Nanothinking and nanoeducation: nanoscientific literacy for responsible consumer decision making

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Abstract

Consciously or unconsciously, the term 'nanotechnologies' is firmly entering the life of every consumer-citizen of the global community designating both relatively simple nanomaterials and goods that have already entered the market, and very complex technologies that are supposed to change radically the future of mankind. Applications based on today's basic research are expected to form the next industrial revolution. The unique properties of nanotechnology applications suggest potential to solve some of the most pressing social and business challenges, but they come with uncertainties and risks as all new technologies.

Taking advantage of technological progress and preventing adverse side-effects requires analysis, evaluation and guidance to ensure technology is developed in ways that benefits wider consumer society and every individual consumer on the planet. Unfortunately, general public lacks understanding and awareness of the basic properties, and sometimes even the existence of nanotechnologies and their implications linked to the consumption of nanoproducts. Moreover, a generally sceptical attitude among society groups prevails towards new technologies.

The general lack of public knowledge about nanoproducts that are already on the market in a full swing is likely to bring irrational and erroneous, potentially harmful, results. Therefore, modern technology requires educated work-force and responsible consumers and hence imperative for educated population.

Our mission had a focus on introducing changes into the curriculum to eliminate gaps in scientific knowledge of students (as potential consumers, managers and scientists) and to foster an active approach to developing responsible scientific consumption practices and to offer an opportunity for students from a wide range of disciplines to learn about nanoscience and nanotechnology, to explore these questions, and to reflect on the place of new technologies in the spheres of their major and in the global society.

Keywords: Nanotechnologies, responsible scientific consumption, consumer identities, nanoeducation, nanothinking

1 Introduction

"While technology shapes the future, it is people who shape technology and decide what it can and should be used for"
(Kofi Annan)

Modern technology requires educated work force and hence imperative for educated population. The needs of new emerging technologies and a beneficial state of society are compatible in this case. There is no monolithic thing called technology. Rather there are various technologies, which converge or compete to fit into what can be called an ecosystem of technological and societal arrangements. 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 individual and contributes to shaping intellectual humankind [1].

The map of the globe does not show a place called Technoworld, yet in many ways we are already its citizens and consumers. Moreover, as consumers, our lives and behaviours are strongly influenced and shaped by an ever-increasing system of modern technology, transcending national boundaries to create a vast technological synergy grounded in complex applications in industrial production, logistics, electronic communications, agribusiness, medicine, and science. We begin to realise that, like it or not, we have become a part of technoculture.

The industrialized world has developed into a production and consumption global community with a highly advanced level of technologies. This process has led to markedly increased demands for a standard of living and consumption.

However, the current economic crisis has provoked a growing consensus that the 21st century consumer society is on a path that cannot promise its citizens a hope

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for sustainable future. The prevailing forms of political economy are failing to guarantee the consumers economic stability, preserve ecological resources and services, reduce social inequality, maintain cultural diversity, and protect physical and mental health of citizens. We face related crises of educational, social, cultural and personal sustainability.

On the other hand, current developments in scientific and technological research raise a number of ethical questions comprising responsibility. Areas of research as nanotechnology and biotechnology, regarding food, healthcare and environmental issues, elicit complex and undeniable debates within society today. Scientific-technological research and investments in different areas do not advocate a common good as their overall aim but serve the interests of those who finance the research itself, whilst forcing those who use these products into commercial traps, often without any research and information regarding the effects they may have on consumers' health.

Striking developments of new technologies, particularly nanotechnologies, are finding applications in all spheres of life and producing rapid, systemic, and far-reaching changes in business, government, society and the environment, alongside with the challenges they pose to society. Furthermore, rapid technological changes are forcing organizations to embrace new technologies and change the way they work and interface with suppliers and customers, thus, leading to changes in many behaviour patterns.

However, there is no one-way-fit-all strategy to guarantee a brighter tomorrow for everyone. Nor can the separate efforts of businesses, governments, organizations and individuals cope with the tasks without complementary contributions of others. Yet everyone can benefit from the insights of reasonable research into the nature of change stipulated by the advent of new technologies and innovation.

2 Knowledge management as a means of social change: Who needs nanotechnology education?

According to Petrides & Nodine (2003) knowledge management (KM) brings together three organizational resources – people, processes and technologies – to use and share information more effectively. Knowledge has become the most valuable resource. Prominent technology leaders, nanotechnology boosters, scientists, policy officials, and environmental organizations have raised important questions about nanotechnology's potential economic, social, and environmental implications. However, there is very little knowledge in wider European society about what nanotechnologies are and what impact they might have on how we live. Many experts acknowledge that uncertainties prevail about this.

The central question on nanotechnology education is 'Do we need nanoeducation?' To answer this question, we should first find out who needs nanoeducation? What is the interest in nanoeducation from those who have expressed the need? What kind of education is needed - expertise, skills, level? For what kind of jobs are skills and knowledge of nanotechnology needed?

Nanotechnology has shaken the world and the advanced countries are investing billions of dollars for its R&D and industrial applications. For example, USA cumulative investments in nanotechnology-related research since 2001 now total over 16.5 billion dollars (environmental, health, and safety research since 2005 now total nearly $575 million; education and research on ethical, legal, and other societal dimensions of nanotechnology since 2005 total more than $390 million) (NNI,[2]). Similar amounts are being spent on nanotechnology by Japan, Russia, China and European Union. Nanotechnology has therefore been taken up in these countries as an important national requirement.

The National Science Foundation (NSF) has estimated that by 2015 the world will require about 2.000.000 multidisciplinary trained nano-technologists, including Europe with about 300-400,000 nano-specialists. Therefore, modern technology requires educated work force and responsible consumers and hence imperative for educated population. The needs of new emerging technologies and a beneficial state of consumer society are compatible in this case.

To create a sustainable, democratic, technologically empowered and intellectual global society, higher education has to be at the heart of these processes and play a double role (Reid, et al., [3]). First of all, it has to provide a top-level multidisciplinary education to produce a highly educated workforce. Secondly, to educate the general public by ensuring accessible information that will allow people to better understand what nanotechnology is, how it will be applied, and its implications for the society. Responsible consumption is based on understanding of advantages and threats of new technologies [5, 6].

Thus, higher education must, in one way or another, come to terms with new emerging technologies and identify the paramount place that new technologies have taken in the society. Therefore, the presence of new technologies – as *means*, *object*, and *context* – in the sphere of contemporary higher education is undeniable (Figure 1).

The European Commission highlights the need to promote the interdisciplinary education and training together with a strong entrepreneurial mindset. It is emphasized that the need for nanotechnologists will not only be confined to the industrial and R & D sectors but will be needed practically in all spheres of life.

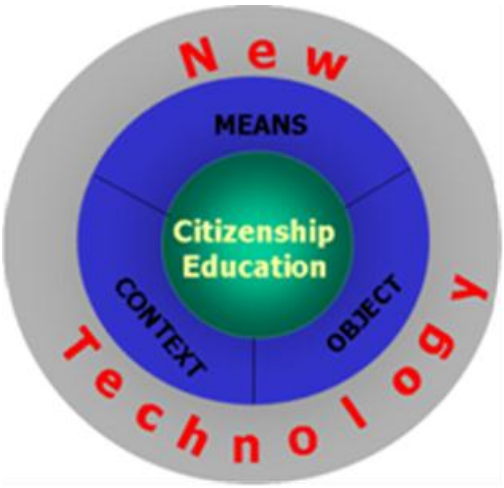

FIGURE 1 New technology as means, object, and context of contemporary higher education

Experts have estimated that marketing of nano-based industrial products will have risen to some 2-3 trillion dollars by 2015, and nanotechnology is going to dominate the socio-economic life of the world for the next 40-50 years [7].

It requires many resources on the consumer side (intellectual, psychological, etc.) to adjust to the rapid changes in the social and business environment by bridging the gap between the change in attitude and the change in behaviour. To a great extent, bridging this attitude-intention behaviour gap is stipulated by the increase of consumer awareness and the raise of the knowledge level.

Therefore, shaping intellectual, responsible consumption practices based on knowledge and awareness is viewed today as the development of civic skills contributing to the sustainable future by enabling people to make their own informed decisions about highly complex technological problems of the day, to take responsibility for their health, their own lives and to contribute to the wellbeing of their communities.

To fulfil the task, it is the job of our higher educational systems of the 21st century to prepare young citizens for the challenges and controversies of the rapidly changing and diverse consumer societies and highly technologically empowered business world. It is the role of higher education to develop skills and values required to enhance democratic life for everyone and to make their informed consumer voices heard in policy decision-making. Democracies need knowledgeable problem solvers and responsible decision makers.

3 Quality education for intellectual youth and sustainable future

The basis of any reflection whether personal or social, rests on an enlightened and critical intellect. Given its ubiquitous nature, nanotechnology is an essential component of responsible citizenship education on the way to intellectual society. It motivates the young adult to shape his thought process, to favour opportunities that refine his critical judgment and allow him to look upon the society of which he is a full member with a clear and constructive eye. He will then be ready to play his role as a knowledgeable citizen and contribute to the ongoing intellectual growth and wellbeing of his community. Sustainability is defined as a long-term maintenance of responsibility, which has environmental, economic and social dimensions and encompasses the concept of responsible management. In its turn, responsible management rests on knowledge and understanding of new technologies and scientific advancements fostering the societal development.

Unfortunately, our previous research on Nanoeducation and Nanothinking has revealed a dramatically low level of basic scientific knowledge and nanotechnology utilitarian value in Latvian students. The research results stimulated the educational component redesign at Information Systems Management University (ISMA), Riga, Latvia. Our mission had a focus on introducing a general nanoeducation course into the curriculum in 2011 to eliminate gaps in scientific knowledge of our students and to foster an active approach to ***Quality Education for Sustainable Future* (QESF).** The general ambition has been to add some non-technical instruction into the curriculum in a way that fits the ISMA Systemic educational model of problem- and project-based learning.

The course is built around active learning methods to promote an active discussion-based approach to developing responsible scientific citizenship and to offer an opportunity for students from a wide range of disciplines, including the natural and social sciences, humanities, business, information technologies, and tourism to learn about nanoscience and nanotechnology, to explore these questions, and to reflect on the place of technology in the spheres of their major and in the global society. We believe that effective and successful development of responsible scientific citizenship depends on a well-balanced integration of the three components:

1) new emerging technologies education,
2) citizenship education, and
3) the humanities education fostering social responsibility.

At the initial stage (the receiving and knowledge levels) the three domains can operate with near independence. Nevertheless, as a person reaches the stage of a high level of techno-scientific proficiency combined with socio-cultural and ethical knowledge (the integration and evaluation levels) the overlap area approaches totality. Scientific knowledge educates citizens about their powers and responsibilities. In this model, the citizen is not a mere consumer of scientific knowledge, but a person whose voice and opinions are heard and valued. Moreover, if the process is strategically targeted, we can view education as a contribution to a scientifically literate, intellectual society (local-European-global)

where young generations are able to take responsibility for its sustainable development (Figure 2).

The QESF course exploits the Systemic approach to the educational process and aims at developing the students' systems thinking, critical thinking, and contextual thinking (learning transfer), as well as organization and communication skills, problem-solving and decision-making abilities, thus, contributing to the integrated skills development.

From the Systemic perspective, an individual, as a social being, educates, self-organizes, and develops his personality through interaction and communication. Inferred from this is the vision that personality is a systemic quality including both biological factors and social formations. Therefore, the Systemic approach to educational process contributes to personality development engaging both biological and social aspects. This process is purposefully organized. From this point of view, the Systemic approach is considered as personality-directed.

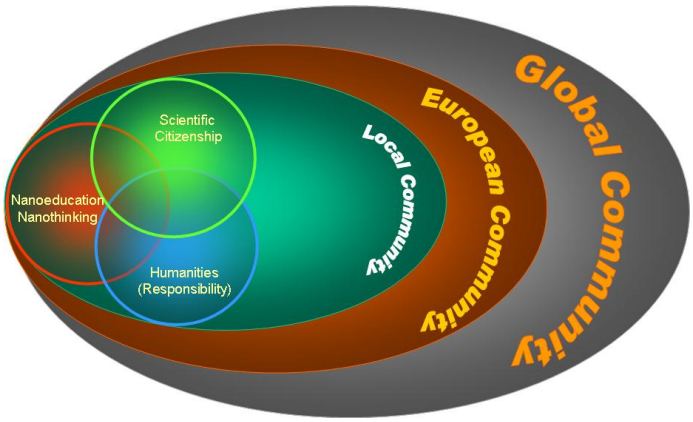

FIGURE 2 Responsible scientific citizenship development based on interdisciplinarity

According to Lev Vygotsky (1991), education can only then be useful if it comes before development. Preceding development, education rests on its achievements, finds the resources for further realization of educational perspectives. Hence is the dynamism of personality development in the educational process. This major principle formulated by Vygotsky means that through interaction and communicative activities, psychic functions (thinking, memory, knowledge accommodation) are formed, as well as social skills, ethic norms, values perception, and self-awareness are developed. From this perspective, the Systemic approach can be viewed as an activity-based approach.

The Systemic education and development promote self-education and self-development, contributing to life-long learning. Inferred from this, we can say that the Systemic approach can be viewed as holistic, leading to the global personality development.

QESF is not a mathematical or technical course. In fact, we spend most of our time on the humanities side of the world, but students get the general knowledge of nanoscience, nanotechnologies and their implications in the society as a result of integration of the humanities with technosciences. The course places emphasis on humanitarian applications of new technologies by focusing on the role of technologies in tackling society's grand challenges such as safety, health and environment. Integration of the humanities with technosciences, envisages the development of scientific competence, providing all the citizens with the abilities to assess new technological and scientific developments, and, thus, be engaged in educated problem-solving forums and responsible decision-making legislatures. The course is to be guided by teams of teachers from a diverse array of disciplines. Science and technology teachers will have to learn humanities and social sciences. Humanities and social science teachers will have to learn sciences and technologies, *promoting interdisciplinarity.*

In the interactive process of interdisciplinary activities, new abilities appear - emergent abilities [8] *that reinforce scientific competence and contribute to its development* (in Figure 3 - arrows inside the circles).

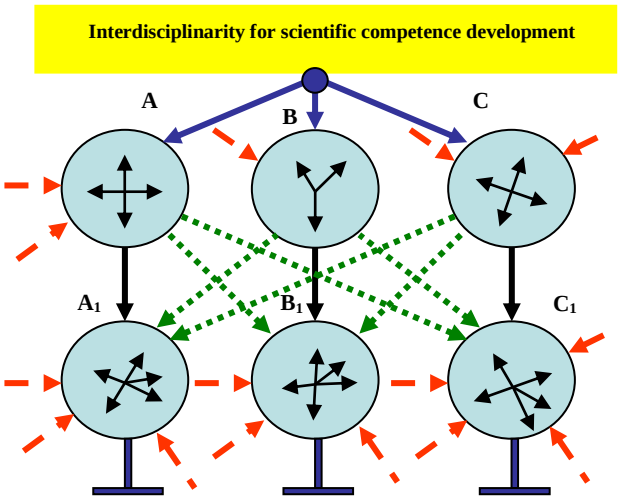

FIGURE 3 Scientific competence development under the systemic approach.

It is necessary to emphasize that the essence of mechanisms showing the emergence of new abilities can be demonstrated only by means of models created within the framework of the systemic approach as these 'new' properties have to be additive.

To a large extent, the course is about connecting disparate questions, concepts, facts, and ideas, and then raising new questions – it is a vital process in this approach to nanothinking because it is a formal way of integrating ideas and communicating.

4 Consumption and wellbeing: Who is consumer?

We commonly think of consumption as something that benefits individuals. We also tend to think of consumption decisions as being made by individuals or families, and not so much by businesses, organizations, governments or other groups. However, in contemporary economies, consumption decisions and consumption benefits are more complicated than this individualistic approach suggests.

From a systemic perspective, consumption is a holistic, cyclic process by which goods and services are used and in the end are disposed of by people (Figure 4).

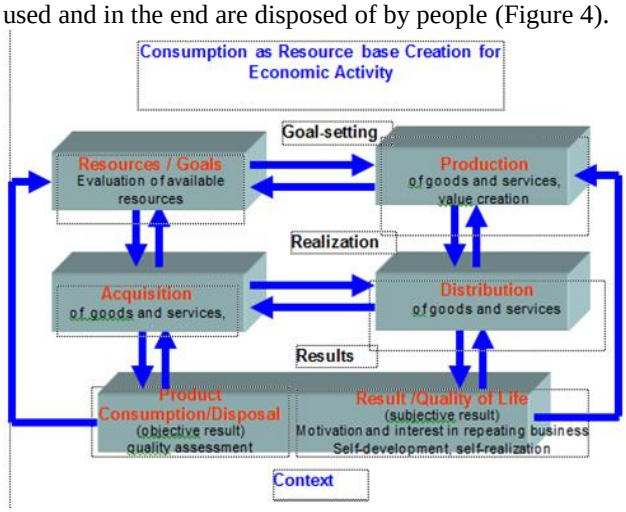

FIGURE 4 Consumption as a resource base creation process for business activity.

Consumption is the final round of the cycle in business activities that starts with an evaluation of available resources and proceeds through production of goods and services, distribution of goods and services, and their acquisition by people or groups. Finally, goods and services themselves come to be used and after their life cycle disposed. The effect of this consumption, including depletion of resources and generation of waste as well as enhancement of people's quality of life and human wellbeing, forms the resource base for the next round of business activity.

Following the concept of a 'cycle' as a unit of the business activities, we can assume that a cycle of production-consumption satisfies a set of important demands:

1) A cycle represents the major relationship 'production – consumption' reflecting the essential certainty of business activity.
2) A cycle is an entire, holistic business act – from the goal to the result, stipulated by feedback ties that ultimately determine the result.
3) A cycle represents a unity of objective and subjective components, which reveals the possibilities for improvement of business activity and product development as well as allows for scientific analysis of the process.
4) A cycle is a system that is open for the influence of the external environment.
5) A cycle represents a model of an objective business reality, since it reflects the basic relationship – the interdependence of production and consumption.

Much of economic discourse, from Adam Smith onward, has assumed that the functioning of an economy is grounded on the final demand for goods and services. As Smith argued, consumption is the sole end and purpose of all production and the welfare of the producer ought to be attended to, only so far as it may be necessary for promoting that of the consumer.

Thus, as the traditional assumption suggests, the consumer is the reason for economic activity and, therefore, for economic theory as well.

Another suggestion is that having satisfied a certain demand, consumers keep the economy going by generating further demand for goods and services. Without this demand, the supply side of the economy would expire. Thus, as a source of demand, the consumer is the trigger that makes the economic system run.

However, people are more than just consumers. Consumption practices most directly address people's living standards or lifestyle goals, which have to do with satisfying needs and getting pleasures through the use of goods and services. The end product derives its value solely from its contribution to the well-being of society and of individual consumers. When everything revolves around the consumer, the question arises: what makes people want to buy and consume?

5 Developing responsible consumer identities through intellectual consumer practices

Marketing professionals strive to influence consumers toward choosing and purchasing a particular brand of their product, at a particular time and place. To succeed, they have to have a clear understanding about what makes people want to buy and consume.

The fast scientific and technological advancements in such areas as neuroscience, genetics, artificial intelligence, biomedical engineering, computer and communications technology, biotechnology, and nanotechnology call for fresh reflections on what it

means, in the 21st century, to be a consumer, and for ethical judgments on how we might shape our intellectual, responsible consumption on the way to sustainable future consumer society.

What is important for a contemporary consumer to be able to cope with all the tasks imposed by new technologies and scientific advancements in order to make independent knowledgeable decisions? But what if those decisions are influenced by producers and aggressive marketing by businesses?

The modern consumer is not an isolated individual making purchases in a vacuum. Rather, we are all part of a contemporary phenomenon that is often referred to as a global consumer society where all people have become increasingly interconnected and interdependent. This aspect could potentially raise greater awareness of the fact that we are all part of a single global community that shares a common consumer identity as a background and destiny.

All of us are human beings and our human identity is the most essential factor that unites all people of the world (Figure 5). At the same time, all of us are consumers: we consume goods and services, and our consumer identity is another major factor making up our commonality.

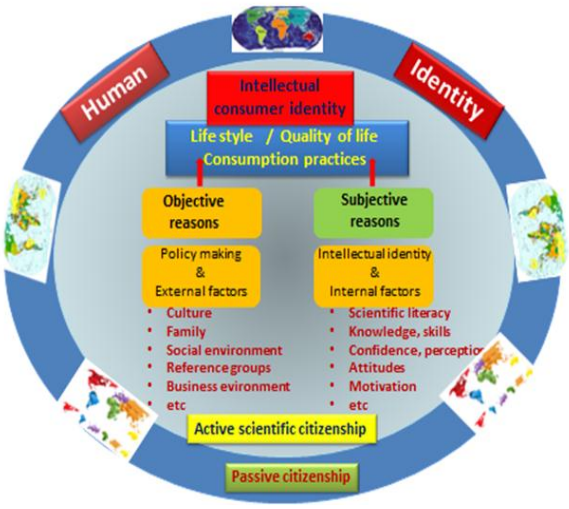

FIGURE 5 Constructing responsible consumer identity through shaping scientific citizenship and intellectual consumption practices

But against the background of this commonality, we develop different consumption practices due to various reasons – botnh objective and subjective. Still, on the subjective side, it is, to a great extent, our intellectual power that shapes our decision-making, our life styles and contributes to the quality of life.

It means that we need to have enough knowledge, skills and confidence in a highly technological business world to effectively construct our responsible consumption practices and develop scientific citizenship with the intention to contribute to innovations, sound business practices and facilitation of responsible and informed policy making to satisfy the requirements of individual consumers as well as contributing to the improvement of the quality of life in general. Education, as a major catalyst, has to help people become effective, scientifically literate, knowledgeable decicion-makers and responsible consumer-citizens. The cost is much greater if it does not.

The rise of consumer culture and the increased scientific literacy can be to a certain extent equated with intellectual citizenship, since a scientifically literate public can better contribute to policy making. Thus, the notions *intellectual citizen* and *responsible consumer* become almost conflated, or, at least, harder to differentiate.

We want our students to leave university with a clear understanding of the political, legal and economic functions of the society they live in, and with the social and moral awareness to thrive in it. Responsible consumption remains a crucial way of organizing people's place in the contemporary consumer society. It will undoubtedly continue to change meaning across space and time in the twenty-first century.

This is why we need to consider the role of new technologies in students' daily lives, in shaping responsible attitude to the consumption practices, and their implications for classroom performances. How closely, for example, should students' worlds outside the classroom match what occurs in the classroom? Why is it important to develop intellectual, responsible attitude to consumption? Intellectual, *responsible consumers* are people showing power of the mind to reason and apply knowledge, who are capable of *choosing* through connecting, of *buying* through thinking, of *consuming* through awareness, of *changing* through understanding.

6 From intellectual youth to intellectual society

In our educational approach we support the idea that instruction should not be separated from practical context and this is the concept that should be maintained as the main classroom philosophy, since skills have not only to be learned, they have to be experienced through the practice of implementation.

Therefore, concurrently with the general nanoeducation course, the quadruple-approach nanoproject ***'From Intellectual Youth to Intellectual Society'*** **(FIYIS)** has been launched that organizes conferences for students as well as the university teachers and general public. Initiated by several professors from Latvia, Israel, and Russia, this project has been designed as an educational supplement featuring the reflections of reputed scientists who propose basic ideas for intellectual growth, while focusing on today's most pressing problems. Among these are Arnold Kiv, Yuri Shunin, Paul Dyachkov, to name a few.

The teaching objectives of the nanoproject FIYIS envision a broad-based integration of technosciences and the humanities at the university level, so that both future technoscientists and humanoscientists develop a common

understanding and, possibly, even a common language to deal with complex social, ethical, legal and political questions arising from the development of nanotechnology and from its convergence with other techno-scientific developments, the answers to which are to be found on the counterbalance of technologies and humanities. Without that counterbalance, society risks scientists without conscience, technicians without taste, and businessmen without responsibility.

The learning context of the NanoProject is subdivided into four basic levels, comprising *Ecological/Environmental Level, Health and Medical Level, Consumer Goods Level, and Information Communication Technologies Level.*

FIYIS – is an integrated skills project that presupposes the engagement of all students into the research of the Nano-world, irrespective of their major. Thus, the 1st year students tackle the 1st Level tasks: through *simulations, role plays, discussions, and negotiations* they develop their communication and social skills. As a *deliverable* of the project, they might make a nanoproduct presentation: home-related nanoproducts.

The 2nd year students learn to select, process and analyse scientific information dealing with the 2nd Level tasks, thus, developing research-based learning skills, and problem-solving skills.

The 3rd year students acquire all the aforementioned strategies and skills and go a step further – the tasks of the 3rd Level aim at developing not only scientific competence but also at a global personality development of the student *through the experience of learning (attitudinal change – to nanoproducts, to each other, and to the process of learning – i.e. motivation, student awareness, and social scientific responsibility).*

The goal is to produce a pamphlet on key nanotechnologies and nanogoods circa 2015 that may have value to producers, managers and consumers, as well as to future iterations of the class.

There is a special merit in the 3rd Level tasks – that is a high degree of task authenticity, globality, integration with other subjects and involvement of all the aspects of the individual's personality, previous experience and knowledge. Nanothinking and creativity are the factors that link all these elements.

The most common approach, however, as at many other universities, seeks to provide the first-year students with an understanding of the commercial conditions in their subject area, and the project work often involves a market analysis of the particular technical or scientific product that the students are learning how to make.

The second approach provides what might be termed an academic understanding of contextual knowledge. The course provides an introduction to the philosophy of science and technology, and in the project work, the second-year students are encouraged to use these philosophical ideas to consider the ways in which knowledge is produced, or constructed, within their fields of major.

The third type, which we have developed in the new educational program in nanotechnology, can be termed a socio-cultural approach to contextual knowledge. In our lectures, we have introduced the local and the ERASMUS students to the cultural history of science and technology and, in their project work, we have advised the students as to how they might address, and, at best, assess the cultural and ethical implications of the emerging technologies in their fields of major. The approach is valuable since it tends to regard issues of social responsibility and of what we have come to characterize as scientific citizenship.

Normally, the project lasts for one semester, although it can be prolonged for the whole academic year, depending on the tasks and goals. The necessary information is gathered from different sources – course books, extracurricular books, the web, site visits, and interviews with specialists and experts. Students should be encouraged to think of projects as not requiring standard, back-of-the-book answers; rather, different teams undertaking the same project could arrive at different conclusions and deliverables.

A brief pre-assessment is given in the first week of class and two more detailed assessments are given in the last week of class. Several feedback surveys are made during the semester. The assessments and surveys show that the students have found the course valuable and that many of the goals in the syllabus have been met.

Continuous assessment has to be used to gain information about the effectiveness of class discussions and enhancement of students' understanding of the interaction between nanotechnology, individual, and society.

At the end of a project, every student must submit a statement of personal growth - what he/she expected at the initial stages of the project, and what has actually been learnt by the end of the project. The statement of personal growth may incorporate non-traditional objectives, containing reflections on:

- the relevance of the project to the community, city, nation, Europe or the world;
- suggestions for follow-up projects and other activities.

Nanoeducation challenges all students to broaden their horizons and gives them ways of acquiring knowledge of things that shape intellectual society. It fuels their interest as citizens so that they would be curious about the state of current knowledge, regardless of their major. It prepares them to follow the evolution of knowledge and technologies, to be active responsible citizens today and speak knowingly on questions dealing with quality of life within their local communities and the global society.

Not only would the practice of open discussion, problem-solving, decision-making, and statements of personal growth encourage healthy introspection, it would also anchor the scientific and technical disciplines with humanities and social sciences. This is especially

important because the exceptional synergy of nanotechnology with other disciplines creates significant social, legal, ethical and political issues that can be effectively resolved and outspoken only by the intellectual citizenry of an intellectual community. Finally, a gap analysis can be implemented to provide the best way of strategic assessment and planning (see, It allows comparing two series: 1) where we are now and 2) where we want to be in some time in the future, making it easy to identify the gaps in knowledge that need to be closed. For each area giving us a complete picture of the situation we ask two questions:

- Where are we now?
- Where do we need to be in 13 weeks' time?

Actually, we have to answer three questions:

- How are we doing?
- How should we be doing?
- How much do we need to improve? (the gap)

We can then quickly identify where the gaps are and whether things need to improve.

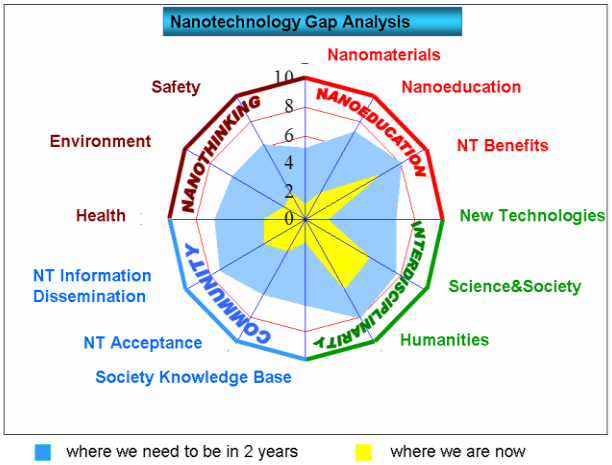

FIGURE 6 Gap analysis of knowledge

7 Towards an open dialogue on the benefits and risks of nanotechnologies with Latvian students

The term 'nanotechnologies' is firmly entering the life of every citizen of the global community designating both relatively simple nanomaterials and goods such as plastic bags or containers, and very complex technologies that are supposed to change radically the future of mankind, such as prosthetic implants that are controlled by the brain and move, feel, and have the sense of touch like real ones; or invisible brain implants that would enhance human memory storing information equal to several big libraries, altering mood and controlling artificial limbs. In fact, nanotechnologies have already entered the market with an extremely wide range of applications comprising food and beverages, food packaging, dental fillers, toothpaste, optics and electronics, clothing, wound dressing, sporting goods, dietary supplements, cosmetics, and many others, but consumers do not seem to notice or care.

Being avid consumers of products, contemporary Latvian youths are very familiar with their wide variety due to the efforts of marketing campaigns, advertising media and their own use of the Internet. However, as they buy and use today's products, they hold no concept of how these products come to exist or how they are made. Overall, general public's knowledge of the production process is relatively limited and unappealing. This lack of knowledge creates a strong demotivating barrier that prevents many potential students from not only entering, but even considering the field. Such a knowledge gap creates a need to educate the students about what constitutes a modern production process enhanced by new technologies, particularly, nanotechnologies, and intellectual consumption.

In this paper, we describe an effort to bridge the technological literacy gap in consumer citizens, currently under way in Latvia. Our previous research on Nanoeducation has revealed a dramatically low level of scientific knowledge in Latvian consumers. The results stimulated the initiation of the project '**A**dopting **I**ntellectual **L**ife **A**pproach' (AILA) at Information Systems Management University (ISMA), Riga, Latvia.

The aim of this research, focusing on the challenges of nanotechnologies in the food and healthcare sectors, is to explore Latvian intellectual responsible consumers: their habits, new technology perceptions, preferences and values. Intellectual, responsible consumption is viewed as an identity project since we will study how Latvian citizens of the recession times construct their identity based on intellectual responsible consumption practices.

The beauty of AILA is that it reaches students from all study programmes – Natural sciences and Humanities, Information technologies and Business studies, Tourism and Management, Law and Environmental design, etc. It is an integrated skills project built around active learning methods to promote an active case-study-, problem-solving- and decision-making-based approach to developing responsible scientific consumption, new emerging identities, and to offer an opportunity for students from a wide range of disciplines to learn about nanotechnologies, to explore their risks and benefits and to reflect on the place of nanotechnologies in their personal life, in their future professional practices, and the modern consumer society.

A questionnaire for the consumer survey comprising a set of questions was compiled based on a Likert Technique or scale and supported by the Consumer Culture Theory by Arnould and Thompson [9]. The main findings of the research are threefold as there were three teaching objectives of investigation: 1) what level of scientific understanding and risk-assessment would be sufficient for consumers; 2) whether consumers are provided with the necessary information; and 3) what more needs to be done in terms of public engagement.

The empirical results have proved a dramatical discrepancy between nanotechnology use in products that

are already on the market and lack of nanotechnology understanding in a modern Latvian consumer society.

The question arises: does higher education today fulfil 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 to ensure sustainable future for themselves, in the first place?

To find the answer to this question, we initiated a pilot research with the second-year students as an educational supplement, as a part of market analysis of a particular product that the students are learning how to make. The first question addressed to the respondents was whether they considered themselves 'intellectual consumers' (Figure7).

Do you consider yourself an 'intellectual' consumer'? (N=120)

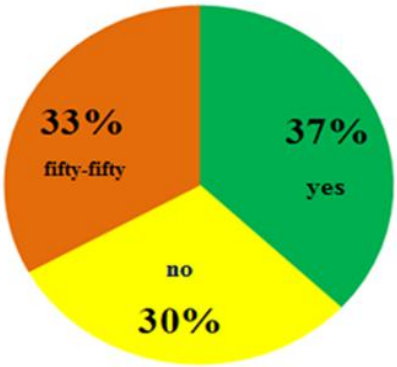

FIGURE 7 The amount of students considering themselves 'intellectual consumers'

As we can see from the pie chart, the answers divided almost evenly among the three groups of students-consumers with a slight shift toward 'intellectual consumer'. Thus, we had to investigate the reasons for 30% of students considering themselves non-intellectual consumers and 33% being doubtful about themselves (Figure 8).

Do you understand the 'labelling' information?

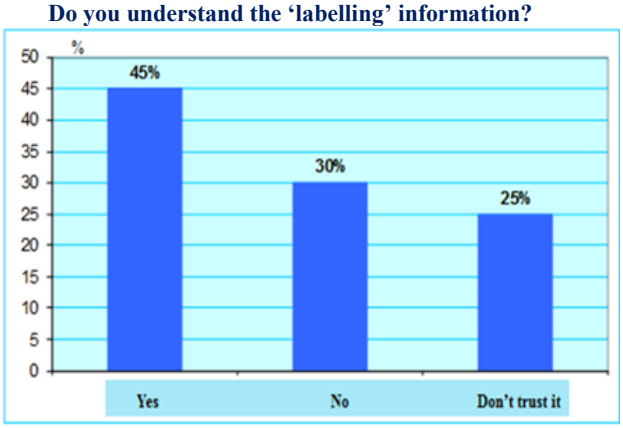

FIGURE 8 Student understanding of the 'labelling' information on products.

As the bar graph demonstrates, the reasons behind such a low self-esteem and doubt are hidden behind the inability to cope with complex scientific inscriptions on the products revealing their ingredients – 30% of students confess not being able to understand all of them. Another 25% of students admit to be very sceptical about information accompanying products because many companies do not label nano ingredients or other unhealthy components for people to choose whether to buy such products or not (Figure 9).

On what information do you base your purchasing decisions?

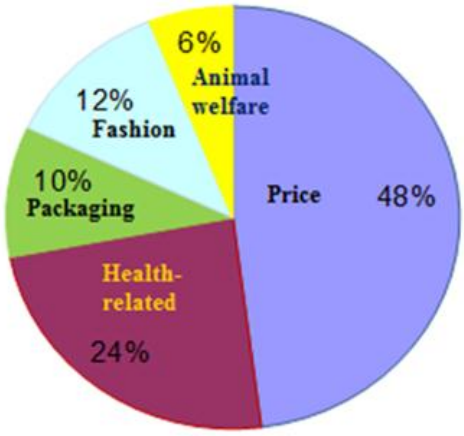

FIGURE 9 The reasons influencing the purchasing decisions of students-consumers

As we can conclude from the pie chart, the major part of consumers is influenced by price in making their purchasing decisions. The second biggest category – 24% of consumers put their health on the first place, which is very reasonable.

Still, judging from the bar graph (Figure 10), the plurality – 62% - have no idea about products containing nano-ingredients, hence we can assume that they cannot make responsible decisions concerning their health.

Do you know what products contain nano-ingredients?

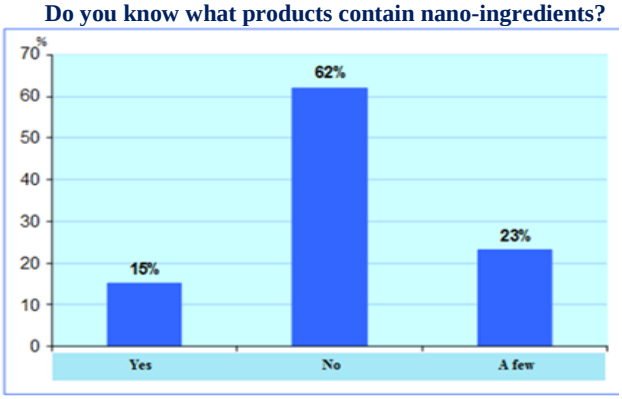

FIGURE 10 Students-consumers' awareness of the products containing nano-ingredients

Only 15% of students-consumers say that they know what products contain nano-ingredients. However, if we sum up 15% and 23% (of shy students, perhaps) we will get that 38% who consider themselves intellectual consumers.

Among students-consumers who make an initial assessment of nanotechnologies, the plurality think the risks and benefits will be about equal, and the votes are divided about evenly between benefits and risks – 60% and 40% respectively (Figure 11).

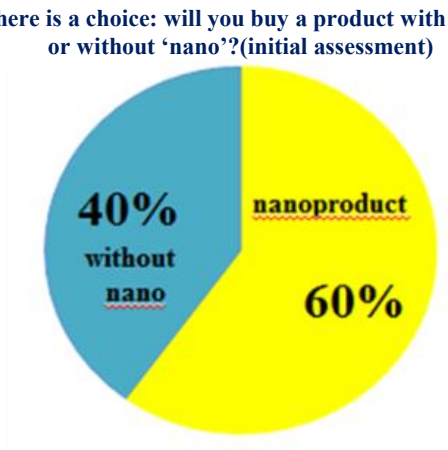

FIGURE 11 Student preferences of buying products with or without nano-ingredients *before* a general course on NTs.

However, when potential risks and benefits are outlined in the general introductory course into nanotechnologies, the greatest shift is toward the need of additional information – 74% or risk – 19% (Figure 12).

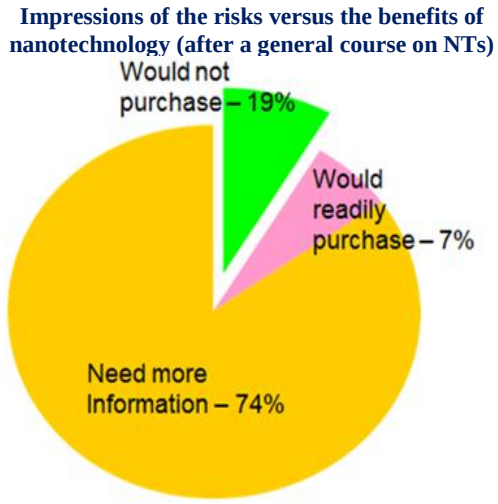

FIGURE 12 Student preferences of buying products with or without nano-ingredients *after* a general course on NTs

As we can see, life itself imposes the necessity of knowledge and education to make informed choices and responsible consumer decision making, thus, ultimately becoming intellectual consumers.

Since Nanotechnology is starting to play an extremely important role in the socio-economic development of all countries for the foreseeable future, it is imperative for higher education that emphasis be placed on producing a properly educated, qualified and trained specialists and consumers that can cater for the future of the society they live in.

It is at this crossroads and the questions raised by the scientific and technological advancements of our contemporary world, that we need to transform the society by educating responsible decision-makers and contributing to the construction of new emerging identities, shaping scientific responsible consumption practices and lifestyles.

Societal and technological arrangements co-evolve. This co-evolution happens most favourably in an educated, intellectual, and responsible 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 responsible mankind' (Gomez-Mejia, [10]). Our choices today will determine what kind of tomorrow is likely to come.

8 Conclusions

There is now a growing consensus that the global society of the 21st century is on a way that is not sustainable. The contemporary forms of political economy are failing to conserve ecological resources and services, to guarantee economic stability, to maintain cultural diversity, to ensure environmental security, and to protect people's physical and mental health. We face corresponding crises of ecological, economic, social, cultural and personal sustainability.

Nanotechnology is expected to radically alter the human condition within a short span of time, probably not exceeding two decades. Human cultures, however, do not change at the same rapid pace. Technoscientists as well as humanoscientists begin to ponder and predict the parameters of possible social, environmental, ethical and legal changes to emerge in the first two decades of the new millennium. At the same time, the preparation of future leaders and engaged citizenry to cope with unpredicted changes has obviously to begin at schools and universities.

Most of today's higher educational institutions are awash in technology but the outcomes for students remain little changed from 20 years ago. The problems are not in our technology but in our universities. The reasons are due to our attitudes toward education - how we underfund it, mismanage it, politicize it and disempower it in our culture. We have to dare shake education out of its two-centuries-old inaction/inertia. New technologies and education are inseparable. Involving the general public into decision making is a key element of social learning for sustainability.

Education for sustainable development should develop knowledge and understanding of the social, economic and environmental dimensions. Addressing the social dimension clearly involves citizenship education based on knowledge and understanding of the new technologies fostering the societal development.

The European Union is stimulating the development of nanoscience education in universities to address complex issues and to solve multidisciplinary problems, in general.

From a practical stance, nanotechnology is widely considered to be 'the next big thing' and is well worth learning more about in order to get a knowledgeable understanding of what is nanotechnology? Is it all hype? Is it dangerous? This essential knowledge will not be developed by chance, but by strategic, targeted teaching.
On another level, at the intersection of technology and society, there is a new angle to think of some timeless issues. Is nanotechnology good? What is progress? How much risk are we ready to take? Why should we care about the societal implications of nanotechnology? These are profoundly important questions the answers to which are to be found on the counterbalance of technologies and humanities. Without that counterbalance, society risks scientists without conscience, technicians without taste, and businessmen without responsibility.

Values reflect and shape the ongoing social development. Understanding the impact of a new technology on society is vital to ensuring that development takes place in a responsible manner. Scientific knowledge is expected to play an important role in educating citizens about their powers and responsibilities. In this case, the citizen is not a mere consumer, but a person whose opinions are valued.

A democracy needs an educated citizenry. What does an educated citizenry in a technological age look like? To participate in a democracy influenced by technology not only do citizens need to know how to understand the multiple perspectives that they encounter, they need to feel an obligation to explore multiple perspectives to fully understand the society they live in and make informed decisions.

When we do not pay close attention to the decisions we make, when we fail to educate ourselves about the major issues of the day, when we choose not to make our voices and opinions heard, that is when citizenship and democracy breaks down.

A new interdisciplinary course, developed at ISMA, places an emphasis on humanitarian applications of new technologies by focusing on the role of nanotechnologies in tackling society's grand challenges such as safety, health and environment. Our hypothesis is that this new approach to teaching about technologies will engage and inspire students who have typically been turned off by the traditional educational experience [11]. Additionally, we believe that this course will better prepare a new generation of specialists to address major societal problems in the future maintaining at the same time an awareness of political, economic, ethical and social constraints on technologies.

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