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Innovation management in higher education: Nano sciences and technologies for scientific citizenship

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Abstract

This paper explores significant trends in contemporary higher citizenship education, innovation management, including a specific focus on the role of market forces, mobility, new technologies, new emerging identities, and quality assurance in higher education that has started to move towards assessing educational and labour market outcomes instead of inputs. Taking into account specific economic, social and cultural contexts, an essential challenge for higher education systems is to combine the encouragement of efficiency and excellence with the promotion of equity and access in the context of increasing competition when carrying out their core missions of teaching and research, when developing and implementing innovative citizenship education programs, and when providing additional privileges and services to individual citizens and the society, the amount and range of which is now vast. In this paper we address these issues both from a quantitative and qualitative standpoint. The key issues under research include the Systemic approach to innovation management as a synergy of technosciences and humanosciences in citizenship education at Riga Technical University, Aeronautics Institute (Riga, Latvia), to comparing the criteria and indices of its study programmes and their compatibility. Sociometric matrix method applied to institutional complex ratings is the factor that integrates all the elements. The research results have demonstrated that the developed Rating Assessment Model of Institutional Performance offers the methodology for citizenship education in Higher Education Institutions that helps to direct efforts to get recognition for maintaining and improving the academic quality by evaluating and demonstrating that high standards are being met and academic activities are also in accordance with the national policies striving to further enhance the standards according to international practices and development and international compatibility. Implementation of the obtained research results can contribute to the development of scientifically grounded concept for innovation management in citizenship higher education, to stimulate compatibility self-assessment, eliminate weaknesses and build upon strengths.

Keywords: *contemporary higher citizenship education, synergy of technosciences and humanosciences, new emerging identities, innovation management and new technologies*

1. A crucial question of innovation

Innovation is critical to the continuous improvement of citizenship education and the delivery of increased learning outcomes, equity, cost-effectiveness and student satisfaction. Innovation is a driver of growth and well-being. Innovation is the spark of insight that leads a scientist to investigate an issue or phenomenon. That insight is usually shaped by an observation of what appears to be true or the creative jolt of a new

idea. Innovation is driven by a commitment to excellence and continuous improvement. Innovation is based on curiosity, the willingness to take risks, and experimenting to test assumptions. Innovation is grounded on questioning and challenging the status quo, as well as on recognizing opportunity and taking advantage of it.

The term innovation can be defined as something original and, as a consequence, new, that 'breaks into' the market or society. A definition consistent with these aspects would be the following: 'An innovation is something original, new, and important in whatever field that breaks in to a market or society' (Frankelius, 1991). Innovation is the process of translating an idea or invention into a product or service that creates value and for which consumers will pay.

Innovation can be viewed as the application of better solutions that meet new requirements, in-articulated needs, or existing market needs. This is accomplished through more effective products, processes, services, technologies, or ideas that are readily available to markets, governments and society.

In the world of education, innovation comes in many forms. There are innovations in the way education systems are organised and managed, exemplified by charter schools or school accountability systems. There are innovations in instructional techniques or delivery systems, such as the use of new technologies in the classroom. There are innovations in the way teachers are recruited, and prepared, and compensated. The list goes on and on. *Our mission* is to promote student achievement and preparation for global competitiveness by fostering educational excellence and ensuring the primary human right – social welfare, the building blocks of which constitute today

- education, which ensures scientific awareness for informed case studies, knowledgeable problem solving and responsible decision making and, as a consequence, better employment prospects;
- new technologies, which ensure the increase of the quality of life;
- healthcare, which ensures sustainable physical activity.

According to Peter F. Drucker, the general sources of innovations are different changes in education structure, industry structure, in market structure, in local and global demographics, in human perception, mood and meaning, in the amount of already available scientific knowledge, etc. Once innovation occurs, it may spread from the innovator to other individuals, groups, or sectors of activity. This process can be described using the 's-curve' (a 'sigmoid curve' or a sigmoid function which is a mathematical function having an 'S' shape, see Figure 1) .

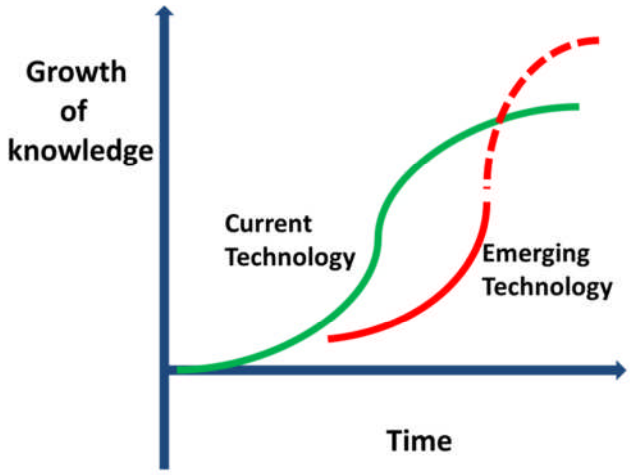

Figure 1. New technology contribution to the growth of knowledge added value against time

The s-curve maps the growth of knowledge added value against time. In the early stage of a particular innovation, the growth is relatively slow as the new product/service establishes itself. At some point, informed consumers begin to demand the product/service and the growth increases more rapidly. New incremental innovations or changes to the product/service allow the growth to continue.

Many scholars claim that you can have the better high tech or software, but there are also crucial learning tasks important for innovation. In 1903, a seminal researcher Gabriel Tarde first plotted the S-shaped curve and defined the innovation-decision process strategies as a series of steps that included:

1. First knowledge;
2. Forming an attitude;
3. A decision to adopt or reject;
4. Implementation and use;
5. Confirmation of the decision (Tarde, 1903).

It is important to develop an effective innovation system as it builds synergies across various domains and disciplines. Innovation is, above all, about combination and convergence.

2. Innovative Converging Technologies for sustainable consumer society

There is nothing more constant in our life than change. Innovation has become our life's imperative! Even within the observable time span there has been a tremendous increase in innovation brought about by technology development but much less impressive gains in human development.

Innovative emerging and converging technologies, products, services and organisations create jobs and rejuvenate industries – while making others obsolete. In the current decade, a new concept of 'Converging Technologies' (CT) has become a buzzword in education, science, and technology research circles. This concept differs from the older notions used, for example, in the computer and media fields.

At the core of the new concept are interrelations, interconnections, synergies or syntheses between broad fields of disciplines, research and development, such as nanoscience and nanotechnology, biotechnology and the life sciences, information and communication technologies, cognitive science, neurotechnologies and even humanities. Robotics, Artificial Intelligence and other fields of research and development are also taken into account. Innovative and converging technologies have therefore been characterised as a platform for exploring the future impact of all sciences, technologies and engineering on the sustainability of the society. Innovation is the process of translating an idea or invention into a product or service that creates value and for which consumer society will pay (Frankelius, 2009).

Society belongs to all of us. What we put into it creates what we get out of it. It is obvious that the society is best when we all bring our energy, intellect and judgment to it (Figure 2). But if we, as consumers, are informatively ignorant and scientifically illiterate, what kind of input can we provide? How can we affect policymaking and expect a dignified output?

Figure 2. Citizen consumer input into the society and the produced output

The question arises: 'Does higher education today fulfill its role as a major catalyst to provide the necessary knowledge and relevant skills mix for our students to be prepared to join the highly technological global economy and to ensure sustainable future for themselves, in the first place?'

Unfortunately, we have to recognise that higher education today has become a marketed commodity (Figure 3). Students, as knowledge consumers, choose universities according to their rating, attractive brand image, labour market accessibility, cost-effective fees, etc.

Universities compete for students as loyal consumers, for ratings, innovative programmes, grants, and so on and so forth.

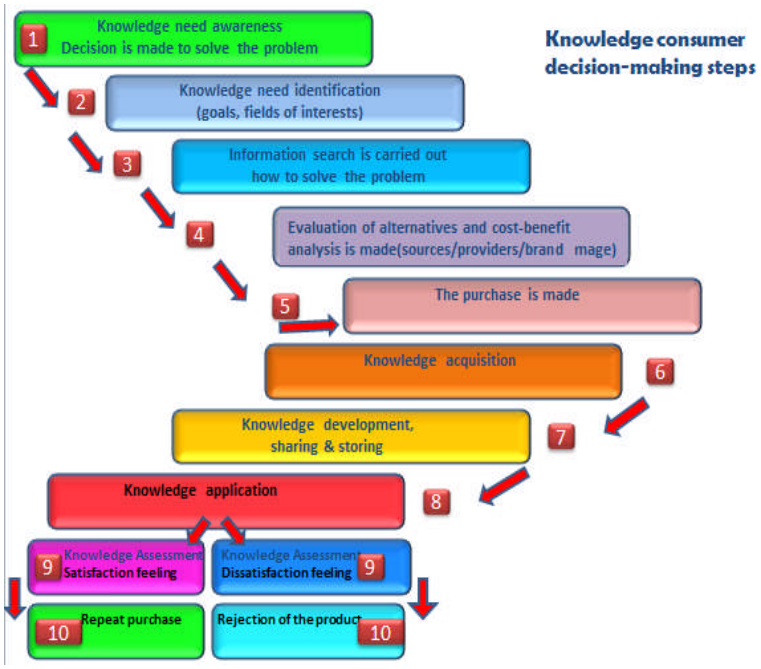

Figure 3. Knowledge consumer decision-making steps

Thus, one of the significant trends on the educational market is that the assessment of education quality has started moving towards the assessment of educational and labour market outcomes instead of inputs. We question ourselves as educators: 'How can we as researchers and educators address this context? Do we need to fundamentally change our practices?' The answer will sooner be – 'Yes'. Because we have to move with the times, to be constantly on our tiptoes – to be innovative, to be able to lead our students being one step ahead.

It is the role of higher education to develop skills and values required to enhance democratic life for everyone comprising both rights and responsibilities, and making their informed citizen voices heard in policy decision-making. Democracies need knowledgeable problem solvers and responsible decision makers to ensure sustainable development of the consumer society.

3. Managing innovation in education: the four pillars

Finding innovative solutions to important educational problems is not only hard, but complex. There are lots of various problems and countless potential approaches to each

one of them. Even the most competent institution, which deploys resources wisely, still, needs to manage innovation effectively.

Unfortunately, *innovation* is often conflated with *strategy*. Strategy, after all, is a coherent and substantiated logical cogitation for making choices, while innovation is a complex, messy business which creates novel solutions to important problems. To put it simply, strategy is about achieving objectives, while innovation is about discovery; we never know exactly where we are going until we get there. Therefore, innovation needs efficient management (Figure 4).

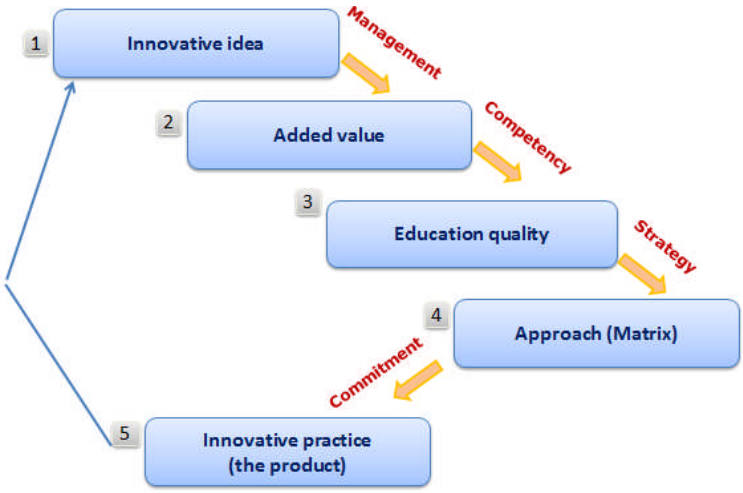

Figure 4. Managing educational innovation: the four pillars

By managing innovation we enhance the quality of education. In its turn, the quality is enhanced by means of knowledge added value, which needs a certain approach to be applied and commitment to achieve the goal. Knowledge added value refers to the contribution of the *factors* of education – for example, innovative technologies taught and used in raising the intellectual capital, thus, consequently increasing the value of the 'product' of education.

Outside of economics, value added refers to 'extra' features of a person or services that go beyond the standard expectations and provide something 'more' while adding intellectual capital to the 'cost' of a person or service. Value added features (in fact, professional competences) give competitive edges to companies that employ young specialists.

Nowadays, value-added methodologies and measurements are being utilised in Latvian education as part of national movement towards raising the intellectual capital and personality features. The method is quite simple: the student's actual score is compared

to the previous score. The difference is assumed to be due to the teacher and the university (Figure 5).

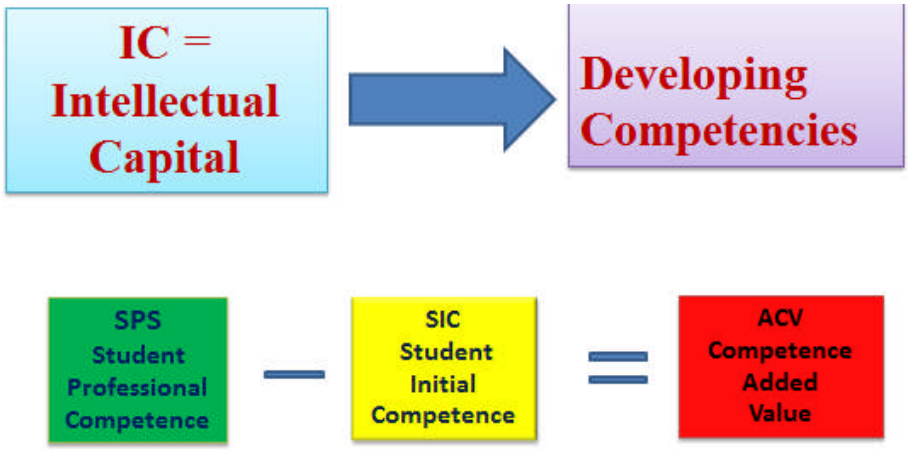

Figure 5. Creating knowledge added value

In this way, value-added modelling isolates the teacher's contributions from factors outside the teacher's control that are known to strongly affect student test performance, including the student's general intelligence, other people involvement - outside tutoring.

4. Innovative measurements of higher education institutions compatibility

Innovations are adopted when users integrate them in meaningful ways into existing social practices. However, unless fundamental changes are made in the educational infrastructure to reverse the general erosion of science, technology, engineering, and math (STEM) education and to address the specific growing need for its synergy with humanitarian education, there will not be any robust workforce with the potential to change the society for the better in a highly technological economy.

Therefore, in our educational practice at Riga Technical University, Aeronautics Institute, we attempt to attract and retain students by offering them a variety of qualifications, the state-of-the-art education and training based on the Systemic approach, innovative programs and methods of teaching building synergies across various disciplines, investment in new technologies (particularly, nanotechnologies by creating applied research laboratories), comfortable educational environment and an appropriate communication system, attractive brand image with the developed organisational culture, advantageous education fees, and lots of other factors, which determine the university compatibility on the local and international educational markets. But this demands a continuous control, because competition is very tough and compatibility is not granted or inherited; it has to be constantly assessed and developed.

To keep the process under control and to assess the quality of education provided, we have developed a method of sociometric matrices – Rating Assessment Model (RAM) based on the sociometric analysis outlined by Moreno in 'Who Shall Survive?'. It consists of five basic stages: 1) criterion selection, 2) matrix formation, 3) sociogram charting, 4) analysis, and 5) application.

Special systemic criteria/factors are necessary to determine (left vertical margin) and conventional competitors are to be defined (top horizontal margin) (Figure 6).

Competitiveness of higher school

1. **Number of students per academic staff units**
2. Number of professors per academic staff units
3. Part of budget places per total student number
4. Part of social credit places per total student number
5. Number of accreditated study programmes
6. Average Cost of Study
7. Social priority of the higher school

Higher School	1	2	3	4	5	6	7
1	16	0,2	0,2	0,5	7	2200	0,5
2	20	0,4	0,1	0,6	10	1200	0,6
3	12	0,3	0,1	0,7	20	1500	0,7
4	14	0,1	0,4	0,5	4	1600	0,4
5	10	0,15	0,6	0,3	8	2500	0,3

Domination Matrix of the 1st factor

$$D_1 = \begin{pmatrix} 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 \end{pmatrix}$$

Figure 6. Rating Assessment Model of institutional performance

The matrix is completed based on the initial data in which all the choices and/or rejections are presented - the so-called a matrix of domination - D. Further on, a ranking matrix according to each criteria/factor is calculated and the results are registered in the appropriate cells (Figure 7).

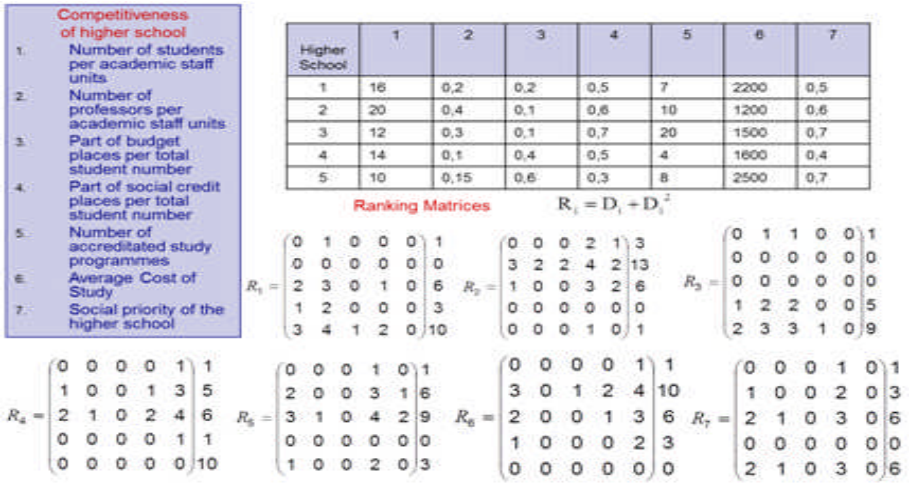

Figure 7. Complex Rating Assessment Model of HEIs

As a result, it is possible to calculate the final institutional ratings of higher educational institutions (HEIs) (Figure 8).

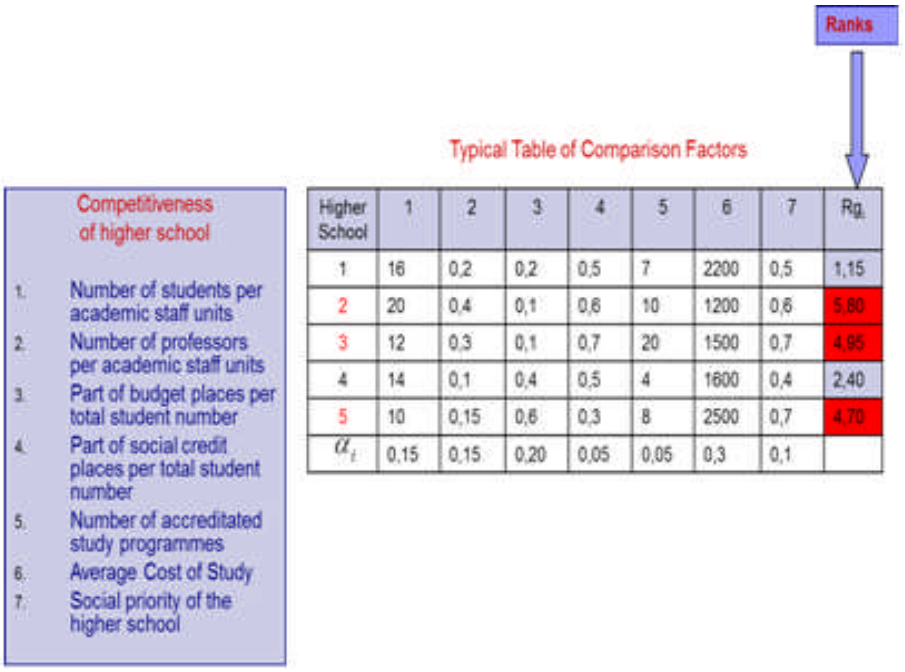

Figure 8. The final institutional ratings of higher educational institutions (HEIs)

The Rating Assessment Model of institutional performance is a very useful and worthy method which allows seeing the real picture of positions occupied by different HEIs in the country (Figure 9).

Competitiveness of higher school

1. Number of students per academic staff units
2. Number of professors per academic staff units
3. Part of budget places per total student number
4. Part of social credit places per total student number
5. Number of accreditated study programmes
6. Average Cost of Study
7. Social priority of the higher school

Typical Table of Comparison Factors

Higher School	1	2	3	4	5	6	7
1	16	0,2	0,2	0,5	7	2200	0,5
2	20	0,4	0,1	0,6	10	1200	0,6
3	12	0,3	0,1	0,7	20	1500	0,7
4	14	0,1	0,4	0,5	4	1600	0,4
5	10	0,15	0,6	0,3	8	2500	0,3

Total Rank of the Higher School:

$$R^{(j)} = \sum_{i=1}^{7} \alpha_i R_i^{(j)} = \alpha_1 R_1^{(j)} + \alpha_2 R_2^{(j)} + \alpha_3 R_3^{(j)} + \alpha_4 R_4^{(j)} + \alpha_5 R_5^{(j)} + \alpha_6 R_6^{(j)} + \alpha_7 R_7^{(j)}$$

where $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7$ $\sum_{i=1}^{7} \alpha_i = 1$

are the weighting (priority) coefficients of research factors

R – is the general rating of a particular institution, j- is the number of the institution, *α* – is the weighting (priority) factor, and *i* – is the number of criteria/factor.

Thus, it is possible to locate the sociometric stars, rejectees, and isolates, which allows seeing the share of a certain criterion in the institutional rating. Stars are those institutions that have received the largest number of positive responses according to the defined criteria/factors. Rejectees receive the largest number of negative responses. Isolates are those institutions that have received no positive or negative responses, they have not been chosen at all (Lobanova-Shunina & Shunin, 2013).

Conclusion

Values reflect and shape the ongoing social development. Understanding the impact of innovative technologies, as nanotechnology, biotechnology, information and communication technologies, neurotechnologies, etc., that converge or compete to fit into what can be called an ecosystem of technological and societal arrangements is crucial for the future development of sustainable consumer society.

Societal and technological arrangements co-evolve. This co-evolution happens most favourably in an educated, intellectual, and affluent society that is tolerant of change and divergent views. By fostering an educated, intellectual society it creates conditions that foster responsible moral and social behaviour of the consumers and contributes to

shaping intellectual mankind. Higher education has to be at the heart of these processes, ensuring accessible information that will allow people to better understand what innovative technology is, how it will be applied, what place it will occupy in their future profession, and its implications for society (Lobanova-Shunina, Shunin, 2011a).

Implementation of the obtained research results can contribute to the development of scientifically grounded concept for higher education institution management, stimulate compatibility self-assessment, eliminate weaknesses and build upon strengths. In terms of management, the key factor becomes economic effectiveness. The research highlights the interdependence of the elements of the institutional management system with key economic indices of its performance and outcomes.

Providing knowledge and skills, sharing the newest technological information is one of the most important roles of higher education. Knowledge has become the most valuable resource. Learning to move with the times, understanding the fundamental knowledge of our day, learning how to share in the governance of our society, and showing responsibility - these are the components of learning how to live together as intellectual consumers as well as the broad guidelines in responsible scientific citizenship education.

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