries and institutions. According to this view, “clusters have resulted to be real platforms for innovation and industrial change” (Izsak, 2014, p. 12) representing “springboards” which strongly increase the networking and cooperation

between businesses, research organizations and universities within various geographical areas like regions or countries (Lämmer-Gamp, et al., 2014; Prelipcean & Bejinaru, 2016).

Researchers and policy makers speak about various types of approaches which could enhance the transition towards the core of the bioeconomy but the developed research was focused to identify those actions which involve the domain of education in general and the participation of the university in particular. Specialists of the domain (Felt, 2007; Ribeiro and Millar, 2015) argue about a series of participatory approaches which in theory are idealistic but in practice might at times become limited:

- public education, whereby ‘experts’ in the public or private sectors provide other individuals and organizations with information on the bioeconomy;
- public dialogue, whereby ‘experts’ in the public or private sectors consult and set up forums for debate with other individuals and organizations;
- public co-production of knowledge, based on cooperation between a range of experts, citizens and interest groups.

Certainly that the examples are many and may be discussed various activities that aim to raise awareness of the bioeconomy among individual citizens and consumers (Pallett, 2012; Ribeiro and Millar, 2015).

## 1.2. The roles of universities in developing the human capital

The universities must take seriously their role in facilitating the access of small and medium enterprises to innovations and technology transfer by disseminating the results of its research and providing the know-how for its implementation. Another mission of the universities is of social leaders. This means that academia can and must offer models for society in terms of education, morality, behavior generating strategic thinking patterns (Bratianu & Bolisani, 2015; Hapenciuc et al., 2016; Bejinaru & Prelipcean, 2017).

Trends in the field of frontier sciences lead to the defining role of universities in the development of human capital engaged in a dynamic equation of bioeconomy at regional and multi-sectoral level. From our perspective, students must be viewed as future leaders shaped by the universities and launched into the market to engage all their knowledge and skills in the direction of achieving the progress for the companies in the branch and implicitly for obtaining an entrepreneurial competitive advantage (Hapenciuc et al., 2015).

Briefly we mention that universities should focus on increasing the impact of education and research; transferring knowledge and training the skills required for graduates to successfully practice their profession; “strengthening the knowledge triangle – education, research, business; increasing the capacity to meet the needs of the economy, creating self-financing mechanisms” (Lassnigg et al., 2017, p. 8).

The literature analysis clearly and unequivocally highlights the fact that macroeconomic strategies focus on key areas, which are priorities for the development of the bioeconomy, such as: fostering research and innovation, primarily in the field of biotechnology; promoting collaboration between industry, enterprises and research institutions; prioritizing the optimized use of biomass by implementation of the cascade principle and by utilizing waste residue streams; and providing funding support for the development of bio-based activities (de Besi & McCormick, 2015, p. 10473).

This research aims at reflecting the contribution of the "Stefan cel Mare" University on the development of intellectual capital (of students – as future leaders and employees), with impact on bioeconomy. The usefulness of the research approach is the overall picture that reflects the role of universities in preparing human capital and generating new knowledge for achieving a sustainable bioeconomy. As future active professionals on the labor market, the students of the "Stefan cel Mare" University will become components of the intellectual capital within the bioeconomy organizations and will make their contribution according to their preparation. Formation of a student in a higher education institution takes place through the transfer and acquiring of knowledge on several levels, namely: rational, emotional and spiritual (Lefter et al., 2011).

### **1.3. Knowledge as components of the entropic model of intellectual capital**

The entropic model of the intellectual capital for the development of a sustainable bioeconomy is build on the following principles: intellectual capital is formed as the effect of the dynamic process of rational, emotional and spiritual knowledge; the potential represented by intellectual capital can be capitalized through the action of organizational integrators; the revitalization of intellectual capital occurs through the creation of knowledge and through continuous learning; the key aspect that determines strategy development and implementation is the vision of leaders considered an entropic driving force within the organization (Bratianu and Orzea, 2013).

Research in the field of intellectual capital has excelled over the last 50 years mainly thanks to contributions by Edvinsson & Malone (1997), Roos (et. al. 2005), Stewart (1997) and Sveiby (1997). A series of innovations in the field of intellectual capital were introduced by Andriessen (2004) and Nissen (2006) who attribute the concept the character of flows and stocks. Further, the conceptual framework was extended by Bratianu (2009) by overcoming the linear mathematical space (used by previous theories) and the association of intellectual capital and knowledge concepts with a strongly nonlinear, dynamic and asymptotic domain.

We propose the conversion of the basic composition of intellectual capital into a new structure of entropic intellectual capital, based on the following innovative arguments:

- the dynamic interactions of rational, emotional and spiritual knowledge are the real generators of organizational intellectual capital;
- organizational intellectual capital is viewed in the two hypostases, both as potential and operational. The transformation of the potential intellectual capital (based on existing internal resources) into the operational intellectual capital (results as products and processes) is achieved with better efficiency through the influence of "organizational integrators: leadership, management and organizational culture" (Bejinaru, 2017, p. 511). Integrators, were introduce as a distinct concept by Bratianu (2009, p. 99) according to whom they represent "a powerful field of forces capable to combine two or more elements into a new entity, based on interdependence and synergy";
- the enrichment of intellectual capital in an organization is achieved through its dynamic capabilities, such as innovation and learning processes;
- this theory of intellectual entropic capital is conditioned by the existence of a strong vision capable of impelling the organization in order to gain competitive advantage and thus reinvent the long-term success of the organization;

The *rational knowledge* is the result of a reflective mental process. Rational knowledge is obtained throughout the processing of data and information using our rationality and for a long period has been the only knowledge accepted by philosophers and scientists due to its objectivity (Polanyi, 1983; Nonaka și Takeuchi, 1995). In this view, rational knowledge can be measured due to its extensive dimension, can be accumulated, stored and disseminated, providing a quantitative description.

*Emotional knowledge* is generated by interaction of the individual with the environment and operates feelings and emotions. These proved to be a critical factor for granting the success of the motivation and innovation systems in organizations (Goleman, 1995; Hill, 2008; Kahneman, 2011). Emotional knowledge can be measured due to its intensive dimension and generate different intensities of feelings and emotions, providing a qualitative description.

Within the spectrum of *spiritual knowledge* are included the core values, goals, the deepest meanings and highest motivations at individual and organizational levels (Zohar & Marshall, 2000). Considering that rational knowledge is the equal of what we think and that emotional knowledge is the equivalent of what we feel than, we may assume that, the spiritual knowledge represents what we are. The power of spiritual knowledge may be used to generate the necessary determination of individuals to reach their goals.

From the perspective of the presented theory of the entropic intellectual capital, we may consider that in any organization there are three fields of knowledge – cognitive, emotional and spiritual – that are in a continuous dynamic. That means that one form of knowledge can be transformed into another form of knowledge, as happens in physics where one form of energy can be transferred into another form of energy under the action of a field of forces.

## 2. Research methodology

The research aims to reflect the contribution of "Ștefan cel Mare" University in Suceava on the development of intellectual capital (students – as future leaders and employees) with impact on the bioeconomy. The usefulness of the research approach stems from the global image that reflects the role of universities in preparing human capital and generating new knowledge for the realization of a sustainable bioeconomy.

The collectivity investigated within this research is represented by the students of "Ștefan cel Mare" University in Suceava, the final years of the bachelor, master and doctoral cycles. We chose to do this research at the level of students in the final years, because the subject is generally not accessible to all students, and we thought that by choosing students who are about to complete a university education cycle, we maximize the chances of getting informed.

The exploratory research has essentially sought to provide a basis for analysis that allows to draw out guidelines on how rational, emotional and spiritual knowledge influences and potentiates, the knowledge in the field of bioeconomy at the level of students in at the "Ștefan cel Mare" University in Suceava.

The selection of students from the "Ștefan cel Mare" University in Suceava is motivated by the fact that starting October 20, 2016, this university, along with economic agents from Suceava and Botoșani counties, the Chambers of Commerce and Industry of Suceava and Botoșani, the Suceava City Hall, the Botoșani City Hall and the Suceava County Council

form the Innovative Regional Cluster of Bioeconomy Suceava-Botoșani. The Association aims to provide an efficient framework for cooperation among its members in order to increase the Research & Development capacity and innovation in the North-East region of Romania, to represent their interests towards third parties, to increase the regional competitiveness in the field of bioeconomy and to increase the capacity to implement European agricultural and industrial policies, including the efficient use of non-reimbursable funds as well as other sources of funding.

The study was based on a sample of 386 students from several faculties (Faculty of Forestry, Faculty of Food Engineering, Faculty of Economic Sciences and Public Administration, Faculty of Physical Education and Sports – Department of Health and Human Development, Faculty of History and Geography, Faculty of Electrical Engineering and Computer Science, Faculty of Mechanical Engineering, Mechatronics and Management) of the considered university. The selection of faculties was based on the connections found between the curricula of these faculties and the priority themes of research in the field of bioeconomy: raw materials, food and chemicals, energy resources, economic and industrial exploitation of advanced biotechnologies.

### **2.1. Research purpose and hypotheses**

The socio-statistical study aimed at identifying the most influential factors in the students' knowledge spectrum, regarding the evolution of human capital in the field of bioeconomy. In order to achieve the previously mentioned goal we have formulated the following research associated hypotheses:

H1: The formation of human capital in the bioeconomy field is influenced by the transfer of rational knowledge to students.

H2: The formation of human capital in the bioeconomy field is influenced by the transfer of emotional and spiritual knowledge to students.

H3: It is possible to identify a major interest of the students of “Ștefan cel Mare” University of Suceava regarding the thematic of the research in the field of bioeconomy.

H4: There are no significant differences between the two gender students in assessing transfer of rational, emotional and spiritual knowledge or in the field of bioeconomy at the investigated university.

H5: There are significant differences between the students from the social-humane sciences faculties and those from the technical faculties regarding the evaluation of the transfer of rational, emotional and spiritual knowledge in the field of bioeconomy at the level of “Ștefan cel Mare” University of Suceava.

H6: There are significant differences between the students from the three education cycles in the evaluation of the transfer of knowledge of rational, emotional and spiritual knowledge and in the field of bioeconomy at “Ștefan cel Mare” University of Suceava.

### **2.2. Design of research**

The research questionnaire was developed on the basis of consultation of the specialized literature and in consensus with the purpose and hypotheses of the research (Hapenciuc et



al., 2008). In view of the hypothesis proposed in this study, we chose to develop an exploratory research based on direct survey (questionnaires were applied by the interviewers to students) combined with the indirect survey through the online questionnaire (the researcher and the investigated persons do not come at all in direct contact) (Hapenciuc et al., 2015) available between January and February 2018.

The advantages identified for this approach are either of a general nature – lower costs, convenience for the respondent, integrity of data, etc.; or of a specific nature – the qualitative nature of the variables of research and the general difficulty makes the poorly operational questionnaire for direct administration, – administration (distribution by post, e-mail, modern means of communication are particular cases of self-administration) is a solution that gives the respondent the time to respond (Savoiu and Dinu, 2012).

As a first step, the questionnaire was subjected to the pilot test procedure on a number of 25 students to ensure its clarity and comprehensiveness (Dinu, Dabija & Savoiu, 2016). During this phase the following aspects were checked: • if the terms used are easy to understand and do not lead to confusion; • if the order of questions does not lead to negative reactions; • if the question form allows gathering the necessary information; • if some questions are not helpful; • if the input and link texts are sufficient and effective; • if the answers to closed questions are exhaustive; • if the questionnaire response time does not exceed 10 minutes; • if the number of open questions is not too big to tire the respondent.

In order to synthesize the collected data, a factorial analysis was performed that allowed identification of the most significant factors capable of describing the coordinates of the investigated population. The accuracy of the method was verified using the Bartlett and Kaiser-Meyer-Olkin tests. The KMO test made it possible to determine the effectiveness of applying the factor analysis to the data collected (Bratianu & Vatamanescu, 2017). In order to perform factorial analysis, the main component extraction is the first step, followed by the rotation process, where we chose the Varimax variant (Arkkelin, 2014).

An analysis of the internal consistency, namely Cronbach's Alpha, of the measurement scale was performed at the level of the identified factors to test the reliability of all the variables. The test results indicated values greater than 0.7, proving a good internal consistency: factor 1 = 0.946, factor 2 = 0.939 and factor 3 = 0.893.

In order to verify the hypotheses of differences in student reporting to the three categories of factors by gender, faculty profile and study cycle, we used a series of nonparametric tests that correspond to the centralized data typology. In the case of alternative (dichotomic) grouping we used the Mann-Whitney U test and in the case of non-alternate variables I chose the Kruskal Wallis test.

### **3. Interpretation of survey results**

Application of Bartlett test retrieved a value smaller than 0,001 allows us to conclude that the correlation matrix is not an identity matrix and consequently the factorial analysis can be applied. Both the Bartlett test and the KMO test suggested a very good accuracy for using the factor analysis for the present research. More specifically, the KMO test value of 0.96 indicates that correlation patterns are relatively compact and factorial analysis can be used on this sample. The values of the Bartlett tests indicate the suitability of the research method for the obtained database, as follows: Chi-square = 8694,65 and Sig. = 0,000.

The values of each factor revealed by the factorial analysis are representing the variance explained by that linear composition (Savoiu și Dinu, 2012; Dinu, Dabija & Savoiu, 2016). Thus, it can be seen that the first factor explains about 42% of the total variance and the cumulative first 4 factors account for about 62% of the total variance. The component matrix retrieved by the Varimax rotation method indicates 3 factors around which the results obtained for the questions in the applied questionnaire are grouped together. The first factor includes 14 variables / indicators, factor 2 includes 13 variables / indicators and factor 3 includes 8 variables / indicators.

Throughout the questionnaire, all the variables related to the knowledge categories were measured on a semantic scale, assessing the degree to which the respondent agreed with the presented claims. A Likert scale was used in seven steps from 1 (total agreement) to 7 (total disagreement).

At the level of the variables grouped under factor no. 1, which refers to the knowledge and willingness of students to participate in bioeconomy research activities, there is generally a moderate degree of approval, the average of answers being 2,71. This situation can be explained by the fact that not all respondents are familiar with the specific notions of bioeconomy, with students being selected from different faculties with different profiles (social sciences, human science, engineering science, computer science and other). Regarding the variables grouped within the other two factors (rational knowledge and emotional and spiritual knowledge) the degree of approval is slightly higher (averages being 2,36 and 2,49 respectively).

Analyzing the results of the Mann-Whitney U test on the differences in the three factors (categories of knowledge) between male and female students, we can say that the differences are not significant (Table no.1).

**Table no. 1. Mann-Whitney U Test of difference between male and female students**

	<b>Gender</b>	<b>Sample's volume</b>	<b>Mean Rank</b>
Factor 1	Male	139	183.23
	Female	233	188.45
Factor 2	Male	139	180.40
	Female	233	190.14
Factor 3	Male	139	194.04
	Female	233	182.00

At the level of factor 1 (*bioeconomy knowledge*) we have an average of 183.23 grades for male students and an average of 188.45 for female students, which is a small, negligible difference (Sig. = 0,651). The data is similar for factor 2 (*emotional and spiritual knowledge*) as we identify small differences between rank averages, like 180.40 for male students and 190.14 for female students (Sig. = 0,398). A slightly bigger difference but insignificant from statistical point of view is found in relation to factor 3 (*rational knowledge*), the average grade for male students is 194.04 and for female students of 182 (Sig. = 0,296).

Neither for the Mann-Whitney U test results on the differences in the three factors (*knowledge categories*) between students from social sciences profile faculties and those from technical profile faculties can be said to be significant (Table no.2).

**Table no. 2. Mann-Whitney U Test of difference between students  
from different profile faculties**

	Faculty profile	Sample's volume	Mean Rank
Factor 1	Engineering/Technical	147	189.72
	Social-humane	239	195.82
Factor 2	Engineering/Technical	147	198.13
	Social-humane	239	190.65
Factor 3	Engineering/Technical	147	189.07
	Social-humane	239	196.22

At the level of factor 1 (*bioeconomy knowledge*), we have a ranks average of 189.72 grades for students from technical profiles and an average of 195.82 for students from social sciences profiles, indicating a difference that is insignificant (Sig. = 0,602). For factor 2 (*emotional and spiritual knowledge*) again, small differences are found between rank ranges, 198.13 for students from technical profiles and 190.65 for students from social sciences profiles (Sig. = 0,522). A similar situation, insignificant from a statistical point of view, is found in relation to factor 3 (*rational knowledge*), the average rank for the students from the technical profiles is 189.07 and for the students from the social sciences 196.22 (Sig. = 0,541).

If from the perspective of the gender and the profile of the faculty we did not find significant differences in the level of the three factors (knowledge categories), the situation is different from the perspective of the cycle of studies (Bachelor's, Master's and Doctorate). Analyzing the results of the Kruskal Wallis test for independent samples on the differences in the three factors (*knowledge categories*) for students from the three education cycles, we can say that the differences are significant (Table no. 3).

**Table no. 3. Kruskal Wallis Test of difference between education cycles**

	Study cycle	Sample's volume	Mean Rank
Factor 1	Bachelor	260	200.76
	Master	107	186.09
	Doctorate	19	135.95
Factor 2	Bachelor	260	202.01
	Master	107	183.43
	Doctorate	19	133.74
Factor 3	Bachelor	260	201.82
	Master	107	187.20
	Doctorate	19	115.11

At factor 1, the willingness to extend their bioeconomy knowledge, we have an average of 200.76 for undergraduate students, 186.09 for those in the master's cycle, and an average of 135.95 for undergraduate students at the doctoral cycle, which indicates a significant difference in these three categories of students (Sig. = 0,036). The lowest score, which differentiates the most obviously from the other two, is found in the students of the doctoral cycle, indicating somewhat greater reluctance presented by them in addressing research topics related to the field of bioeconomy. This issue can be argued by the fact that the course of doctoral research is relatively rigid, the research theme chosen is difficult to

change, especially if the coverage of such a thematic area was not considered in the research plan. Therefore, we consider recommending a stronger promotion among coordinating teachers of the importance of this thematic area in the field of doctoral research. For bachelor and master courses, this reticence is not noticeable and it is gratifying that students are open to deepening and having research concerns in the bioeconomy field. From this perspective, a curricular adaptation is recommended, which includes a larger proportion of disciplines related to bioeconomy.

For factor 2 (*emotional and spiritual knowledge*), we find a similar picture, as there are significant differences between rank ranges, 202.01 for undergraduate students, 183.43 for master students and 133.74 for students from the doctoral cycle (Sig. = 0,020). Again, the lowest score, which differs significantly from the other two, is found in the students of the doctoral cycle, indicating that the doctoral students feel to a lesser extent the influence of the academic environment on the orientation of students to the thematic area of bioeconomy.

The differences appear to be more pronounced in terms of factor 3 reporting (*rational knowledge*), the average rank for students in the Bachelor's cycle is 201.82, for Master's students is 187.20, and for students in the cycle PhD is 115.11 (Sig. = 0,004). These differences indicate that with the advancement of university cycle education, students become increasingly aware of the technical and material endowment needs of specialized teachers to enable them to conduct a sustained and performing research activity in related bioeconomy.

### **Conclusions**

Bioeconomy is considered at European and world level as a fundamental source of competitive advantage throughout the transfer of scientific knowledge generated by research centers and universities to innovative industries in order to produce goods using renewable biological resources from soil and sea – such as crops, forests, fish, animals, microorganisms as well as waste – as raw materials for food, feed and industrial and energy production. Because the field of bioeconomy is a new and extremely complex one, it requires an advanced knowledge base on different niches. Universities must seriously take a participatory role in facilitating companies' access to innovations and their implementation so as to provide society as a whole with sustainable solutions for enhancing competitiveness.

This idea must be transposed into a convergent national policy, which means that with the efforts invested in educating students, a certain degree of development can also be achieved for the area of the bioeconomy – when they will integrate into the labor market. In order for the previous policy projection to become viable, universities should address and implement a strategic management process within a series of actions applied to the educational process, the research process, the inclusion of highly qualified young people in the labor market and the process of collaborating with enterprises.

The theoretical implications aim at changing the scientific perspective on intellectual capital and introducing the new entropic model, both in terms of its principles of functioning and the characteristics of its components, namely rational knowledge, emotional knowledge and spiritual knowledge.

The entropic model of intellectual capital is particularly relevant to top managers because it offers the possibility of evaluating the organizational resources by independent and non-overlapping components. Dynamics of knowledge and intellectual capital must be the priority concern of managers as they are permanent active sources for innovation, creation and solutions.

For the category of "policy makers" the advantage lies in the fact that there is a more precise delimitation of the components of the entropic model of intellectual capital that preserves their intellectual dimension and independence. This perspective is managerial and not accounting.

Thus, we considered it important to evaluate to what extent the essential components of the entropic model of intellectual capital influence students' behavior in terms of their attractiveness and availability to improve / specialize in the current field of bioeconomy.

By using the main component analysis method, we were able to identify 3 factors around which the results recorded for the questions in the applied questionnaire are grouped together. Thus we can say that the first two hypotheses of the study are confirmed, according to which we state that the formation of human capital in the field of bioeconomy is influenced by the transfer of rational, emotional and spiritual knowledge to the students.

The descriptive statistics obtained from the application of the questionnaire at the students of "Ștefan cel Mare" University of Suceava showed that there is a major availability of students regarding the current themes of bioeconomy research, which allows us to assume that hypothesis number 3 is also confirmed.

Applying the Mann-Whitney U test to the collected data has allowed us to point out that there are no significant differences between the students by gender in the evaluation of rational, emotional and spiritual knowledge transfer and in the field of bioeconomy at the level of the Ștefan cel Mare University, from Suceava. This allows us to assume that hypothesis number 4 is confirmed.

Also, through the same type of test, we pointed out that there are no significant differences between the students from the social-humane faculties and those from the technical faculties regarding the evaluation of the transfer of rational, emotional and spiritual knowledge in the field of bioeconomy. This fact is encouraging and allows the use of a unitary university-level strategy to popularize bioeconomy research topics at the students' level. Concluding the above, we can say that hypothesis number 5 is not confirmed.

The Kruskal Wallis Test for testing statistical independence revealed that there are significant differences between the students in the three education cycles in assessing the transfer of rational, emotional and spiritual knowledge and in the field of bioeconomy at the level of "Ștefan cel Mare" University in Suceava. The test showed that the greatest difference is found among the students of the doctoral cycle, indicating a greater reluctance on the part of them in addressing bioeconomy research themes. Therefore, we believe that stronger promotion among coordinating teachers of the importance of this thematic area for doctoral research is required, and curricular adaptation, including a larger proportion of bioeconomy disciplines, is also recommended. Conclusively, we can say that hypothesis number 6 is confirmed.

In this analytic approach we evaluate to what extent these types of knowledge (as essential components of the *entropic model of intellectual capital*) are influencing the behavior of

students. Thus, based on the results of the statistically processed data from the investigation, we can discover the influence of each type of knowledge on students' behavior and we can further identify the composition of the most powerful influence factors.

The main action directions for universities for the purpose of developing the European bioeconomy field could be synthesized as follows: to foster new skills important for science; to have an integrative approach of research, education and co-operation; to create partnerships between universities, research centers and businesses; to enlarge inter and multidisciplinary approaches; to intensify knowledge and technology transfer and not the least to increase the public awareness and thus to facilitate the communication of science towards the society. We note that no similar research has been carried out with the application of a questionnaire aiming to identify the intellectual capital elements according to the entropic model. In the future, these results will be able to contribute to the programming of the educational process and to the transfer of bioeconomy knowledge to students in order to improve and develop the human capital that is a product of the university.

The main limitation is represented by the investigated collectivity, represented only by the students of "Ștefan cel Mare" University of Suceava, with heterogeneous distributions across the 6 counties of the North-East Region. Though, we consider that by analogy, the survey might be successfully applied to students from other universities also. Another limitation is represented by the short/limited period possible to be allocated for the survey, which restricted the number of the variables included in the questionnaire. A third limitation specific for this survey, we consider to be the relatively low number of respondents for the study domains which influence greatly the level of knowledge, the types of knowledge and the quality of knowledge feedback. For the future continuation of this research the stated limitations should be eliminated in order to obtain much more relevant results.

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