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Interview: "Creativity in Science"

Perl, Martin

1. What is the essence of the contribution for which you received the Nobel Prize?

Until my discovery of the tau lepton, just two families of elementary particles were known. The first family consisting of the electron, the electron neutrino, the up quark and the down quark was already known. This first family makes up the ordinary matter of our world. The second elementary particle family, partially known, consists of the muon, the muon neutrino, the charm quark and the strange quark. But these second family particles are unstable, contributing indirectly to the behavior of ordinary matter.

I developed a theoretical idea, called sequential leptons, that postulated more families of elementary particles. I then went on to discover experimentally the tau lepton that is a member of the third family of elementary particles. This third family was eventually filled out with the later discovery by others of the tau neutrino, the top quark and the bottom quark.

Since my discovery of the tau lepton there have been many rigorous searches for similar, additional families of elementary particles. But none have been found. Only three families are known. There is no explanation of how it is that nature limits the elementary particles to three families. There are no theories, simple or exotic, that explain the number three, for example the much touted string theory models have no explanation. Therefore my discovery has led to a greater unsolved puzzle. I don't know the answer. Perhaps the answer will be found by a young Serbian physicist?

2. *What are the impacts of this contribution?*

My discovery introduced the existence of more elementary particle families. No more of the three types of elementary particle families have been found. But there are other possible types of particles. For example we know through astronomical observations that there is another type of matter called dark matter and we know that this dark matter does not consist of particles from the known three elementary particle families. Thus we may still be at the beginning of our knowledge of elementary particles.

By the way I am skeptical of the so-called super symmetric model of elementary particles in which it is postulated that every known particle has an unknown partner. There is no proof of this model and its parameters are forever shifting.

3. *What are the applications of your contribution that may change everyday life?*

There are no direct applications to everyday life of the discovery of the tau lepton and the third elementary particle family. But there are deep contributions to our understanding of our world

4. *Can you shed more light on the last answer?*

Our culture has many parts – literature, the visual arts, theology, horticulture, architecture, mathematics, philosophy, dance, crafts, music, sports and Science. The language of Science is universal. Science in culture studies all of nature. Science is in the stars. Scientific experiments can be beautiful. Science

teaches humility and rationality. Science is full of dreams.

5. We learned a lot from your lectures on Creativity, in Japan, Tokyo and Sendai. Can you tell us, what are the issues that we have to teach our kids, so they become creative when they finish studies?

Creativity is sought everywhere: in the arts, entertainment, business, mathematics, engineering, medicine, the social sciences, and the physical sciences. Common elements of creativity are originality and imagination. Creativity is intertwined with the freedom to design, to invent and to dream. In engineering and science, however, creativity is useful only if it fits into the realities of the physical world. A creative idea in science or engineering must conform to the law of conservation of energy (including the mass energy mc^2). An inventor that thinks that she or he knows how to violate the conservation of energy will have to disprove a vast amount of laboratory measurements and accepted theory.

Creativity in science, engineering and computer science is constrained by feasibility and practicality. Consider the work in the US on a nuclear reactor powered airplane in the 1950's. Before the development of intercontinental missiles there was a desire to build a bomber that could fly around the world. There were three severe problems faced by the designers: the weight of the reactor and the shielding, the shielding of the crew from the reactor radiation, and the contamination of an area if the plane crashes. Tests went as far as connecting a nuclear reactor to an engine. But the plane was never built. This idea violated the constraint of feasibility.

Since the maturation of automobile technology and powered aircraft technology, inventors have dreamed of a flying car, a vehicle used by the public that could be driven on the road or flown. The vehicle would have easy convertibility between the two modes. There have been a few temporary successes but the concept does not meet the constraint of practicality. How is the airspace to be regulated?

Where are the wings when the vehicle is used as an automobile. What is the cost of purchase and maintenance?

6. What are the major things to keep in mind, when you form a team for a scientific experiment, or similar?

I follow a two-part theorem that I always pass on to my graduate students and postdoctoral research associates: (1) Don't choose the most powerful experimental group or department—choose the group or department where you will have the most freedom; and (2) There is an advantage in working in a small or new group; you will get the credit for what you accomplish. When I received my Ph.D. in 1955, I had job offers from the physics departments at Yale, the University of Illinois, and the University of Michigan. At that time, Yale and Illinois had better reputations in elementary particle physics, so I deliberately went to Michigan.

7. What are the people to avoid, when trying to generate a break-through achievement?

The most important thing I learned from Isadore Rabi, my Ph. D. thesis professor, is to avoid fast talkers and fast thinkers. This is very important for young people. I try to avoid working with fast talkers. I don't mind working with fast thinkers if they say very little. And, the best thing of all is to work with people who are smarter than you, who think faster than you, but never say anything.

8. What is your opinion about the impact of math?

You don't have to be a mathematical genius. There are science fields where mathematics is secondary. Nonetheless, you must be competent in mathematics.

9. *When targeting a major breakthrough, how sensitive one has to be about the direct interests of tax-payers?*

In democracies such as Serbia and the United States, the tax-payer is the boss. Try to convince the citizenry of the wisdom of reasonable investment in applied and pure science and engineering.

10. *What is the major driving force that motivates a Nobel Laureate to continue to create and generate results after he-she receives the Nobel Prize?*

I am not young but I have three dreams. I would like to contribute to understanding the nature of dark matter. I would like to contribute to understanding the nature of dark energy. I would like to understand the nature of mass as exemplified by the mass spectrum of the electron, the muon and the tau. The so far hypothetical Higgs particle will not explain this mass spectrum even if it is discovered at the Large Hadron Collider.

11. *For small nations like Serbia, what is your advice, which road to take, when it comes to science?*

- (a) Build on special strengths that are already developed in Serbia. Do not try to do many things in science in engineering. No nation can succeed

in many areas in science and technology. For example the United States excels in medical research and technology but is way behind in automobile technology and storage batteries. The United States should copy Japan and other countries in automobile technology and storage batteries. It is much cheaper to pay royalties than to try to catch up in a well developed field.

- (b) Develop cooperative projects and investigations with small or medium size countries.
- (c) Serbia should stay out of grandiose science and new technology projects such as ITER, the international project being developed since 1985 to demonstrate net power production via controlled nuclear fusion.

12. *What road to take, when it comes to its general future development plans?*

Serbia has a distinguished scientific and technical history and tradition as exemplified by Nikola Tesla, Mileva Marić and Michael Pupin. (I did my Physics Ph. D. research in the Pupin Laboratory of Columbia University in New York City.

I don't know enough about the specific interests and strengths of the present scientific and technical communities in Serbia to make suggestions.

Radical Innovation Challenge versus Organizational Motion Reality

Lepage, Alain

Abstract — *Analyzing team members' perception of their own interdisciplinary work, particularly of the incremental / radical nature of the innovation at the center of their activity, we saw the emergence of continuous motion in the organization, directly correlated with the innovative intensity of the team's activities.*

In every observation of the human systems in the companies studied, we noted this effect of innovation on movement in the organization. We can hypothesize that, conversely, each time the organization appeared static and basically designed, the integral innovation process failed.

The paper proposes a theoretical study of the organization schedule, in the context of innovation, elaborating an interdisciplinary model based on a biological analogy, able to simulate the organization's permanent motion.

Finally, we pose the question of the relevance of the incremental/radical concept, compared with the emerging role of motion in organization.

Index Terms — *Incremental Innovation, Radical Innovation, Organizational motion, Biological analogy*

1. INTRODUCTION

Ten years work on radical innovation, by many researchers, shows that it generates new products, services or processes whose performances are highly-improved, compared with those generated by incremental innovation. These effects influence the market, inducing major changes in customer use and sales features (Leifer, Dermott, O'Connor, (1)). Consultancies offer solutions for the replacement of the incremental approach by radical innovation. They consist of problem solving and the continuous improvement in micro structures, designed by team building inside advanced organizations, to increase financial and market performance. Some particular methods come from a Japan / U.K. mix such as "Breakthrough" (Stefik M. and Stefik B. (2)), (Shiba, S. (3)), which principally consists in learning data, coming from teams working on incremental innovation and classical product or service design, allowing a breakthrough to a radical solution to be found. This enables the designers to pass through the usual thick wall of market and product constraints.

The radical and incremental concepts come from research carried out ten years ago at Harvard Business School. They are accepted as the key point of business success, that radical innovation implies a good market share as a result. However, by what kind of team working does the organization find the best way to achieve desired business results? These working methods have not been studied often, inside the research /development or design / innovation teams, using a trans-disciplinary research approach. So we propose to share our analysis of several interdisciplinary teams working intensively on innovation, from a dual research point of view, management and organizational sociology, and taking in account the theory of complex systems.

Observing the internal collaboration in the innovation teams, we validated one of Von Hippel's (8) research works about the nature of the innovation process facilitating business success. He gave the confirmation of the importance of radical innovation in business success, but not by a process of manager decision, which would impose upon the nature of the innovation of the working teams, but rather by the ability to catalyze a facility of working in the teams, making members creative and market oriented. The validation of the research, as presented in chapters 2 and 3, is that the motion induced in the organization by teams working on intensive innovation, and which is easily measurable, is the best way to assure that innovation will be efficient.

Our research questions are:

- i. Does this excellent working process systematically offer innovation success in the market?
- ii. Is this kind of intensive innovation, as organizational style, predictable and manageable towards the targets of a desired business success?
- iii. Are the radical or incremental criteria relevant, as the nature of innovation, to assuring business success?

As our research method was based on internal observations of the functioning of the teams, and on the team members' perceptions, in several companies having business success with new products and services, we made correlations

between collaborative approaches in teams and market results, which generated questions about what is important to business excellence: the innovation's classification, whether radical or incremental, or the movement in the working process, whatever was the nature of the innovation.

Firstly, we propose to clarify the radical concept which can be confused with the disruptive concept. They are both included in the 'Breakthrough Process' concept. In order to understand the original break process at the center of new and large innovation success in the market, we can refer back to Clayton Christensen: "The innovator's dilemma." (4). The real causes of large organizational changes in firms, adapting themselves to new markets and technologies, are based on the impact of environmental changes, and bad financial results, on the firm, producing an urgent global re-engineering of the previous organization. We can find the same perception in Goodrich & Aiman - Smith work at Harvard Business School (5). Thus, we feel that the original meaning of the radical concept has been distorted. However, is it really different from the case of incremental applications in the firms, and could not the real effects, of both the incremental and radical approaches in the organization be similar? Here is the major question at the heart of our observations of innovation teams in firms, which are presented later.

2. Daily innovation practices:

The paper elaborates conclusions from project management of interdisciplinary and multidisciplinary teams working on new products, services and innovation in several firms in various areas: pharmaceuticals, mechanics, public building, insurance and banking, design equipment, and car construction. We were charged with implementing the first team building in interdisciplinary configuration, and enumerating customer's expectations and needs. Each time, the senior management's strategic target was the avoidance a poor future financial or quality result. Therefore, product and service innovation was made, at least as significant as that of competitors, in order to avoid difficulties for the firm. We therefore implemented the "Voice of the customer" approach (Griffin & Hauser (6), Shiba (3), Lepage (7)). We began with the "one to one" interviews of the customers, which were thought to be highly relevant, and carried out "by customer perception innovation making" (Von Hippel (8), Goodrich & Aiman -Smith (5), Snead, Wycoff (9)). The sound reliability of this "contextual interviewing" method has been

validated by many researchers (Lepage (14) and Christensen and Raynor (10)) and is best expressed as "The primary purpose of Contextual Interviewing is to understand the "job(s) that need to be done", or the problems that need to be solved by your business model, service or product. The unmet needs of your 'Most Important Customer' must be uncovered". The other significant part of the approach is the ability to work in multi/inter/trans-disciplinary collaborative teams. Participants are trained to be open-minded in creativity meetings, able to co-design elements, with experts from other corporation, and to be customer-needs oriented. Some authors have commented on the key success factors of these methods, (Snead & Wycoff (9)), and about the automatic behavior - change effects in the organizations (Dillon & Lee & Matheson (11), Kirton (12), Lepage (13)): people making personal changes in cognitive processes in order to understand their work, and teams working in an autonomous context naturally applying principles of continuous change. The implementation of these methods allows us to analyze the level of success in the teams and the effects in the running of the organization.

2.1 Innovation for new product/service success

In this case, "The voice of the customer" method, as stated by Von Hippel (8), is used for teams which have volunteered to carry out innovation. The daily experience of contextual interviewing, among customers and multidisciplinary collaborative meetings, allows the agents of the organization to discover a new, important purpose in their work. In their perception of their role, they become dependent on customer power-shift, and forget earlier internal, hierarchical rules of decision making. This creativity is not perceived as the result of individual skill and experience, but as the result of the qualities of a floating conglomerate of internal and external participants in the organization. Those involved can see that the creativity and innovation outcomes are greatly increased, but that they cannot be linked to individual efforts and qualities. The board heading the organization adapts its decisions to the natural evolution of the innovation, particularly in the case of large new product/service success. Therefore, we observed a new drive in organizations, brought about both by the customers and a self-development in the team's performance.

2.2 Innovation for an increase in employees' creativity.

Frequently, firms use an external consultant to increase creativity methods inside their teams: problem solving, brainstorming and psychodynamic aspects of the design leading (Wycoff (9), Von Hippel (8)), or mixed methods, based on adapted tools distributed to corresponding individual psychological profiles of members in the same team (for example brainstorming, TRIZ, and "One to one" sharing, by Alberti & Lepage (15)). The employees learn to become uninhibited and avoid the constrictions of formal, classical relations and static procedures, and to discover a new self-expression. New participants come from other parts of the organization, having working links with former team members, following their participation in the team. We observed, in this case, that the teams are more likely to achieve innovation success when there are incentive schemes which generate working methods free of constraint. However, when top management continues to use classical business or project performance indicators in employee evaluation, they fail because these instruments are designed to observe former, standard activities (eg.—the ordering of stock by an employee). Therefore they cannot compare the real performance of cross-collaboration in creativity between team members, nor the potential value added by a "genius solution", which would have offered large-scale royalties or sales in five years.

2.3 Innovation for adaptation to a tough context

We had to manage several applications in the case of stake-holder change, particularly when the firms were bought by pension funds and hedge funds, inducing the re-engineering of the internal processes, with a financial target such as 24% net margin after a year's production and sales. The first means to match the strategy was to re-design all the products and services so that they became the best competitor in the major divisions of the market. All the teams were under pressure and did their best towards ensuring the firm's success. As we employed the same tools as previously described, ("The voice of the customer" with multidisciplinary collaborative approach), we observed that the highest performances, in the design results, were due to optimal practices in the teams using adapted – but different – tools for chosen individual profiles in crisis situation, as it is partly presented by some specialists in the "New-contingency Theory" (Hollenbeck (16)) (see also 'Actor's Collaboration Under Crisis', Lepage (17)). In this crisis situation, the new product/service innovation was only oriented to be better than

that of competitors. We observed, each time, that the team members launched, by their own classification, both incremental and radical innovations, in equal numbers. This surprisingly good outcome is due to the motivation of team members working on new products and elaborating new processes. First, they used new materials to produce one major new product. These new production means, particularly on new processes, allowed the teams easily to deploy many different roots of product and services as to be the first in the market, and not already conceived by current competitors. Therefore, the question here is not to have incremental or radical innovation, but to elaborate new conception and production processes able to offer whatever kind of outcomes. The second effect we observed, in the form of these disruptive innovations, was the swarming of micro self-interactions, between internal and external actors, generating new, permanently evolutionary organization(s). It appears that the board preferred to adapt itself to the movement and to take a "go" option each time new products and innovations were presented for a production decision.

2.4 Innovation for a 'Best in class' target.

This is frequently the case in firms having the advantage of good financial and market results, in which the board makes the strategic decision to encourage some team members, on targeted product/service design projects, to become outstanding actors compared with current staffs. We had the opportunity to make this kind of monitoring, based on creative approaches (Snead & Wycoff (9)), and offering a panel of creative tools, adapted to the profiles of different actors constituting the teams (Alberti & Lepage (15)). We observed the same production of free innovation as in the previous case (§2.3), but with poorer results, because no vital outcome was demanded. The major difference in this case concerned the board's attitude. As the teams felt the necessity to redesign their own organization, the board ordered the team members to remain in their original places in the previously-scheduled general organization. The same attitude appears concerning the strategic "Go/No Go" decision to push further the innovation in the market, with the observation that the more frequent decision was "No Go". In this case, the outstanding approach is to deploy the performance of high competencies, possibly interesting to use in the case of emergency, and the board remains in a research and development management position, maintaining the classical static organization.

3. HUMAN AND ORGANIZATIONAL ASPECTS OF THE MOVEMENT INDUCED BY INNOVATION.

This part displays the human and organizational aspects of the motion induced by innovation in organization. We also examine the state of existing simulation models for this movement and propose our modeling of the motion with biological analogies.

3.1 Human resistance to and acceptance of the movement induced by innovation

In the different cases that we observed, we found that innovation produces automatically a permanent movement in internal organization. The analysis of human attitudes and behaviors at the center of this motion shows the pathway by which actors contribute to the evolution of the organization. We recognized the principal parameter, in the induction of the configuration of the organization, a real human presence, as the central characteristic of a second order cybernetic system (Pangaro (18), Heylighen (19, 20)). We observed also that team members, working on innovation, generate a permanent movement of multi-combinations and links between actors, producing a 'self-design' of the organization inside the firm. We can also say that it is a true (auto) organizational learning, which is the second attribute characterizing the second order cybernetic system (Ashby (21)). This motion phenomenon is well described by John Bessant (22), who presents as "evolutive systems" those firms redesigning themselves as evolving organizations, in order to be able to produce outcomes of driving permanent and multiple innovations within themselves, particularly "discontinuous" ones (like "disruptive").

Therefore, we apply the same definition of motion that John Bessant proposed: "motion is the evolving ("evolutive") characteristic of the system (working team or organization in a company). For us, motion is the evolving aspect of parts of the organization between two observations, at different times. Details, like individual responsibilities, knowledge and procedures remain similar, but roles, the team's configuration and interfaces between the team and the global organization have been changed. We measure this evolutive process by the percentage of parts of the system, or the percentage of individual tasks, which have changed between two observations of the system separated by a time interval of "t". Therefore, 100% motion means that all the parts of the system have changed between two observations. Here, the measurement is made on very simple data, roles and situations observed inside the teams. We take into account only the fact that

they have changed or, conversely, that they have remained similar between two observation points. We show in figure 1, below, the good positive correlation between the % of motion in organization and business success, measured by the % of design projects which enable the company to enhance market share, due to the newly- developed product or service:

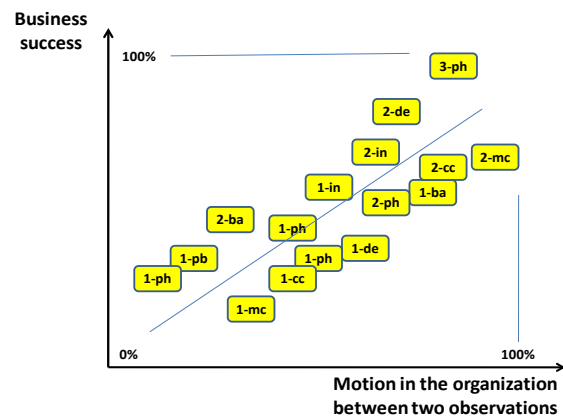


Figure 1

On the graph, the companies are classified as follows: ph (pharmaceuticals, mc (mechanics), pb (public building), in (insurance), ba (banking), de (design equipment), cc (car construction).

Here, the team cognition, the interpersonal collaborative approach and the impact of context in the team's functioning are not considered. Otherwise, we would have had to modify the measurement, taking into account the variations, due to the complexity of human behaviors, making the system a second order cybernetic one (Heylighen (19,20),Pangaro (18)). In this research, we observed and measured the system as a first order cybernetic one.

Our involvement, in the actual projects within companies, allowed us to analyze the internal links between teams and the global organization. We were able to put aside an introverted view of the system, and spend much more time in our laboratory, and thus reflect on the psychological, social and organizational aspects of these episodes of entrepreneurial life. These internal/external analyses, in a dozen firms, respect the principles of the "quali-metric" reliability of research approach, which we continuously apply (Lepage, (23)). These observations enabled us to validate that top management is mostly opposed to the movement. Obviously, if the board is made up of members accustomed to the practice of market-driven creativity, the firm can drive innovation in a motion sense. However, in most of cases, firms with varying order books and unpredictable financial resources are unable to apply the system. Of course, conversely, more often we

saw board members panicking each time that innovation was generated by a team. Therefore, they preferred to hedge in the innovation projects with many constraints and limitations, proportionally to the importance of the innovation's potential. They frequently made a "No Go" decision, in meetings with team members, in which everybody gave their opinion of the project's efficiency. It is not necessary to comment further on the effects of this kind of meeting on the motivation of team members. We acknowledge, however, that it must be really very difficult for most of the managers to understand actually what is the permanent movement in organization (organizational motion, Lampel & Shamsie (24)). In each case studied in the firms, we observed that project management criteria, which are well known to be a rigid control style of management, squashed the breath out of the natural innovation and reduced its creativity level almost to zero. In all cases, we validated the necessity to reduce the project table and to leave the innovation team to run, by itself, towards success.

The other aspect of firm global management is performance evaluation. In classical business, in stable and easily-understood organizations, managers are accustomed to using global indicators to analyze business success. These are employed at all levels of the organization, from the top down to the last member in a team. In organizational motion, we have many difficulties in linking individual creative efforts with team success in product design, and it is impossible to balance added value, produced by a team, with the global business expectations of the firm, particularly about order levels. This effect is described by Dave Ulrich (25) who explains that some top firms fired the lowest 10% of creative team members to obtain 20% more in global net margin. However, he demonstrates first that classical, individual indicators, used in employee surveys, tend to destroy people's motivation and generate more than a 30% loss in net margin. We are able to state that classical top management practices, in business reporting and employee evaluation, generate resistance against the free development of organizational motion driven by innovation.

3.2 Simulation of motion in organization.

Some simulations have been carried out to describe human organizations, mostly using animal and human body analogies, in first order cybernetics approaches often named "simply systemic". However, in the case of organizational motion driven by innovation, we found two types of analogy recently proposed to represent this movement.

The first model proposed is the genetic one, based on natural genetic diversity. Making

algorithmic simulations to preview all kind of situations, it offers a panel of choices to be decided, with less than twenty internal parameters to be changed in less than ten modes. It performs large equations with the use of a reasonable parameter number. (Miura & Maini (26)). However, our problem in organizational motion is, conversely, based on simple equations of the system, with a great number of parameters, making the system unstable and unpredictable.

The second model is based on human metabolism, simulating the self development and the organizational learning movement. Researchers observed this phenomenon in the case of high level innovation practice in project teams in charge of new products (see Hatchuel and Weill (27)). This is a useful simulation model, from our point of view, because it seems to mirror the free, "anarchistic" increase of living interactions between elements, in the phase of innovation generation, compared with the change in metabolism with the rise in body temperature. Particularly, the analogy with a bunch of grapes (Hatchuel) seems to be relevant in simulating the acquisition and learning of competencies and skills in innovation teams. However, it seems to be only truly analogous in the first phase of metabolism. Indeed, we are not completely satisfied with this solution, at the end of the cycle, because the metabolism cycle dictates an automatic return to the initial point of equilibrium. This is the case with innovation under constraint, or under strict project management control, evaluated by "Go/No Go" meetings in non-motional organization in which the top management remains committed to a research and development culture and constantly returns to an identical business configuration in order to be reassured. This attitude could be defined as "zero risk management", diametrically opposed to innovation.

In true motional organization, driven by innovation, we need a model simulating an open, natural evolution with a stable, but unpredictable first phase, following the necessary period of transformation. Therefore we propose the analogy with fermentation. The process begins with the crushing and pressing of fruit, and sometimes with the addition of a little sugar. The juice is held in tanks and maintained at controlled temperatures in two phases, and then filtered, before being transferred to another tank and the 'must' left for sedimentation to occur. At this stage we leave the fermentation phase, which is triggered naturally in vinification, and can enter the "seeding" process in acetification, with the introduction of *Acetobacter*. The two processes are similar in the final phase of fermentation, because they are both based on the twinned

development of two chemical reactions: alcoholic fermentation and acetic fermentation, (the former mycological and the latter bacteriological). This last part is very important and very difficult to achieve, with the precise control of temperature and addition of powdered yeast. Of course, oenology is deeply involved at this stage, with human intervention, based on skills coming from knowledge and experience. These skills are at the center of the quality of the products obtained. Interviewing oenologists, we learned how, annually, they assure a continuum of taste and high quality of wine, or vinegar, as the case may be, whatever the quality of grapes, the weather, the natural sugar concentration, external temperatures and the quality of the oak used in the barrels. These are some simple examples of the real multitude of variable parameters which apply in wine production. Oenologists say that they are not able to master the process from their knowledge alone. The system is simple at heart, but becomes very complex due to environmental impact, the natural variability of ingredients, and many unknown factors which arise during the progress of central process: parameters, environment and human intervention. It is impossible to simulate the system in equations, but oenology has been able to cope with problematical factors, a second order cybernetics system, and, by experience, sensing how to assure the quality, whatever the actual conditions are, sometimes making a fine, delicate adjustment in a small part of the freely developing system. We propose this biological analogy with the natural evolution of the innovation process, as a prescriptive frame, with the parameters of the analogy as under:

- cells and materials involved in the fermentation process are similar to members' profiles, and technological knowledge available to the team;

- oenologist's interventions on temperature, and experience of the fermentation process, are similar to skills, collaborative tools and methods in interdisciplinary team management.

Now, this frame was tested on the sixteen teams, mentioned in figure 1, that we observed in companies. At present, we have not received all the data, and, therefore, can neither analyze nor validate the model. Obviously, it will be the subject of a further research paper.

4. Conclusion

Based on our Beta–Binomial validation research method (Griffin & Hauser (6), Lepage (7, 23)) our observations in firms involved in intensive innovation show that, whatever was the desire of the top management to keep radical or incremental innovation as an outcome of their strategic decision, the actual daily innovation practice produces a permanent movement in organization. We observed also that, each time design teams volunteered to acquire good methods, like the contextual interviewing of customers, and collaboration management, to induce a continuous movement of the organization towards market and environment, the innovation was successful, even if the staff's strategic decision was against the launching of the innovation process. In every case, in which working teams became professionals in customer-need oriented innovation, and inter/multi/trans-disciplinary team collaboration, the firm had the advantage of producing permanent innovation outcomes, even if it was not desired by the strategic board. However, it has the problem of being unable to drive the self-developmental movement inside its internal organization. As validated by Stefik, M., and Stefik, B., (2) innovation is a breakthrough which takes people by surprise. Therefore our research shows that, when firms work with outstanding innovative teams, using advanced methods to produce "best in class" business results, it is not opportune to focus on the attribute of the classification of incremental or radical innovation. It is more relevant to use the concept of motion, applied to the heart of the new permanent development of the organization which has been created by the new radical best practices with their "disruptive" properties. This motion, centered on human activation, allows the firms to function in a second order cybernetics system (Heylighen(20), Ashby (21)). The most pertinent question to ask is not what kind of innovation – radical or incremental – is crossing the organization, but whether the organization of the working life of the firm is in permanent motion, or not.

As top managers in charge of their organization need tools to drive this permanent evolution, we propose a prescriptive frame of a possible model, coming from the biological analogy with fermentation. We focus on measuring several robust parameters to extract a systemic part of the organization, which is able to model the motion inside the complex global system in the firm. This analogy is derived from the approach, used in oenology, to obtain an annual continuum of best product quality, giving best customer satisfaction, whatever is the high level of complexity in the fermentation process or external conditions.

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Intellectual Property Management of Biotechnology Start-ups and Companies in Japan

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Abstract— *Intellectual Property (IP) management is crucial for biotechnology start-ups or companies (hereinafter biotech start-ups) which have as their foundation specific proprietary technologies. Furthermore, patentable inventions have become more various with the rapid progress of biotechnology. Through the administering of a questionnaire, the present study investigates the IP management of biotech start-ups in Japan and attempts to show how biotech start-ups manage and exploit their IP. The survey shows that the 'new-drug' group of start-ups put more of an emphasis on IP management including patent protection of inventions by filing applications than the 'non-new-drug' group, and that large companies play an important role in licensing activity of biotech start-ups. Additionally, it is shown that networking seems to play an important role in their IP information management, from an interview study. In short, the Japanese 'new-drug' biotech start-ups file patent applications for protection of their technologies as other new-drug companies generally do and it is important for them to develop networks and form beneficial alliances with large companies according to their IP strategies.*

Index Terms—*Intellectual Property Management, Biotechnology start-ups in Japan*

1. INTRODUCTION

This study attempts to analyze Intellectual Property (IP) management including IP information management of biotechnology start-ups or companies (hereinafter, biotech start-ups) in Japan. There is little evidence from research to indicate how biotech start-ups, with little labor and financial capital, manage their IP, including patent protection of their inventions.

This paper considers the idea that biotech start-ups, especially those involved in the production of new-drugs, do manage IP and they could do so by effectively making use of external expertise and by forming alliances with large companies.

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2. BACKGROUND

2.1 Management of Intellectual Property in Biotechnology

IP, especially in the form of patents, is very important for companies producing new drugs in the pharmaceutical industry, because a substance patent for pharmaceuticals provides extensive coverage for property rights, a small number of patents can cover one new drug and each patent is extremely valuable.

Patentable inventions have become more various with the rapid progress made in biotechnology and, as a result, the number of patent applications in biotechnology fields has increased. In some cases, traditional rules or practices for the granting of patents do not adequately correspond to recent biotechnology inventions.

Therefore, biotech start-ups, especially 'new-drug' start-ups have to file patent applications to protect their technologies with patents, in proper accordance with such changes in the industry and in patents.

2.2 Biotechnology start-ups in Japan

The number of biotech start-ups in Japan has increased because of government support through policies for the promotion of start-ups, especially since 1999. The Japan Bioindustry Association (JBA) reported that the number of biotech start-ups in Japan in 2006 was 586 including 157 'new-drug' start-ups[1].

2.3 Management of Intellectual Property for Biotechnology start-ups

Biotech start-ups have to cope with the changes in patents for biotechnology inventions, which is a burden for them. Start-ups generally have a small number of employees and it is difficult for them to assign their employees to IP management like patent protection. In Japan, although there are more than 500 biotech start-ups, many of them are in preliminary stages with a small number of employees.

Therefore, it can be said that it is difficult for

Japanese biotech start-ups to manage IP.

There are papers which have reported results from case studies of biotech start-ups' business strategies in the US [2]-[6]; there has been a comparative study of Japanese biotech start-ups' business with those of Europe and/or the US [7]-[8] and there has been a study of strategic alliances of entrepreneurial biotechnology firms in the US [9]. There is also a report regarding IP management of biotech start-ups in the US, in which IP management techniques are classified into both an offensive strategy (filing many patent applications) and a defensive strategy (filing a selected number of patent applications)[10]. Thumm[11] reported on the management of IP rights in European biotechnology firms. He demonstrated that patents are an important incentive for research and development in the European biotechnology industry and patents are used strategically, in different ways.

Tsutsumi[12] reported on the patent strategy of one biotech start-up in Japan in relation with its business strategy. She pointed out that the biotech start-up filed many patent applications as a large company generally would, even though the fees to file patent applications are very expensive for small and medium size companies.

It is necessary to file patent applications to protect inventions and 'new-drug' biotech start-ups have to file as many patent applications as possible for inventions necessary and important for their business.

Biotech start-ups should make effective use of external resources, including existing expertise in IP management, because start-ups are more restrained by their economic and human resources.

3. METHODOLOGY

3.1 Questionnaire Survey

Questionnaire was delivered by mail to 277 biotech start-ups. The 277 samples were drawn from "The Whole of Bioventures (BIOBENTYA TAIZEN)" (2005) (Nikkei BP Inc.) [13] from February to March of 2007. 47 usable responses were obtained (the response rate of the postal questionnaire survey was 17%).

The questionnaire included inquiries about the following topics:

- (1) The number of patent and utility model applications and registrations in Japan and other countries
- (2) IP licensing activities and alliances with other companies
- (3) Information resources for alliance partners
- (4) Utilization of external services relating to IP
- (5) IP strategy

3.2 Characteristics of Biotech start-ups respondents (N=47)

Tables 1a-1c demonstrate the characteristics of respondents (Tables 1a-1c).

Table 1a. Overview of Respondents (years of business)

years of business		ratio (%)
-5	Sample	20
	Respondent	11
5-9	Sample	52
	Respondent	64
10-14	Sample	11
	Respondent	11
15-19	Sample	6
	Respondent	4
20-	Sample	11
	Respondent	11

Samples: N=273, Respondents: N=47

Table 1b. Overview of Respondents (number of employees)

Number of employees		ratio (%)
1-4	Sample	13
	Respondent	6
5-9	Sample	23
	Respondent	13
10-19	Sample	26
	Respondent	23
20-49	Sample	25
	Respondent	43
50-99	Sample	9
	Respondent	18
100-	Sample	5
	Respondent	2

Samples: N=247, Repondents: N=47

Table 1c. Overview of Respondents (Capital Scale)

Capital Scale (million yen)		ratio (%)
less than 50	Sample	35
	Respondent	26
from 50 to less than 100	Sample	14
	Respondent	13
from 100 to less than 500	Sample	28
	Respondent	23
from 500 to less than 1000	Sample	9.4
	Respondent	15
from 1000 to less than 5000	Sample	9.8
	Respondent	19
5000 or more	Sample	4.1
	Respondent	4.3

Samples: N=266, Repondents: N=47

Samples are drawn from "The Whole of Bioventures (BIOBENTYA TAIZEN)"(2005)(Nikkei BP Inc.)[13]. The number of Samples are different among the three items, because the data with no answers are excluded.

Respondents contained few biotech start-ups in preliminary stages and few of a very small-size with respect to employees and capital than Samples.

The group of respondents contained few biotech start-ups in preliminary stages and few of a very small size with respect to employees and capital.

The data of this survey should, then, be interpreted as reflecting a view of biotech

start-ups other than those in the beginning stages of business and of a very small size.

The respondents are divided into 2 groups: the 'new-drug' group and the 'non-new-drug' group, based on their type of business.

The 'new-drug' group (N=19) includes respondents whose business scopes include the production of new drugs or the search for seeds of new drugs.

The 'non-new-drug' group (N=28) includes all respondents other than the 'new-drug' group, whose business scopes are research tools, supporting services for new drugs and other such things.

3.3 Interview study

2 biotech start-ups were interviewed.

Both of them are 'new-drug' biotech start-ups in roughly their eighth year of business.

4. RESULTS

4.1. The number of patent or utility model applications and registrations

From the questionnaire, it was found that more than 90% of biotech start-ups (N=47) have filed more than one Japanese patent or utility model application and more than 70% of them have filed more than one US patent applications, even though the number of patent or utility model registrations is low. One reason for the small number of patent or utility model registrations would be that it takes several years for processing from the filing date of applications for registration and their applications have not yet been completed and therefore the patents are not registered yet.

The biotech start-ups which filed no patent or utility model applications both in Japan and in the US are 'non-new-drug' companies. The biotech start-ups that filed more than 10 US patent applications are 'new-drug' companies.

Therefore, IP is more important to 'new-drug' companies than it is to 'non-new-drug' companies and it can be said that 'new-drug' biotech start-ups are more aggressive in filing patent applications.

4.2. Utilization of External services relating to IP

There are many resources providing IP information or services in Japan, including various websites, seminars, and so on provided by the Japan Patent Office (JPO), the Small and Medium Enterprises Agency, and the Municipal Intellectual Property Right centers.

The results from the questionnaire relating to the utilization of external resources providing IP information or services are as follows:

(1) More than 50% of biotech start-ups used the JPO's website, seminars and other resources

(79%) and also used IP experts like lawyers and patent attorneys (61%). Other external resources were used by only a small number of biotech start-ups (9-38%).

(2) The 'new-drug' group has a policy for more actively making use of IP experts like lawyers and patent attorneys in the future than the 'non-new-drug' group (Table 2).

Table 2. Utilization of external resources

resource	Priority to use in the future ¹⁾				t value (p value)
	New-drug		Non-new-drug		
	Mean	SD	Mean	SD	
Japan Patent Office (website, seminars etc.)	4.1	1.5	4.1	1.6	0.16(0.44)
IP Experts like lawyers and patent attorneys	4.3	1.5	3.5	1.6	2.06(0.02)*

*: p<0.05

¹⁾Five-level Likert Scale(very important 5 -not important at all 1)

The 'new-drug' group has a policy for more actively making use of IP experts like lawyers and patent attorneys in the future than the 'non-new-drug' group.

The JPO is a government authority and patent attorneys are authorized experts specialized in IP. It can be said that biotech start-ups, especially those of the 'new-drug' group, rely on specialized IP resources when choosing among many external resources.

4.3. IP strategy

Table 3 demonstrates that the 'new-drug' group gives greater priority to exploiting the rights exclusively, hindering others' entry in the market or product imitation, and using the rights for earning license income than the 'non-new-drug' group.

Table 3 also demonstrates that the 'new-drug' group gives priority to forming beneficial alliances, presenting their own technology to potential investors, and giving incentives to employees.

Table 3. IP strategy of Biotech start-ups in Japan

Item of IP strategy	Priority level ²⁾				t-value (p-value)
	New-drug group		Non-new-drug group		
	Mean	SD	Mean	SD	
Exploiting the rights exclusively in order to rise up own share in the market	4.8	0.3	4.4	0.8	2.1(0.02)*
Hindering others' entry in the market or product imitation	4.7	0.3	4.3	0.6	2.1(0.02)*
Open to others for earning as a license income	4.5	0.6	3.5	0.9	3.9(0.00)**
Taking advantage in cross-licensing	3.6	1.3	3.3	0.7	1.0(0.16)
Enjoying priority in alliances	4.2	0.7	3.8	0.5	1.8(0.04)*

Free open and growing up own company together with a market growth	1.6	0.6	2.5	1.1	-3.5(0.02)*
Permitting others to use patents widely in order to make own technology as the Standard in its field	2.4	2.1	2.5	0.9	-0.3(0.40)
Presenting to customers different points of own products from others'	4.3	1.2	3.8	1.0	1.5(0.07)
Presenting own technology to potential investors	4.4	0.9	3.7	1.1	2.5(0.01)**
Funding by IP on mortgage	3.2	1.8	2.9	0.8	0.9(0.20)
Giving Incentives to employees	3.6	1.0	2.9	0.9	2.4(0.01)**

*:p<0.05, **:p<0.01

²Five level Likert scale(Very important 5 – not important at all 1)

The important purposes to file applications and to obtain rights of IP for new-drug group are to use as exclusive rights and to gain income by licensing.

This demonstrates that the most important reasons behind the 'new-drug' start-ups' filing applications and obtaining IP rights are to obtain exclusive rights to their products or processes, to gain income through licensing, or both.

Therefore, it can be said that the purpose to obtain IP rights for 'new-drug' biotech start-ups is to be able to exploit these.

4.4. Licensing Activities and Information resources for alliance partners

Table 4 shows the main partners for out-licensing are companies other than start-ups and small or medium enterprises (SMEs), while the main partners for in-licensing are companies other than start-ups and SMEs and universities. The number of start-ups which did cross-licensing is few in number.

This demonstrates that companies other than start-ups and SMEs, that is, large companies play an important role in licensing activity.

Table 4. Licensing Activity

Alliance		Out-licensing	In-licensing	Cross-licensing
Partner	Total number of start-ups	17	22	2
	Start-ups	18(%)	18(%)	0(%)
SMEs		18	23	0
Companies other than start-ups and SMEs		82	45	50
Universities		0.6	50	0
Government Research Organizations		0	23	50
Others		0.6	18	0

The main partners for out-licensing are companies other than start-ups and SMEs and the main partners for in-licensing are companies other than start-ups and SMEs and Universities. The number of start-ups which did cross-licensing is few in number.

4.5. Information resources for alliance partners

As a channel for biotech start-ups to find partners for licenses, referring to the customer

companies (43% of respondents) and networking such as getting acquainted at academic societies (70% of the same), are found to be the most commonly used methods. Other channels like Technology transfer and Licensing Organizations (TLOs), business or university websites, patent market, patent search, patent distributor and trading companies are found to be used by only 0-26% of respondents.

Differences in information resources for alliance partners between start-ups with licenses and those with no licenses are found to be few.

4.6. Interview study

The following information was found through the interviews of two 'new-drug' biotech start-ups (A and B):

(1) They both actively file patent applications and are selective in their choice of patent applications because of economic restraints.

A selects the number of patent applications by dividing into inventions for which to file applications and specific know-how to keep as a secret.

B files patent applications first and then selectively abandons certain applications.

(2) They both make use of patent firms (lawyers or patent attorneys) as external services.

A and B rely on networking to obtain the persons or companies, who or which will support their business.

A obtains information relating to IP from the JPO's website and filters the information through networking, when too much information is provided.

B obtains information regarding inventions or patent applications from universities through networking developed anywhere.

This demonstrates that 'new-drug' biotech start-ups should selectively file patent applications and networking is a useful IP information management tool. IP information obtained through networking leads these companies to manage IP effectively.

5. CONCLUSION

'New-drug' biotech start-ups in Japan file patent applications and their purpose for obtaining IP rights is focused on eventual exploitation of these. As well, 'new-drug' biotech start-ups in Japan file patent applications for the protection of their technologies as other new-drug companies generally do.

From many external resources, biotech start-ups select resources with expertise in IP.

This is one strategic IP management method for start-ups with a small number of employees.

Large companies play an important role in the licensing activity of biotech start-ups. Customer

companies and networking are used the most as channels for finding licensing partners.

Therefore, it can be said that biotech start-ups should develop networks and form close ties with large companies, especially as customer companies.

The results of this study are based on a small sample of biotechnology companies, which affects the relevance of the findings.

Adding more companies to the sample is necessary for determining whether the results of this study can be generalized for biotech start-ups in preliminary stages.

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The Responsibilities of a European Union Member State as a Social Market State in the Implementation of Competitiveness Increasing Measures

Korže, Branko

Abstract - *In this paper, the author studies systemic conditions to be taken into account by a social-market state, an EU member state, in the implementation of measures to increase competitiveness. His study is based on the need for balance between the economic and social functions of competition as a condition for the functioning of free competition as a long-term public interest. On these bases, he evaluates measures introduced from the EU's Lisbon strategy for increasing the economy's competitiveness, and the implementation of these measures in the Republic of Slovenia as a member of this integration. He finds that in the implementation of these measures Slovenia has followed only those European Union goals that are – according to its competences under Article 2 of the EC Treaty – only oriented towards supporting the economic functions of competition, without concurrent adaptation of measures to support the social functions of competition. According to the author, the consequence of this omission is a breach of human rights and fundamental freedoms, on which the social-market state and free competition are based. The author believes that the improvement of competitiveness required by globalization can be achieved through the appropriate proportion and combined effect of the economic and social functions of competition. The promotion of economic functions alone leads to liberalism, which has short-term effects, while in the long-term it leads to economic and social instability.*

1. Topic

This paper explores measures aimed at increasing the competitiveness of the economy adopted by the European Union (hereinafter EU) and its member states, as well as the effects of these measures on free competition in the EU single market, and in the national markets, of its member states. Free competition in a social-market state is established as an economic freedom, limited by public interest in order to ensure not only economic but also other social values enabling the market participants put into effect free economic initiatives to an optimum degree. Competition is free when balance is established between its economic and social functions. According to the mentioned systemic frameworks, the measures of the EU and its member states are aimed at improving competitiveness on the market, which then promote the economic functions of competition and should be followed by measures aimed at the appropriate preservation of the social functions of competition, i.e., for their adaptation to the economic ones. This paper explores the nature of the EU measures, and the application of these measures in the Republic of Slovenia (hereinafter RS) as a EU member state, establishing the extent to which these measures are applied at the level of the EU and/or member states, and whether these measures are in conformity with the fundamental principles of social-market state, i.e., to what extent they merely pursue economic effects characteristic for market liberalism.

2. Problem statement

2.1. Free entrepreneurial initiative is a human economic freedom deduced from the human right to freedom as an expression of human dignity¹. It is exercised through numerous fundamental human rights, particularly the right to personal property (Article 1 of the protocol No 1 of the Convention for the Protection of Human Rights and Fundamental Freedoms² - hereinafter ECHR Article 33 of the Constitution of the RS) and its economic, social, and ecologic functions (in the RS, Article 67 of the Constitution); through freedom of work and employment (*mutatis mutandis* Article 4 of CPHRFF, in the RS, Article 49 of the Constitution); the right of assembly and association (Article 11 of CPHRFF, in the RS, Article 42 of the Constitution); the right of equality and/or prohibition of discrimination among people or legal entities (Article 14 of CPHRFF, in the RS, Article 14 of the Constitution), and through providing support to the principles of the rule of law and social state (in RS, Article 2 of the Constitution). In a social-market state, the defined rights and freedoms are the basis of free competition, and its goal is to ensure optimum social welfare. This is optimal when the economic and social functions of competition are balanced, when convergence is established between them, so that the economic functions enable social functions to the maximum possible extent. At the same time, social functions have a return effect on economic functions as support for their functioning. The European Union has not formally acceded to CPHRFF³, but we can note that when regulating competition, the EU has observed CPHRFF in part.⁴ This is reflected in

¹ Korže B., Do takeovers downgrade the contents of human rights and freedoms in EU?, A publication of IPSI Bgd Internet Research Society, New York, Frankfurt, Tokyo, Belgrade, January 2006, vol. 2, No. 1, p. 51 – 60.

² Council of Europe; Convention for the Protection of Human Rights and Fundamental Freedoms.

³ Lalić G., Temeljni akti Evropskih skupnosti (Basic Acts of European Communities), Uradni list RS, 2002, p. 12.

⁴ The Treaty of Lisbon amending the Treaty on European Union and the Treaty establishing the European Community, OJ of the EU C 306 vol. 50, 17. 12. 2007, which is currently in the procedure of adoption by the Member States (Article 6) as the primary source of law in the EU, is formally

that the membership of states in the EU is made conditional on their membership in CPHRFF⁵, and in amendment of Article 2 of the European Community Treaty (hereinafter EC Treaty). Since the initial contents of the treaties establishing the Community⁶, according to which the communities were established exclusively as international economic integrations, the Treaty of Maastricht, in line with the goals of the Single European Act (hereinafter SEA), has established legal foundations for the single market as an economic integration, pursuing not only economic objectives but also harmonious, balanced, and sustainable development of economic activities, a high degree of employment and social security, gender equality, continual and non-inflationary growth, environmental protection, and a high level and quality of life so as to establish cohesion between the economic and social goals.⁷

The subnational competition system⁸ as a whole is not comparable to the objectives of competition which must be pursued – on the basis of the defined human rights and freedoms – by a social-market state. Social goals and environmental protection defined in Article 2 of the EC Treaty only partly correspond to the social goals, which a social-market state is obliged to create through its social functions. The gap between the goals results from the fact that the EU regulates competition protection on

eliminating this deficiency, and in a Protocol to the Treaty announces accession to the Convention in the part relating to the enforcement of hour economic freedoms.

⁵ Leonard M., Why Europe will Run the 21st Century, Fourth Estate, London and New York, 2005, p. 45.

⁶ Treaty establishing the European Coal and Steel Community in 1951, The Treaty of Rome establishing the European Economic Community in 1957, the Treaty establishing the European Atomic Energy Community in 1957.

⁷ Grilc P., Pravo Evropske Unije, druga knjiga (European Union Law, second book), Cankarjeva Založba, 2001, p. 362.

⁸ Grilc P., Plahutnik A., Komentar Ustave Republike Slovenije, Podjetništvo kot temeljno načelo gospodarske ureditve države (Commentary to the Constitution of the Republic of Slovenia, Entrepreneurship as the Basic Principle of the National Economic Organization), Fakulteta za podiplomske, državne in evropske študije, l. 2002, p. 713.

the EU single market alone, i.e., on the market that is broader than the national markets (EU relevant market), and only to the extent required to ensure the four economic freedoms⁹. In addition, certain social objectives of competition can only be implemented in the frame of national states, since these objectives are defined by human rights and freedoms, while the contents of these rights and freedoms are determined by the level of economic development of a particular social community, its historical and wider sociological constants, and social, cultural and other conditions¹⁰. The original responsibility of the member states is thus to establish social goals to be pursued through the social functions of competition. In addition to implementing individual programme objectives of the EU in social and environmental protection areas, the member states are also obliged to use the social functions of competition to ensure legal mechanisms providing economic operators with equal opportunities for entering the market, which prevent discrimination among these operators on the market, which also prevent the market participants from abusing their economic power, which furthermore prevent their influence on political decisions when creating economic and competition-related policies, and as well in the legal regulation of the market, management conditions, and in the broader enforcement of the democratic social order.

2.2 According to the presented concept, 'market' is only conditionally an unconscious creation, functioning according to the "law of supply and demand" since its organization and function is influenced by the state as well as other social formations¹¹. The responsibility of the state is to provide the conditions necessary for the

⁹ Free flow of goods and services, capital and labor (people).

¹⁰ Korže B., Uticaj ekonomske globalizacije i regionalizacije za zaštitu slobodne konkurencije u tržišno socijalnoj državi (Impact of Economic Globalization and Regionalization on the Protection of Free Competition in a Social-market State), Pravni život časopis za pravnu teoriju i praksu, Udruženje pravnika Srbije, Beograd, 1. 11/2004, p. 487 – 503.

¹¹ Zabel B., Tržno pravo: teorija in praksa pravnega urejanja trga (Market Law: theory and practice of (legal)** market regulation), Gospodarski vestnik, Ljubljana, 1999 p. 107.

implementation of free economic initiative, and to establish such mutual relations between the economic and social functions of competition that the social welfare resulting from them will be optimal. By organizing the market, defining market participants, ensuring access to the market for interested participants, and performing the selected economic activity under nondiscriminatory conditions the state creates conditions for the enforcement of free economic initiative, the right to private property, equality of legal persons and their right to free choice of profession and activity. The state creates conditions for implementing the free economic initiative and principles of the rule of law by establishing mechanisms for preventing individual entities from abusing their economic power on the market, and mechanisms for preventing influences on political decisions and influences on legislative regulation of the market – which is the consequence of the economic power of these entities. By defining the type and scope of the citizens' social rights, the state defines conditions for the enforcement of social state and social function of property. In doing so, it must make sure that in terms of their type and scope the social rights will provide optimum support to the economic functions of competition. An important task of a social-market state is also to prevent any performance of activity and acquisition of profit which might threaten the lives and health of other legal entities (conditions for performing some activities), and to take care of healthy and clean environment (ecological function of property).¹²

2.3. In view of the defined baselines, the state's responsibilities in the field of market organization and functioning can be divided into systemic measures used by the state to regulate economic policy, systemic measures used in the public interest to prescribe conditions and restrict economic operators in their execution of free economic initiatives, and measures of limited duration used for market interventions in

¹² Zabel B., Tržno pravo: teorija in praksa pravnega urejanja trga (Market Law: theory and practice of market regulation), Gospodarski vestnik, Ljubljana, 1999, p. 103.

order to prevent the consequences of unexpected market irregularities.¹³

2.4. According to the Lisbon strategy,¹⁴ a synonym for the European Council conclusions adopted in Lisbon in March 2000 and/or conclusions relating to the environmental objectives adopted in Gothenburg in 2001, by 2010, the European economy is to become the most competitive, dynamic, and knowledge-based economy in the world. As stated in this strategy, the set objectives should be achieved by economic measures and measures necessary to modernize the European social model and welfare. The strategy includes the following economic measures: measures in the field of information society, particularly by providing access to the internet, measures relating to research and innovations, particularly by encouraging international research, industrial property development, tax incentives for high-tech companies; establishment of favorable conditions for entry into the market and business operations of small and medium-sized economic operators. These refer, in particular, to decreasing administrative barriers and providing financial incentives, and reducing incorporation costs; acceleration of processes establishing contestable markets by dividing infrastructural activities to the part where competition can be ensured in the successive phase of performing services or by enabling the entry of new competitors into this phase, and by restricting state aids; measures to increase integrations and efficiency of financial markets; and on the macroeconomic level, measures to decrease labor taxes, stimulating taxation of education and research activities, which should also be financed from the budget. Among the measures to modernize the European social model, the strategy includes: measures to encourage education and training for the needs of industry and trade, particularly by increasing public funds for education, as well as for the education of the young; measures to encourage employment policy, particularly lifelong learning and

¹³ Korže B., Vpliv državnih intervencij na svobodno konkurenco (Influence of state interventions on free competition), doctoral dissertation, Ljubljana 2004, p. 80.

¹⁴ Presidency Conclusions Lisbon European Council 23 and 24 March 2000, Presidency Conclusion Gothenburg European Council, 15 and 16 June 2001.

opportunities for education; measures to modernize social security, particularly in association with the development of education, improvement of healthcare system and long-term employment; and measures to provide connection between poverty reduction and knowledge-based society.

2.5. Before joining EU, the RS adopted the Slovenia's Development Strategy¹⁵, in which faster development and the improvement of the competitiveness of the economy are defined as priorities. The measures to improve competitiveness include promotion of technological development, education and training, investments, and strategic development-oriented projects, and enhancing of service activities. In its Action Plans for 2005 and 2006, the RS planned rational implementation of the system for granting aid to the economy, increased financing from the EU funds, improved access to support services for small and medium-sized enterprises, and increased investments in knowledge and development. In 2005, the Government of the RS adopted the Reform Programme for Achieving the Lisbon Strategy Goals in Slovenia¹⁶. While implementing this programme, the Government enacted gradual abolition of tax on paid-out wages (up to 2009) and introduced cedural (severally) 20% dividend tax, and taxation of interests and capital income, reduced the legal corporation tax 25 to 20%, retained allowances for investments in research and development, and decreased progressive income tax. In the social security area, it tightened the payments of unemployment compensations and social relief. In the labor law area, it introduced numerous measures aimed at flexicurity¹⁷. The Government introduced

¹⁵ Šušteršič J., Rojec M., Korenika K., Strategija razvoja Slovenije (Slovenia's Development Strategy), Urad RS za makroekonomске analize in razvoj UMAR, 2005, Ljubljana.

¹⁶ Decision of the Government of the Republic of Slovenia adopted at the 92nd regular session held on 12 October 2006: Reform Programme for Achieving the Lisbon Strategy Goals in Slovenia: Programme implementation report 2006.

¹⁷ Končar P. The Evolution of Labour Law in the new Member States of the European Union 1995 – 2005

measures to reduce administrative barriers to the incorporation of economic operators. It allocated more funds to research. In the protection of competition, it adapted the system to the EU law, and announced the withdrawal of the state from the economy.

2.6. The analysis of the nature of measures aimed at increasing competitiveness provided in the Lisbon strategy shows that the majority of measures are intended directly for support to the economic functions of competition, while the measures of social nature, free movement of goods, services, labor (people), and capital provide indirect support. In this sense, Hatzopoulos¹⁸ finds correctly that the EU has also gradually – in line with the development of economic freedoms – developed mechanisms for restricting economic functions of competition on the single market, and he states that it has developed minimum social standards. He also correctly expresses his misgivings regarding measures to increase competitiveness because of decreasing the prices of production factors, particularly the price of labor (by changing employment and social security), since such measures lead to economic liberalism. However, in connection with this I believe that with the mentioned measures the EU observes only Article 2 of the EC Treaty, according to which individual social functions of competition on the EU single market – in terms of their types and scope – are intended only for undisturbed implementation of economic functions. In order to establish the content-related meaning of the social-market system based on the shown limited economic freedoms, the member states should, concurrently with the implementation of the EU measures, introduce such restrictions of market freedom (market liberalism) that all the social goals of competition are achieved to satisfactory extent and not only the social and ecological ones which are pursued, within a minimum scope, by the EU.

Country study of Slovenia, University of Ljubljana, Faculty of Law, vol. 37.

¹⁸ Hatzopoulos V., A (more) social Europe: a political crossroad or a legal one-way? Dialogues between Luxemburg and Lisbon, Common Market Law Review, Dec. 2005, Netherlands, vol. 42.

3. About existing solutions and their essential drawbacks

On the basis of substantive study of the legal bases mentioned in the preceding chapter, which were adopted by the RS to implement the Lisbon strategy, we can find that with these legal bases the RS quite faithfully pursues their goals of increasing competitiveness. However, in accordance with the presented basic premises, according to which a social-market state must constantly harmonize the economic functions of competition with the social ones, the RS should simultaneously adjust the social functions of competition to the introduced changes and balance them with each other. By omitting this, it acted contrary to the basic principles of free competition in a social-market state.

4. On the proposed solution and why it should not possess the same drawbacks

On a short-term basis, promoting only economic functions of competition can result in higher competitive capacity of economic operators, as is required by the economic globalization, but on a long-term basis such economy stagnates because of inadequate support by products and/or effects of the social functions of competition, and it is also exposed to cyclic oscillations. The effects achieved by countries by favoring the economic functions of competition can be achieved by social-market states through the impacts of the social functions of competition on the economic ones (e.g., preventing the abuse of economic power on the market, preventing the influence on the formation of economic and legal order on the basis of economic power, respective increase of social rights, preventing the discrimination of market participants, providing local supply¹⁹, etc.), whereby free competition on the market

¹⁹ Korže B., Naloge tržno socialne države pri vzpostavitvi varstva majhnih udeležencev na trgu (A market social state tasks at the small economics retail traders security restoration), št. 6-7, GV Založba, Ljubljana 2007, p. 1669.

has a long-term stable effect ensuring optimum social welfare.

5. Types of analyses performed

This paper has been formed according to the prescriptive method, and it evaluates the nature of measures aimed at increasing the competitive capacity of the EU and the implementation of these measures in the legal order of the RS through human rights and fundamental freedoms forming the basis for free competition in a social-market state.

6. Basic conclusion of the analysis

When implementing the EU measures to increase competitive capacity, the RS – an EU member state – implemented only the measures aimed at supporting the economic functions of competition, while as a social-market state it failed to implement the measures to support the social functions or respective adjustments to these functions, which consequently means that they have remained unbalanced with each other.

Index Terms-Key words or phrases in the alphabetical order, separated by commas (in the part referring to the list)

ABBREVIATIONS

EU – European Union

RS – Republic of Slovenia

CPHRFF - The European Convention on Human Rights

EC Treaty – Treaty Establishing the European Community

SEA - Single European Act

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A Model for Integration of m-Learning into Learning Management System

Vukmirović, V., Dragan, Miloradović, R., Nataša; and Bogdanović, M., Zorica

Abstract - Mobile activities and services are present worldwide. Education follows these trends. Although it seems natural to use powerful small portable devices, capable of presenting rich content, basic educational goals imply designing solutions for the use on the most common device – mobile phone with GPRS and JAVA technologies, rather than elitist ones.

This paper describes an approach to blending mobile learning into the existing e-learning system in the Laboratory for e-business, Faculty of Organizational Sciences, University of Belgrade. We have conducted a research in order to determine possibilities for introducing mobile learning into this system. Based on the results of the research a pilot project was carried out. The results show that mobile activities contribute to efficiency of the education system and are willingly accepted among students.

Index Terms — blended learning, content delivery, mobile devices, mobile learning, WCSS

1. INTRODUCTION

Mobile technologies are widely present in many areas of human activities: communications, business, fun industry, etc. Education also incorporates them. M-learning can be seen as learning on the go, mediated through mobile technologies.

M-learning happens across locations and takes advantage of learning opportunities available through portable devices. Learners tend to use whatever available technology asset for accessing necessary information. In that light, mobile telephone emerges as a device that is handy, always with the user, always on, and with available Internet connection. In the continuum of electronic devices used for learning there is a tradeoff between functionality and mobility. Although learning materials can be accessed from different places from laptop computers, or even desktop computers true mobility is connected with using small and lightweight devices, those “which a lady can carry in her handbag or a gentleman can carry in his pocket” [1].

2. CONCEPTS OF M-LEARNING

A. Advantages and disadvantages of mobile learning

Main advantages of using mobile devices in education are:

- It makes possible learning anywhere and

anytime. The time formerly spent in transport or similar activities can be used for learning, checking results, etc.

- A small device has enough memory to store a huge quantity of data which sometimes replaces considerable amount of books and papers, and makes moving easier.
- It provides for registering and data entry on the practical lessons outside, where the desktop computer is not available.
- Mobile devices are in most cases less expensive from the desktop computers.
- Just-in-time learning – it can be used for data access on-site, for instance for the use of step-by-step tutorials for solving some practical problem.
- SMS can be used for delivering information like the changes in the class schedule or similar. This way of informing is much faster than the email.
- Mobile device is always with the student and is naturally personalized, unlike desktop computers shared among several persons on the faculty.
- The interaction among students is more intensive.

Major disadvantages of m-education are mostly of technical nature and some of them like processor strength, battery autonomy or the speed of mobile connections will be solved with development of technology. The others like small screen size or the absence of keyboard or mouse are connected with the small size of the device, and will be present in the future too. Maybe touch screen or voice entries are going to solve the problem of input, but screen size, text representation and navigation through text will remain a limit. Despite all disadvantages, m-learning is becoming more popular with the development of mobile technology.

Major disadvantages and constraints of m-education include the following [2]:

- Existing learning materials and applications are designed for the use on desktop computers and have to be customized for the capabilities of presentation on mobile devices.
- There are different types of mobile devices. Even when concentrating only on mobile phones, one faces a huge variety of models with

different features and capabilities. This implies that not only “small”, but different sizes of small have to be present, when it comes to content delivery.

- The majority of the mobile devices do not have classical keyboard or mouse, but use other ways for entering data. The navigation through the applications is more difficult in this way and has to be encountered when designing the software and learning materials.
- The accessed bandwidth in a mobile environment is always narrower than in a wired environment.
- M-education offers possibilities for learning in different surroundings which can be full of distraction and therefore fragment the concentration of learners.
- Solving security problems in mobile environment is expensive.
- Battery capacity determines the autonomy of the device.

The drawback of using mobile devices for education in Serbia is that the market of mobile services is not yet fully developed. Mobile access to the Internet is expensive for most of students.

B. Technical aspects of delivering mobile content

Content is delivered to the mobile devices by the means of WAP (Wireless Application Protocol). Typical mobile browsing scenario (PULL scenario) is shown on the figure 1. The request goes from mobile device, through wireless network to WAP Gateway/Proxy, where the request is forwarded to Web server through public Internet. Requested content is located and sent back as a HTTP response to WAP Gateway/Proxy. There, it is sent back to mobile device through proprietary wireless network.

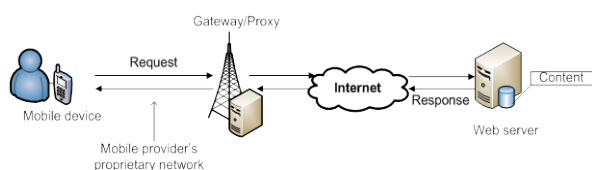


Figure 1 Typical PULL scenario and passage through WAP Gateway/ Proxy

WAP 2.0 supports WML and XHTML MP while WAP 1.x supported only WML. WAP 2.0 supports WCSS and makes possible customization of the output. In WAP 2.0 gateways act more like proxies. While WML supported WMLScript for client side scripting, first versions of XHTML MP present from year 2001 could not support client side scripting. From version 1.1, available since 2007, XHTML MP supports ECMAScript for client side scripting.

Table 1 WAP 1.x vs. WAP 2.0

WAP 1.x	WAP 2.0
Only WML 1.x	WML 2.0, XHTML MP
Gateway	Proxy
WAP stack – HTTP stack transformation	WAP stack like HTTP stack with wireless profiled TCP and HTTP
Binary – Textual transformation	

Principle of proxying the content is used in mobile browsers Opera Mini and Mozilla Mobile. These browsers force the proxying of content via their servers where the customization of the pages for mobile delivery and compressing of files for quicker pass through the wireless network is done.

Other approach is the customization and content adaptation at the origin server, known as server side customization. WCSS themes are chosen per session, based on the detection of the user agent, when they request the page.

C. Mainstreaming the mobile learning

Mobile technologies can support and enable teaching and learning, but there is no guarantee that learning will occur. For long term success of m-learning it is necessary to address the majority of students, and to make the content reusable. The solutions have to rely on existing free or low cost, and feasible technologies.

M-learning requires a client platform that is available to most learners anywhere and anytime. This excludes PDAs, iPods, and similar devices. [3]. However, we expect almost all students to own a mobile phone that uses Java MIDP (Mobile Information Device Profile) software and sends and receives IP data traffic.

M-learning works best as a part of blend [4]. Blended learning itself is a way of combining different educational methods, types of content delivery and variety of communication channels (Figure 2). For the normalization of mobile phones into the curriculum, educators need an easy way of quickly and cheaply constructing course materials. This is available through the use of modern software systems for e-education like Learning Management Systems and Virtual Learning Environments.[5] It is natural to try mixing the m-learning into this proven blend by customization of these platforms. These software systems have standardized forms of learning materials that makes them reusable [6].

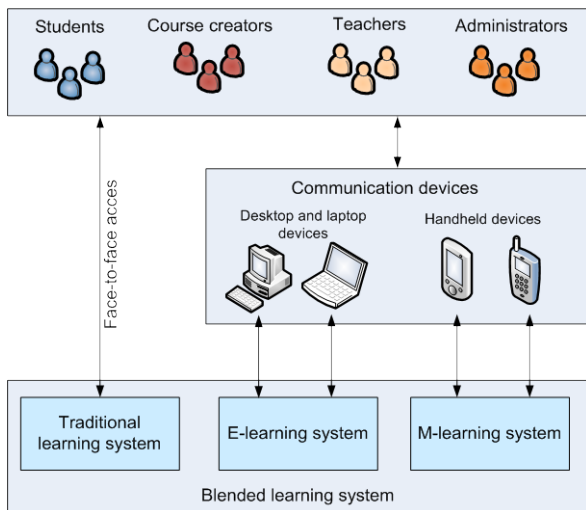


Figure 2 Access to the blended learning system

3. MODEL FOR BLENDING M-LEARNING INTO E-LEARNING

In the previous period in the area of mobile learning there have been many researches, mainly focused on recommendations for mainstreaming the mobile education (Keegen [1], Doering [3]), theory of m-learning and pedagogical models (Sharples, et al. [7],[8]) or methodology for developing m-learning applications (Millard, et al. [9]). Many recommendations and conclusions from these researches can be applied when introducing m-learning system, but there may also appear many problems. Basic criticisms of the past researches can be summarized through following:

- These researches are primarily directed towards communication of participants in educational process, informing and summaries, rather than educational materials delivery, learning or assessment.[10]
- In those cases where delivery of educational materials and assessment was primary goal, mostly rich content capable devices were used, without taking into concern what capabilities of content presentation are common for the majority of students' devices.
- The systems for m-learning considered were mostly viewed as stand-alone systems, without intention of blending them into existing e-learning systems.
- There is no evaluated methodology for introducing m-learning systems and their integration with existing e-learning systems; existing models are technology dependant.
- The efforts to integrate m-learning into LMSs usually fail because of fast development of LMSs and incompatibility of m-learning applications with their newer versions.

Taking into account recommendations published by leading researchers in the field of m-education, we have proposed a model for

introducing m-learning into the e-learning system at the Faculty of Organizational Sciences. (Figure 3.)

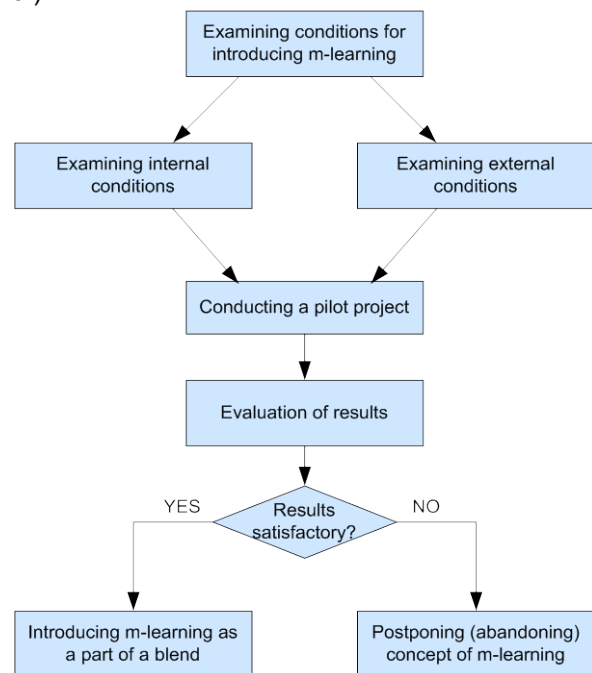


Figure 3 Model for introducing m-learning

Basic requirement for introducing m-learning as a part of a blend is the existence of stable and fully operating system of e-learning. This includes conditions of:

- Internal environment – are there available human resources and technical equipment within existing e-learning system?
- External environment – do students posses adequate knowledge and infrastructure to use m-learning?

After examining conditions for introducing m-learning as a part of a blend, a pilot project will be conducted. The students will be assigned some mobile activities as a part of their learning process.

Data collected during pilot project will be analyzed in order to conclude if it is possible to effectively blend m-learning into the existing e-learning system. We expect to get conclusions about which types of activities, types of learning materials and tempo are best suited for this purpose.

Finally, conclusions will lead either to postponing implementation of m-learning as a part of system for e-learning, or to introducing it for certain types of activities as a standard part of blended learning system.

4. EXAMINING THE CONDITIONS FOR INTEGRATING M-LEARNING INTO E-LEARNING SYSTEM

Technical conditions for integrating m-learning into e-learning systems include adequate infrastructure in educational institutions, available skilled personnel and possession of mobile devices among students.

D. Prerequisites for blending m within e – internal environment

In the Laboratory for e-business, Faculty of Organizational Sciences, many undergraduate and postgraduate blended courses have been conducted for several years. The Laboratory is equipped with necessary technical infrastructure and there are available, qualified and experienced human resources.

The system for e-learning in the Laboratory for e-business is based on SME server v7. Web server hosts learning management system Moodle. About 700 postgraduate and undergraduate students of the Faculty of Organizational Sciences get their yearly tuition through the e-learning system. Skillful and experienced teaching and administration personnel are involved in creating, maintaining and teaching more than 40 online courses.

We derive the conclusion that necessary internal environment conditions are present.

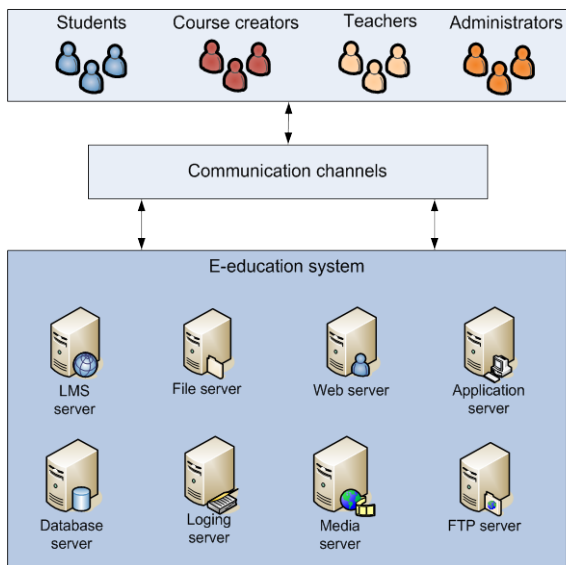


Figure 4 Infrastructure of e-education system

E. Prerequisites for blending m within e – external environment

In order to determine students' possibilities for using mobile content and activities in learning process, we have conducted a survey. Goal of the survey was to determine:

- type of devices that students own and

technologies supported by these devices

- experience and habits of using WAP services and mobile Internet
- the use of additional features of the cell phones, such as calendar, e-mail, audio, video and textual notes

We created a questionnaire divided into several groups of questions. First group of questions was created to determine type of device that is most commonly used by students at our Faculty.

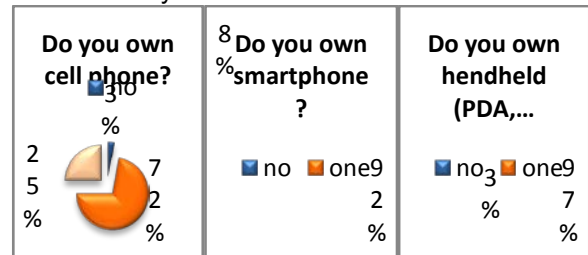


Figure 5 Ownership of mobile devices

The results show that more than 97% of students own mobile phone, while smartphone or handheld own less than 8% of students (Figure 5).

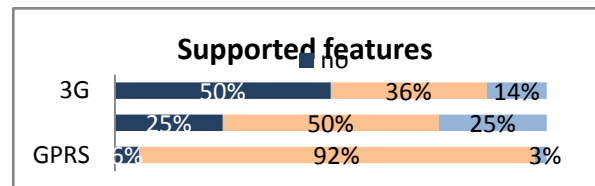


Figure 6 Supported features

When analyzing features supported on students' mobile devices, we could see that more than 92% of devices supported GPRS. Students answered that only about 50% of devices supported Java, while about 25% did not know this data. Further, objective analysis of models they have stated to own, showed that Java is supported on about 86% of devices and GPRS on 96%. 3G features are supported on about 36% of students' devices.

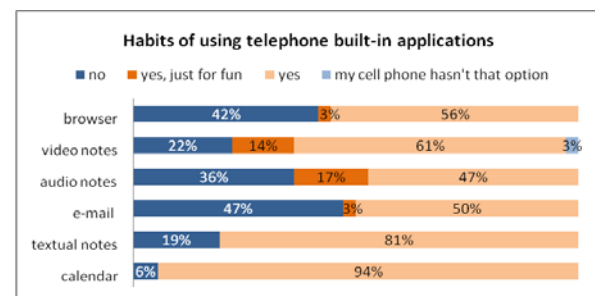


Figure 7 Habits of using built-in applications

Most frequently used application is calendar (94%), followed with textual (81%) and video

notes (75%). Audio notes (64%), browser (59%) and e-mail (53%) are less frequently used, but still majority of the students had experience of using these applications on their cell phones.

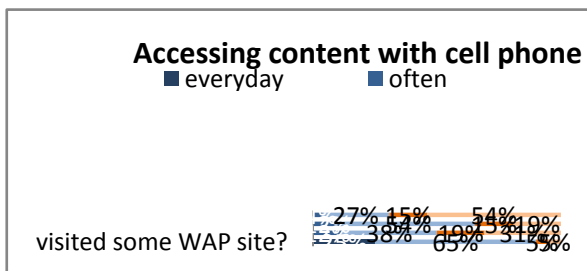


Figure 8 Experience with different types of wap content

When looking into details about different wap browsing/downloading experience we could see that actually about 95% of students had mobile browsing experience, but that only 25% are everyday users. Pictures are most downloaded content (81% of examinees had experience with it), followed by music (69%) and video (46%).

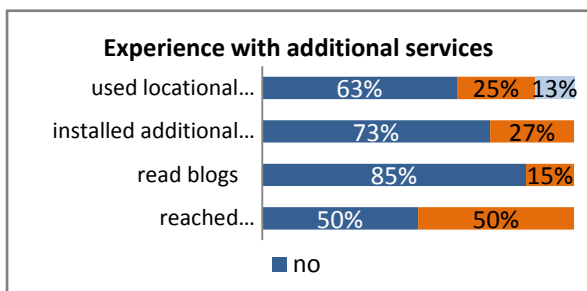


Figure 9 Students' experience with m-services

Additional services use only about one quarter of population. However, it is interesting that even 50% of students have already

accessed learning materials on their phones.

The most important conclusion from this survey was that GPRS and Java technologies are widely present on students' devices, and that they can be used as target technologies for delivering mobile content for m-learning. Educational content should be customized for the use on cell phones, not only smartphones and PDAs.

It is also important that significant number of students is not aware of possibilities of their devices and is not used to mobile browsing. In order to effectively blend m-learning into e-learning, some students will have to be given some training in using their mobile devices for learning purposes.

5. THE PILOT PROJECT

Not all activities and teaching materials used in e-learning system are suitable for mobile delivery. Before allowing students to access one of their learning activities via mobile device, some consideration have to be made.

F. Moodle Activities

Moodle allows a teacher to create many versatile activities. Most frequently used activities are Assignments, Quizzes, Forums, Resources, Lessons and Choices. For the pilot project it was necessary to analyze constraints of these activities and choose most suitable one for mobile delivery. Table 2 shows most frequently used Moodle activities, considerations and constraints for delivery on mobile phone for each activity.

Table 2 Moodle activities and mobile delivery

Moodle activity	Suitability for mobile delivery	Considerations/constraints
Forum	Yes	Constraint: slow input
Assignment – online text	Yes	Suitable only for short submissions
Assignment – upload file	Yes	Only for uploading audio or image files created on the mobile device; it is better to use it as a desktop activity
Chat	Yes	Constraint: slow input
Glossary	Yes	Constraint: slow input
Workshop	No	-
Quiz	Yes	Not all types of questions are suitable
Choice	Yes	Very simple, no constraints
Lesson	Yes	Only for small text lessons, without multimedia content

Among all activities, we have chosen to implement quizzes for the mobile delivery in pilot project, for the following reasons:

- 1) The content and format that is presented in quizzes can be controlled best.
- 2) Quizzes have proven value either as self assessment or as a method of collecting information on students' knowledge.
- 3) Quizzes are widely used in existing e-learning environment and have big impact on students' final grade.

Pilot project consisted of two experimental mobile quizzes, and inquiry on the immediate experience. For the purposes of mobile quiz assessment we created an application blended into Moodle. Moodle (Modular Object-Oriented Dynamic Learning Environment) is one of the most frequently used learning management systems (LMS) for organizing and carrying out e-learning courses. It is open-source, web-oriented, user-friendly platform for online learning.

G. The Mobile Quiz Application Blended into Moodle

Moodle is written in PHP. It used to rely merely on MySQL database. Moodle API is present from the version 1.7. It enables uniform database access for different DBMSs.

Mobile quiz application is written in PHP, based on Moodle API. For its mobile delivery it uses XHTML MP. It can be accessed from the mobile telephone default browsers, and from Opera Mini, which is favorite free mobile browser. Opera Mini is JAVA application and can be installed on any cellular telephone that supports JAVA MIDP.

The application is based on server side customization of pages for mobile delivery.

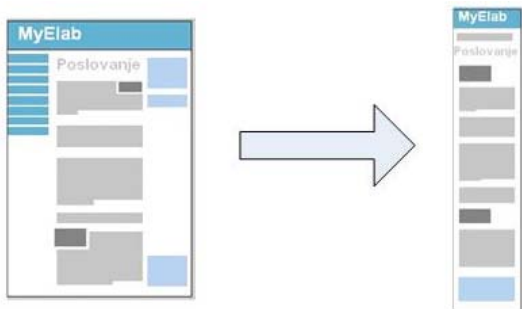


Figure 10 Desktop version of the web page and web page optimized for the mobile device

Desktop Moodle presents the course content in 3 columns. The auxiliary blocks are positioned on both sides of the screen, while the main

course content is presented in the center of the screen. Mobile applications generally present content in one column wide exactly as the screen, so that there is no need for horizontal scrolling. Mobile Moodle Quiz application does the same. Auxiliary blocks are collapsed to necessary links. The application was developed using Larman methodology. Use case diagram is shown in Figure 11.

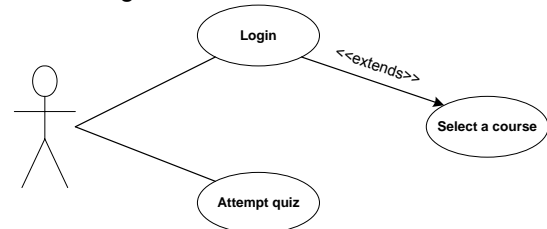


Figure 11 Use cases for the Mobile Moodle Quizzes Application

The Use Cases for the mobile application are

1. Login
2. Select a course
3. Attempt quiz

Login use case

Student activates the application. The System checks the student device and redirects it to the mobile application. The Student fills in his username and password and calls the system to log him in. The System checks the provided data and shows the available quizzes in the course, or the available courses, if the student is enrolled to more than one course.

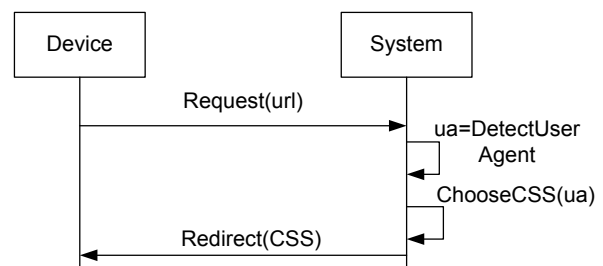


Figure 12 A fragments from the login UC explaining the adaptation of content.

During the login UC the application uses WURFL (Wireless Universal Resource File) to get the user agent header and to detect the device, redirects the user to the correct version, and decides which WCSS theme to select from 3 themes that we have created for different mobile user agent presentation capabilities.



Figure 13 Main course mobile page and Quiz question mobile page

H. Evaluation of the pilot

Survey on the usage of mobile quizzes application included mobile students' assessment and a questionnaire.

First quiz had five questions of different types (matching, multiple answer, yes-no, short answer), about the organizational aspects of their undergone E-Business subject. Students were well informed about that matter. The aim of this introductory quiz was to get students acquainted with the question types' interface, and loose the pressure or fear from mistakes. The following questionnaire examined the usage of new media, clarity of interface, and adequacy of appearance as well as the impressions about difference from desktop approach. The second quiz was on the matter from the E-Business course. Similar ten-questioned quizzes these students had to pass during the semester, through Moodle, only this time without the usual 10 minutes time limit. After the quiz the students were again asked about the interface, if they got used to it, some questions about fatigue and distractions while taking the quiz.

It took on average 234.2 seconds to finish the first quiz. That is 3 minutes and 54 seconds, 46.84 seconds per question on average. We have compared the results and time taken with the introductory quiz the students did on E-business course on their desktop computers.

Table 3: Average time taken and average scores on two mobile quizzes and control, desktop quiz

	total time	number of questions	time per question (sec)	average score (%)
first mobile quiz	3 min 54 sec	5	46.84	78.68
second mobile quiz	6 min 58 sec	10	41.79	37.01
desktop quiz	5 min 33 sec	10	33.27	83.80

Attempting that introductory 10 questioned quiz lasted on average 332.67 seconds or 5 minutes and 33 seconds, 33.27 seconds per question on average. The obvious time difference per

question (40%) is due to the longer loading of the (smaller sized) pages. Some additional time could have been taken for reading the question text. The average time per question on the second mobile quiz was shorter 41.79 sec per question. It can be explained by the fact that students got used to the interface and new medium, but also with giving up from answering. It can be concluded, with the average score of 37.01%, that the tested students were not prepared and that the questions were difficult.

The majority (58%) of the students had affirmative opinion about mobile quizzes. 17% answered that they liked it, 42% found it interesting, 8% unusual, and 33% gave negative answer (somewhat exhausting). No one chose the answer boring.

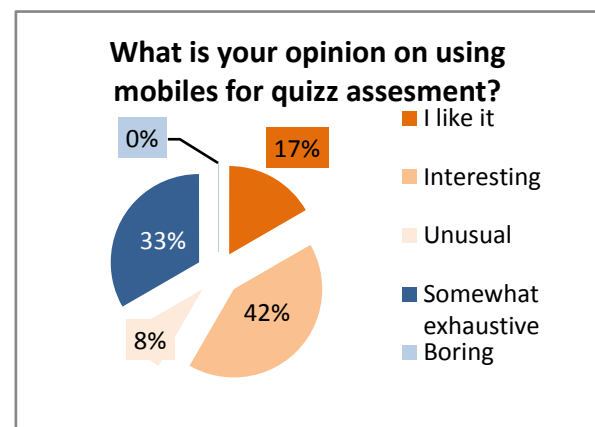


Figure 14 Students' impression on mobile quizzes

Comparing to the appearance of the other question types multiple answers has lower position on the chart. This fact leads to the conclusion that WCSS for this type of questions should be changed by using smaller fonts, so that more text fits into the screen. Short answer type of question, on the other side got a little bit better grade than the other types, probably because its form resembles SMS that are cell phone users accustomed to.

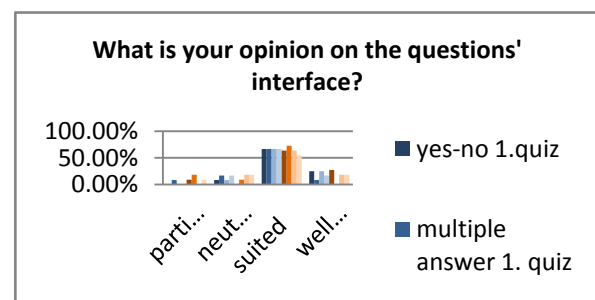


Figure 15 Opinion on the questions' interface

The usage of the application depends on the easiness of continuous usage. Therefore the examinees were asked if they sensed fatigue. After 11 minutes of assessment some of the examinees felt tired to some extent (overall fatigue about 30%), especially when the eyes are concerned (about 40%).

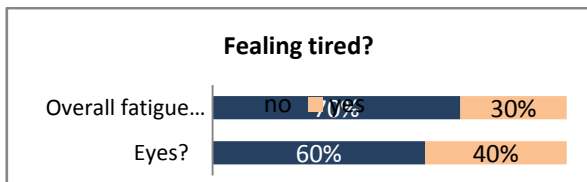


Figure 16 Fatigue during mobile quizzes

6. FUTURE WORK

Previous results suggest that the best usage of mobile tests and mobile learning is with short forms that are similar to the everyday usage of mobile phones. Positive impression that mobile testing has left over the examinees leads to the conclusion that this type of learning activities would be welcomed in the blend of e-learning and other learning activities, for raising motivation, and as a useful media. We expect that it would raise efficiency and effectiveness of e-learning systems. Cost-benefit analysis should be performed in order to determine the exploitation costs of the system, since it includes third party – mobile providers. From the aspect of education we expect long term success of the integration if we carefully perform following steps:

- Some students should be given prior training of more advanced usage of the devices they already possess.
- Evaluation of mobile quizzes should be done on regular subject matter, not just on example tests.
- Planning and preparation of content for mobile learning.
- The effect comparing to the matter learned more traditionally has to be measured, as well as
- How often and why is mobile approach chosen rather than desktop if it is not mandatory?
- Possibilities of web based usage of audio and video formats that are already supported by GPRS enabled phones have to be thoroughly examined in the context of Moodle activities.
- Adaptation of other Moodle activities to mobile delivery has to be performed.
- SMS learning activities – forms that resemble SMS could be used for collecting opinions, impressions, and ideas.
- MMS activities - it is desirable to include, because of easier usage, besides textual, other types of materials; for instance, MMS for collecting audio and video clips with answers or

opinions on particular topics.

- Mobile learning should include edutainment and JAVA applications.
- Mobile learning should be in short forms that resemble everyday usage of mobile phones.
- For the beginning mobile learning activities should be built more on text than on multimedia while in general students gain better devices.

7. CONCLUSION

Mobile learning concepts are presented in this paper. We have described the aspects of mainstreaming of learning and the implications on usage of target devices. Blending of m-learning within the systems for e-learning was described as best practice. The research was divided into three parts. The circumstances under which students use mobile phones were examined and target technology was chosen. Moodle API based mobile learning application was designed for the purposes of research. The evaluation of system was done and conclusions were made. The research suggests that students willingly accept mobile learning activities, but that frequency of mobile usage, type and lasting of the activities should be carefully chosen. This leads us to further research on these particular topics. Finally, the quality of mobile learned matter should be compared to the quality of one accepted more traditionally.

Fast development of mobile technology will certainly bring new, powerful devices with prices affordable to the majority of population. Current models already offer enough possibilities, with built in cameras, audio and video capturing, data transmission and decent textual interface, to be used for creative multimedia education.

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Information in Plants

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Abstract — *Information in plant leaves is determined by the morphology and by the physiological activity of a plant leaf. The information I sent by a plant leaf can be connected with the luminescence spectra emitted by the leaf. The quantity of information I being emitted is specific for a plant species. Obtaining the information I can help us to increase our knowledge about response from plant concerning living environmental conditions and changes in its morphology and physiology.*

Index Terms — *plant leaf, emitted information*

1. Introduction

In the plant world, the changes of morphology and physiological conditions of a leaf are always followed by the change of the leaf color (the emitted light). Several examples will be presented. The change of the leaf color can be direct consequence of destruction of the photosynthesis apparatus caused by the effect of high [1,2] or low [3] temperature. The insufficiency of minerals will always cause change of the leaf color [4]. The changes in the genetic structure of a plant will result in the changes of the emission spectrum of the plant leaves [5]. On the other hand, it is well known that the chlorophyll fluorescence in vivo is connected with the mechanism of photosynthesis [6]. Therefore, it is obvious that every change in the photosynthesis process will result in the change of fluorescence [7]. In accordance to all previously said, it can be assumed that the change of the color of a plant leaf (the position of the emission maximum and the shape of the spectrum) can give the information about the physiological condition of a plant as well as about the resulting changes in a leaf.

2. Theory

Helmholtz free energy F is equal to the difference between internal energy U and product of entropy E and temperature T [8]:

$$F=U -TS \quad \text{Eq.(1)}$$

Decrease of working ability, i.e. live system's free energy F decreasing, means that ability for performing assimilation and dissimulation has decreased [9]. According to theory, one can write that information I which was emitted by biological system is directly proportional to the entropy S of the system [8]:

$$I = \frac{0.693}{k} S \quad \text{Eq.(2)}$$

, k is Boltzmann's constant. From Eq.(1) one can express entropy as $S = (U-F)/T$ and placing in Eq.(2) we have:

$$I = \frac{0.693}{k} \frac{U - F}{T} \quad \text{Eq.(3)}$$

Considering plant leaf, which presents biological system, it could be assumed that the efficiency of photosynthesis apparatus in performing photosynthesis is equal to the ability to perform assimilation and dissimulation. Determining photosynthesis apparatus' efficiency is based on Kautsky's effect and gained R_{fd} , factor of induced kinetics that presents measure of photosynthesis apparatus' efficiency [10]. It can be concluded that $F = R_{fd}$, so relation Eq.(3) is transformed into :

$$I = \frac{0.693}{k} \frac{U - R_{fd}}{T} \quad \text{Eq.(4)}$$

On the other hand a plant reminds visible over extended periods of time and has to gain as much energy as it loses during energy exchange with environment by radiation. Plant leaf surface are nearly black and have emissivity ϵ between 0.95 and 0.98 [11]. Therefore, we considered flat plant leaf

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fluorescence emission from point of view of black body radiation. We assumed, in agreement with Stefan-Boltzmann law, that area under the flat plant leaf fluorescence curve is equal or close to the total energy a plant leaf can emit in environment. According to the facts mentioned above the total energy budget of a flat plant leaf can be expressed by area under the fluorescence curve of a flat plant leaf: $U = A_{\text{PLF}} Q_{\Sigma\text{epi}}$ Eq.(4) one obtained:

$$I = \frac{0.693}{k} \frac{0.965 A_{\text{PLF}} - R_{\text{fd}}}{T} \quad \text{Eq.(5)}$$

From Eq.(5) it is clear that in order to obtain information I which plant leaf emitted in environment, sufficient way is to use plant leaf optical measuring dates (chlorophyll fluorescence and induction kinetics/Kautsky effect).

2. RESULTS AND DISCUSSION

It is well known that any environmental unfavorable conditions can cause change in plant structure [12] and morphology [13]. At the same time, it can influence on fluorescence spectra and induction kinetics [14]. Therefore, one can conclude that any change in fluorescence spectra and induction kinetics is direct consequence of change in plant structure and photosynthetic activity. In agreement with facts mentioned above and Eq.(5) it is expected that information I which plant can emit in environment can be changed. In the other words, any changes in plant structure and photosynthetic activity can cause change of information which plant can emit in environment. Later in the paper, we present several examples, which clearly show connection between changes in plant morphology, photosynthesis activity and emitted information I.

From the other point of view the same problem can be considered inversely. So, one can say that any change in information I which plant emit in environment can be indicator that something happened in plant (destroyed or decrease of photosynthesis, changes in structure etc.) as direct consequence of change living environmental conditions.

Furthermore, we can show how information I, which plant can emit in environment is connected with plant state and its response on changes of environmental living conditions.

As we previously said any change in environmental conditions can cause changes in structure and photosynthetic activity in plant and at this way can cause changing in system (plant) order - entropy S. This leads toward conclusion that information I which plant can emit in environment can be change. One illustrative example is cadmium-induced alteration in photosynthetic activities of *Zea mays* L.[15]. The data are presented in Table 1.

Taking great changes in plant photosynthetic activities, which is one the most important process in plant, into account, can cause great changes in plant order in the manner: greater changes in photosynthetic activities, greater changes in system order at thus way in system entropy S. Increase of Cd concentration causes damage of the photosynthetic apparatus [16]. Greater change in S can cause greater change in information I that plant sent to environment. Data from Table 1 suggest on conclusion that increasing Cd concentration can induce decrease of information I that mean great change in system (plant) order.

Table 1. Cadmium-induced change in information I for *Zea mays* L [15].

Treated with Cd (mM)	R_{fd}	A_{PLF}	I [bit/s] x 10^{18}
0.00	1.32	208726	3.45
0.01	1.27	194314	3.21
0.1	1.43	167450	2.77
1.00	1.48	108877	1.81

In this example we can consider connection between information I and structural changes in plant leaf. We can consider change of information I due to change of concentration of photosynthesis pigments. It is clear if the concentration of the most important constituent

[Ch(a), Chl(b), caroten] for photosynthesis decreases itself, the ability for photosynthesis in plant leaf can also decrease. In final state if the molecules of mentioned important pigment disappear or are completely destroyed, photosynthesis stop and plant is dead with the greatest change order at this way in the greatest change in entropy S. According to Eq.(2) it means the greatest change in information I. Information I calculated using literature data for Chery-laurel (*Prunus laeocerasus*) [17]. In the Table 2 obtained data are presented for chery-laurel (*Prunus laeocerasus*) [17]. One can see that information I, which plant, can emit in environment increase with decreasing pigment concentrations. It is expected, because smaller pigment concentration is connected with greater system disorder /greater entropy S. Also, data in Table 2 suggest conclusion that decreasing of photosynthesis pigment concentration is followed with adequate information I increasing.

Table 2. Effect of pigment content of Chery-laurel (*Prunus laeocerasus*) information I [17].

$\Sigma[\text{Chl(a)}+\text{Chl(b)}+\text{carot.}]$ [$\mu\text{gr}/\text{cm}^2$]	R_{fd}	A PLF	I [bit/s] $\times 10^{14}$
66	2.90	110	17.68
40	2.30	165	26.88
6.5	2.00	275	45.11

In this case, the effect those completely different sources have on information I which plant can emit in environment is described. Namely, influence of unfavorable living environmental condition on information should be considered. Global warming and the increase of UV radiation, due to damaging the ozone layer, are obstacles for the normal photosynthetic activity and present a treat to the survival of the plant life itself.

Numerous researches point out that UV radiation doubtlessly induces multiple and various changes on plants. Gradually, it becomes one of the major ecological problems. But beside numerous experimental data there are contradictory results regarding the effect of

UV radiation to the plants. So, exposure to increased UV-B radiation has been shown to reduce photosynthesis in many plant species [18].

A few studies show that UV-B radiation did not have significant effect on chlorophyll concentration at rice and pea plants [19]. In the Table 3 data about effect of the UV-B and UV-B/A radiation on soyaben (*Glycine max*) plant information I are presented. We used data of the effect UV radiation on soyaben (*Glycine max*) for calculating information I [20]. It is clear that information from the sample is smaller for plant exposed to UV-B and UV-B/A radiation comparing to the control plant. In agreement with conclusion about effect of UV radiation on plant we are not able to conclude if it has positive or negative effect on plant but it is sure that effect is not neglected.

Table 3. Effect of the UV-B and UV-B/A components of solar radiation on soyaben (*Glycine max*) information I. [20]

	R_{fd}	Area	I [bit./s] $\times 10^{15}$
Control.	0.694	612	10.10
UV-B	0.699	553.96	9.14
UV-B/A	0.695	490.53	8.09

Finally we can consider morphology change in plant leaf and its effect on information I. As we mentioned above any change in plant morphology can cause change in efficiency of plant photosynthetic activity regardless the reason, which cause change. Sometimes unforgivable environmental conditions such γ -radiation can cause genetic change in plant and direct consequence can be mutant. Thus, in any mutant of one plant species genetic difference can cause difference in structure and morphology and in this way difference in photosynthetic activity. Direct consequence of changing plant photosynthetic activity can be change of the florescence spectra and induction kinetic. Changes in genetic mean

changes in structure and in the same way changes in order – entropy S . According to Eq.(5) it is expected that information I which plant emit in environment can vary from species to species. In other words, change in information I unambiguously can show that change in morphology occurred. In Table 4 data for five mutants of the cowpea (*Vigna unguiculata* (L) Walp) varieties [21] are presented. One can see from Table 4 that for the same variety information I change with its age: information I increases with age. This change can be connected with change in structure and functionality of the photosynthesis apparatus efficiency due to getting old. Described change – increase of information I due to getting older is understandable. Namely, process of getting older is unavoidable for all biological objects. Destruction and retrogression of biological object's structure and decreasing of physiological processes follow it. Direct consequence of these changes is increase of system's disorder, measured by entropy. It means that entropy of the system will be increased too. By getting older, biological systems move from the state of higher order (higher entropy S) toward states of lower order (lower entropy S). In accordance to the information theory, it can be said that the information I , which is sent to the environment, is directly proportional to the system entropy S [8]. Therefore, in agreement with facts mentioned above, discursion and information theory obtained increasing information I with plants getting old are expecting. Also, one can see (Table 4) that information I is different for the same age of varieties. One of reasonable explanation can be that different mutant during the growing process change its order, entropy S , slower or faster and have different "grooving rate". At this way slower or faster change of entropy can cause slower or faster change in information I . This fact leads to conclusion that rate of change in information I can be measure of biological system vitality. In the simple words: slower change of information I mean greater biological vitality and contrary faster change of information I mean lower biological vitality.

Table 4. Information I in cowpea (*Vigna unguiculata* (L) Walp) varieties [21].

Cowpea (<i>Vigna unguiculata</i> (L) Walp) varieties				
		$R_{fd}^{[22]}$	A_{PIF} [cm ²]	I [bit/s] x 10 ¹⁵
V1	6 week	3.4	250.11	4.076
	7 week	3.4	340.30	5.567
	8 week	3.4	510.81	8.385
V2	6 week	3.4	684.25	11.25
	7 week	3.4	1032.65	17.01
	8 week	3.4	2593.84	42.81
V3	6 week	3.4	353.53	5.785
	7 week	3.4	584.81	9.608
	8 week	3.4	1890.82	31.19
V4	6 week	3.4	296.40	4.841
	7 week	3.4	628.81	10.34
	8 week	3.4	1713.06	28.26
V5	6 week	3.4	358.75	5.871
	7 week	3.4	1328.32	21.9
	8 week	3.4	2659.17	43.89

Taking facts mentioned above into account, if we define information rate I_r as change of information I in chosen time interval $\Delta I/\Delta t$ it can be possible to determine biological vitality. Time interval Δt may be defined as second, day, months or years depend of biological object, growing condition etc. So comparing I_r of several different biological objects in unforgivable environmental condition it can be determined which one have greater vitality, abilities to keep its properties better then the other ones.

3. Conclusion

Information that plans can emit in environment could be used as tool to give answer on questions:

- Did unfavorable environmental conditions cause damage in plant;
- What is plant ability to adapt to unforgivable environmental conditions
- Did unfavorable environmental conditions cause change in plant genetic.

4. Acknowledgement

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