THE MARKETING OF HIGH-TECH INNOVATION: RESEARCH AND TEACHING AS A MULTIDISCIPLINARY COMMUNICATION TASK

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ABSTRACT

Economically successful high-tech innovation is one of the driving forces for global welfare. Like innovation half-life, break-even time to market or technology acceptance, effective multidisciplinary communication between engineering and marketing is a critical success factor. This paper aims to show the requirements of multidisciplinary communication in B2B marketing of high-tech innovation and methodical approaches in research and academic education:

1. Requirements in high-tech innovation marketing as an ongoing dialogue between technology, finance and marketing.
2. Experimental method of marketing test beds for innovative high-tech start-ups based on a multidisciplinary approach
3. Results of a multidisciplinary education scheme conducted by three universities that cooperate in high-tech innovation marketing by setting up workshops in pharmacy and health, agricultural and bio products, and information and communication technology (ICT).
4. Requirements of a multidisciplinary network spanning the triangle of science – education – business.

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KEYWORDS: High-tech innovation marketing, multidisciplinary communication and education, marketing test bed, student teams, multidisciplinary education, pictures as communication device, CEE universities, topic group

1. REQUIREMENTS OF HIGH-TECH INNOVATION MARKETING AS AN ONGOING MULTIDISCIPLINARY COMMUNICATION

Many business decisions in marketing and sales, R&D, purchasing, manufacturing and storing involve different knowledge disciplines. Multidisciplinary research has received increasing attention by bridging and combining the viewpoints of different disciplines [45: p. 11]. The multidisciplinary approach as a cognitive style is analyzed in the case of multidisciplinary creativity [38]. Operational teams and management teams often consist of members from different knowledge disciplines. Each knowledge domain has its own domain language. Multidisciplinary communication (MDC) deals with content and communication partners who belong to different knowledge disciplines (domains), and exchange their views on content from different disciplinary viewpoints (see [25]: fig. 4, The relationship between disciplines and MDC).

Although MDC is an everyday phenomenon, the field of MDC in high-tech innovation marketing shows a knowledge map with many blank spots. The purpose of this paper is twofold:

A) To show the requirements of MDC in business-to-business (B2B) marketing of high-tech innovation;

B) To show methodical approaches in research and academic education to cope with MDC challenges.

High-tech innovations are characterized by attributes that require multidisciplinary communication (MDC) [1]; in medicine, for example, see [18: MD rounds in medicine], [26: p. 716]. Marketability strongly depends on the communicability of the innovative features which are demanded by the addressed customer target group. Since high-tech innovations result from natural science and technical engineering disciplines, their linguistic representation uses mostly syntactic forms, semantic meanings and pragmatic patterns originating from the natural science disciplines. Innovations are considered successful if their market entry [10] and their market presence result in a positive commercial yield, usually measured by business ratios such as return on sales (RoS) or return on investment (RoI). Hence marketability is a basic requirement for economically viable high-tech innovation.

1.1. Criteria of High-Tech Innovation Marketability

High-tech attitude implies nearness to natural scientific basic and applied research. From a business viewpoint, high-tech innovations are judged as a high-risk, high-profit business.
The criteria C1 to C6 (similar approach in [21]: table 3) of high-tech innovation can be described by the features below:

(C1.) Innovativeness:

The degree of innovativeness can be described by:
- the level of invention;
- the competitive position of the innovator with regard to the estimated time span of
- innovation half-life in relation to the best competitor known to the innovator;
- the degree of comprehensibility within the MDC.

(C2.) Testability:

The degree of testability can be described by:
- the ability to perceive failures, caused by malfunctions of the innovative system;
- the availability of compliant sensors with adequate detection limits to measure the errors;
- the ability to understand error causality and to take correcting measures within the required time limit. The performance ratios include mean time between failures (MTBF) and mean time to repair (MTTR).

(C3.) Controllability:

The ability to sustain system stability by efficient failure management.
The efficiency criteria expressed by:
- minimal amount of system downtime in a specified period of time;
- sufficient variety of actuating variables to compensate failures;
- temporal functional availability of the system.

(C4.) Compatibility:

The ability of the high-tech innovation to seamlessly interoperate with the existing, functionally designed modules in compliance with industrial standards and legal regulations. The degree of modularity and interface standardization has a direct impact on the quality of multidisciplinary comprehension. Modularization contributes to the reduction of complexity and reduces the risk of poor understanding.

(C5.) Implementability:

The ability to implement the high-tech innovation in the organizational environment in line with corporate culture, technological requirements, and social and environmental standards.

(C6.) Assimilability:

The ability to assimilate the high-tech innovation in the working environment, seamlessly understanding its functional behavior, and to work with the sustainable assimilation of the innovation in a specified working environment.

1.2. Innovation Acceptance

Innovation acceptance [8], [9] and innovation resistance [29] are drivers of and barriers to an economically successful market entry within George Day's "window of opportunity" [10] to conquer the market. In the case of technology innovation, the models and methods of technology acceptance may be used to evaluate the degree of acceptance of and the degree of resistance to innovative technology. This paper focuses on high-tech innovation in business-to-business (B2B) marketing.

In B2B marketing, the evaluated criteria C1 to C6 heavily influence companies` purchasing decision behavior. The case of B2B marketing requires understanding the purchasing behavior of a buying center (buying group). A buying center can be seen as a cross-functional project team [30]. Cross-functionality is a proven economic success factor in high-tech innovation and implies cooperation between different knowledge disciplines. It means a specific organizational form of multidisciplinary cooperation [30: p. 213] for problem solving, therefore also MDC in a problem-solving context. The buying center is represented by a multidisciplinary buying team, through which the required knowledge for evaluation of C1 to C6 is used for the buying decision. Each member of the buying center shows a domain-specific knowledge and experience profile. The member's profile of technology acceptance or technology resistance before and after the decision to buy or not buy reveals important information. In general this information is not completely known to the innovator in detail. The available information may be used by the innovator in designing and fine-tuning marketing communication, thereby minimizing the risk of misunderstanding or rejection of the selling offer. The articulated expression of enduring innovation resistance after a company's buying decision is a steadily growing assimilation gap (see [15]).
Technology acceptance [8], [9] is explained by two variables:

- Perceived usefulness (PU);
- Perceived ease of use (PEoU)

Since the technology acceptance/rejection decision is a buying center group decision, MDC communication to evaluate the content of the aforementioned criteria C1 to C6 requires an MDC rule system. From the semiotic viewpoint, the buying/selling process for high-tech innovation turns out to be an articulated MDC process. Since the marketing process deals with buying/selling decisions, perceived usefulness (PU), perceived ease of use (PEoU), and perceived risk, the semiotic dimension of communication (syntax, semantics and pragmatics) play a decisive role in the MDC game between innovator and B2B customer (see Chapter 3: Empirical Results in Multidisciplinary Education).

1.3. Selected Semiotic Aspects of MDC

The predominant aspect of MDC in this context is MDC-data quality. The data quality approach of G. Shanks and B. Corbitt [35: p. 786] also considers the extrinsic characteristics "usefulness" and "usability." Based on this structural affinity with technology acceptance models, data quality can be defined as "fitness for purpose." From a risk analysis viewpoint, the five intrinsic data quality problems are: "incompleteness, meaninglessness, ambiguity, redundancy and incorrectness." The semiotic framework recommended in [14: p. 9] is a valid model to analyze MDC. In addition to the three semiotic layers (syntactic, semantic, pragmatic), it considers the physical layer, the empirical layer and the social layer [14: p. 54, fig. 3.5-2]. Applying this "semiotic ladder" to the analysis of MDC in the technology acceptance context enables us to distinguish different quality layers for efficient MDC.

MDC deals with content and communication partners who belong to different knowledge disciplines e.g. [29] and exchange their views on content from different disciplinary viewpoints [25: fig. 4: The relationship between disciplines and MDC]. Content diversity of terminologies implies the risk of communicative non-understanding or misunderstanding [34]. Hence members of multidisciplinary teams incur the risk of non-efficient communication. This fact raises the question "Which strategic options exist to lower the risk of non-efficient communication to the MDC partners?"
There are several strategic options:

- **Option A**: "Learn how to go into detail in a non-familiar knowledge discipline"
  Option A is time-consuming and not applicable in the context of high-tech innovation marketing because of scarce time resources within the sub-goal "minimizing time to market!" Taking into account the aspect of competitiveness requires highly specified, multidisciplinary knowledge to convince the early customer to trust in an innovative technology.

- **Option B:** "Tentative acceptance of discipline-black boxes"
  Option B is less time-consuming but entails:
  (a): The risk of partial non-understanding caused by different semiotic lacks (see [16]: multi-functionality implies multidisciplinary; [43: chapters 3, 4], [44]: "misunderstanding," "accidental relevance" of "cautiously optimistic hearer");
  (b): The chance to focus the communication process on the pragmatic communication target by applying the cognitive principle of relevance (see [44]).
  (c): The principle of "accepted black boxes": This communication option entails the temporary admittance of so-called syntactic, semantic and pragmatic black boxes for all communication partners in the MDC process. Those semiotic parts that are pragmatically considered to have less relevance at a specific point in time are suppressed and treated as "accepted pragmatic black boxes". Knowledge-based engineering approaches (e.g. [7: p. 7340, Design and Engineering Engine] seem to offer a viable framework for MDC and multidisciplinary engineering. The importance of tacit knowledge influence on communication efficiency varies depending on the granularity of distinguishing knowledge disciplines. It seems that the finer the granularity, the higher the knowledge affinity between different but similar disciplines, but this also implies lesser influence of tacit knowledge. Tacit knowledge is only a problem if it is not shared between the communication partners, but nevertheless referenced in communication. Fine granularity in distinguishing disciplines generally will ensure that tacit knowledge is shared within a discipline. For MDC tacit knowledge must be enclosed into the black boxes in order to avoid the problem.

- **Option C**: "Decomposition and modular MDC":
  Decomposition reduces complexity and therefore increases comprehensibility. We make the distinction between decomposition and modularity [16: p. 5]: "modular systems differ from decomposable systems; while decomposability requires a full decomposition of a complex system into subsystems, modularity requires a system architecture in which subsystems are still connected via interface standards." We consider the design structure matrix (DSM) approach [3: p. 295] a viable approach to model information flow and communication tasks of multidisciplinary teams in a decomposable, modular organizational environment. The application of the DSM approach to multidisciplinary team building shows sustainable improvement of MDC [3: p. 296: "simply building the Design Structure Matrix encourages disparate people and teams to increase mutual awareness and understanding"]. The selection of modularization criteria is driven by the below-mentioned cognitive and communicative principles of relevance in semiotic research. A modular MDC is communicatively efficient if each module:
  a) applies the principle of cognitive and communicative relevance;
  b) supports the communication via interface standards between the modules.
  There is a strong relation between principles of relevance and multi-criteria decision making. The buying decision for a high-tech innovation is a multi-objective, hence multi-criteria decision task to find a

non-empty compromise set over partially overlapping preferences of the participating MD team members (deciders, buyers, users, influencers, gatekeepers).
Option C reduces complexity by decomposing the MDC object into modules, and by applying the principles of cognitive and communicative relevance to the MDC-process. Modularity lowers the risk of misunderstanding and reduces complexity by offering oversight in multidisciplinary domains. The cognitive principle of relevance [44: definition (15): "Human cognition tends to be geared to the maximization of relevance"] and the communicative principle of relevance [44: definition (18): "Every utterance (or other act of overt communication) communicates a presumption of its own optimal relevance"], which are applied by all MDC partners, result in a pragmatically controlled and efficient MDC process. In an ongoing MDC process the degree of relevance is time-wise non-stationary. It may shift when formerly accepted black boxes transform into currently highly relevant and understood white boxes, requiring additional semiotic capacity of the involved MDC team members. The time-wise, non-stationary attributes of a multi-stage communication process for an entrepreneurial decision of market entry with an innovative high-tech product consist of an increasingly specified degree of precision of questions and answers. However, a non-stationary team structure requires a three-dimensional approach for DMS application [3, p. 295]. Matrix of semiotic dimensions of MDC applied to an example of electrical energy storage using Vanadium Redox Flow Battery Technology:

Table 1: Example of semiotic dimensions in the Electrical Energy Storing Development Project

Electrical Energy Storage Innovation Project					
Multidisciplinary Know How		Electrochemistry	Electronics & electrical engineering	Innovation Marketing
Know How Type		A	B , C	D
Semiotic dimension	Syntactics	Stoichiometry	IC-Logic, rule set of electrical engineering, non-linear charging rules	Market response function model, social percolation
	Semantics	V_2O_5: Divanadium pentoxide; electrolyte concentration of sulfur acid, graphite surface attributes, fluid dynamics, etc.	Charging/discharging, electrolyte lifetime, heating behavior, environmental conditions (external temperature, risk of corrosion)	TAM,[2] willingness to pay, price model, business model,
	Pragmatics	Self-discharge => Min.! Power density 500mW/cm^3	Availability > 99,99% Charging time < 3 hrs. DoD[1] > x%	Optimize ROI! Optimize ROS! Maximize PU![3] Maximize PEoU![4]
		How to design MDC?		
		How to cope with mutual goal conflicts?		

There is a trade-off between mutual personal trust between MDC partners and the required degree of semantic specification. The higher the mutual trust the lower the perceived semiotic uncertainties.

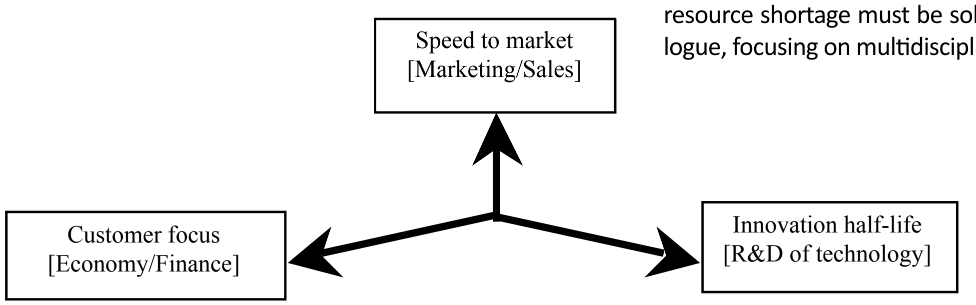
Tacit knowledge [28] cannot easily be communicated between individuals. Consequently, when black boxes need to be opened during the MDC process (thus becoming white boxes), tacit knowledge gets exposed to other members of the MD team. Given the usual lack of time, tacit knowledge needs to be accepted due to personal trust. The validity of the issue to be decided may never be questioned. Real semiotic uncertainties may be much larger than the perceived uncertainties. Additional risks, which cannot be discussed here in detail, emanate from tacit knowledge during the phase of transfer of knowledge to the customer. Moreover, the communication process itself depends, in addition to a formal framework, as explained above, on communication skills, which are a prime example of tacit knowledge.

[1] Degree of discharge
[2] Technology acceptance model
[3] Perceived usefulness
[4] Perceived ease of use

2. DECISION CRITERIA FOR MARKET ENTRY OF HIGH TECH INNOVATION

According to Chakravaty [6], the management decisions for market entry in high-tech marketing are positioned in a three-dimensional decision space:

Figure 1. Decision Space of Innovation Marketing



Between these three dimensions trade-offs exist:

- The higher the speed to market (= the lower the time to market), the lower the innovation lead.
- The higher the speed to market (= the lower the time to market), the lower the customer focus.
- The relation between customer focus and innovation lead is ambiguous and depends on the type of customer and on the half-life of the innovation lead [19]. If the customer is a launching customer who is actively involved with the extent of the innovation lead, then there exists a complementary relation between usefulness of innovation, as perceived by the launching customer, and the innovation lead of the supplier.

The entanglement of technology, marketing and finance is easily shown by the management ratios expressing the decision stress for market entry projects in innovative high-tech markets.

We distinguish, in conformance with the dimensionality of the decision space, three ratios of resource capacity. Each ratio measures the relation between resource requirement to attain the project (sub-) goals and the resource availability. If this ratio >1, then it signals a shortage of capacity, which can be interpreted as a symptom of stress with regard to goal attainment:

(1) Break-even time to market (BE-TTM) =
[Required TTM for BE / Available TTM for BE]:
If BE-TTM >1
=> Break-even time to market stress

(2) Competitive innovation lead (R&D-CIL):
[Required time for CIL / Available time for CIL]:
If R&D-CIL > 1
=> Innovation half-life stress

(3) Profitability of innovation return on sales (ROS-INN):
[Required ROS-INN / Achievable ROS-INN]:
If ROS-INN >1
=> Profitability stress

The entanglement of the different knowledge disciplines is obvious for each ratio. Enumerator and denominator show the amount of time of technical, commercial, legal or other resources ("man-days," "man-months") that are the required (enumerator) or the available (denominator) input for goal attainment. Causal relations for these industrial ratios have multidisciplinary origin. Hence the management communication process in this context shows a quite complex multidisciplinary structure. The conflicts in goal attainment caused by resource shortage must be solved by a multidisciplinary dialogue, focusing on multidisciplinary resource usage.

2.1. Marketing Test Bed: A Multidisciplinary, Experimental Approach to Market Entry of High-Tech Innovation

In an ongoing research project [13] on high-tech innovation that focuses on "how to support market entry through efficient marketing mix measures," we develop an experimental approach by setting up "marketing test-beds (MTBs)." MTB is a methodical support for market entry of innovative high-tech products or services [20]. It differs from a technical test bed (TTB) [e.g. 2] by focusing on customers' technology and product acceptance in terms of PU and PEoU, willingness to pay (WtP), and formation of marketing mix per market segment. As an experimental approach in B2B marketing, MTB supports the critical phase of market entry in innovation marketing, based on qualitative market research procedures such as problem-centered interviews and focus groups. Only a few MTBs are described, mostly for mobile communication products and services (see, for example, [39]). A comprehensive approach of MTB is given in [21]. In the "Cross-Border Hi-Tech Center" research project [13], different aspects of MTBs for high-tech innovation [27] are analyzed and validated using real examples:

Example 1: MTB for medical care robot for post-operation rehabilitation: testing a continuous compliant passive motion device for shoulder rehabilitation.
Example 2: MTB for hazard detection robot in fire-fighting and underground coal mining.
Example 3: MTB for auto-adaptive temperature regulation by phase change material in building materials applications.
Example 4: MTB for collaborative computing software in knowledge management.

All four MTBs are characterized by a challenging need for efficient MDC [40]. Looking at MDC in greater detail, one finds a hierarchy of disciplines and sub-disciplines of knowledge within natural science, socioeconomic science for example [4: p. 10, with MD discussion] and algorithmic science [41]. A convincing example of multidisciplinary understanding in teamwork can be found in [42: p. 3]: "multidisciplinary team-working requires mutual understanding between professions. Good communication is only one aspect of multidisciplinary interaction." The following features of MTB show the different aspects compared with TTBs:

- Innovation near to market: "functional proof of concept prototype stage";
- Market segmentation criteria, e.g. technological affinity, strain of bottleneck ("economic strain due to lost opportunity to increase productivity"), but also [5] for mobile communication;
- Type of scale: qualitative vs. quantitative market research;
- Segment-focused specification of marketing mix (McCarthy's 4Ps).

The MTB configuration uses community-based innovation (CBI) and open innovation (OI) approaches [19], and applies technology acceptance/resistance models [15], with PU and PEoU [8], [9], as key variables of the respective technology. In a follow-up MTB stage, the applicability of social anti-percolation [12] as a possible model for technology resistance will be under study.

From the viewpoint of European Network of Living Labs (ENoLL) [32], MTBs can play an important role as a multidisciplinary experimental approach of testing the efficiency of community-based innovation and user-driven innovation as manifestation of open innovation, as well as being a feasible source of experimentally controlled MDC.

3. THE CASE FOR MULTIDISCIPLINARY ACADEMIC EDUCATION

3.1. The Starting Point

Universities originally covered all fields of knowledge and were usually structured into four faculties. With the rapid expansion of knowledge starting in the 18th century, this system came to be seen as inadequate. Specialized universities were founded, devoted to subjects such as economics, technology, agriculture or mining.

In some Central and Eastern European (CEE) countries, universities have moved from their traditional monothematic orientation towards a polythematic system that integrates natural science, technological science and socioeconomic science.

Under monothematic-oriented academic education we identify natural science- and human science-oriented universities (Comenius University in Bratislava, Charles University in Prague, and the University of Vienna, even if these universities have a classic structure, covering many fields of science); technological universities (the Slovak University of Technology in Bratislava, the Czech Technical University in Prague, and the Vienna University of Technology); and economics- and social science-oriented universities (the Economic University in Bratislava, the University of Economics in Prague, and the Vienna University of Economics and Business).

Other CEE countries, namely Hungary, Poland, and Slovenia, now have multidisciplinary universities offering a combination of natural and socioeconomic science. For example, at the Budapest University of Technology and Economics, formerly known as the Technical University of Budapest, which dates back to 1782, the Faculty of Natural Sciences and the Faculty of Economic and Social Sciences were established in 1998. Slovenia's University of Ljubljana comprises six different faculties: art, economics, philosophy, medicine, technology, and natural science.

3.2. Innovation Marketing Aspects

Product and technology innovation is the driving force behind current socioeconomic trends, national economic growth and increased competition between enterprises. Exploitation of innovation for economic growth requires the ongoing education of new experts as well as leading-edge management methods that have an impact on the reform of academic education and research. From the viewpoint of industry, the focus of academic education [11] requires multidisciplinary design by applying rules of multidisciplinary teamwork [23], proactive project design and international networking. These trends necessitate the generation of organizational units in the academic environment that can control current social and business processes and stimulate new technological trends and their commercial implementation. This raises the question of whether the conventional catalog of knowledge disciplines at a monothematic university correlates with current business rules and expectations regarding the qualifications of new alumni. Business and commercial units will increasingly work with cross-disciplinary [31] and multidisciplinary management methods [46], professionally mixed teams, and projects [24] that focus on innovative business process concepts. Academic education systems must reflect these trends, which create new challenges for academic structures.

3.3. Multidisciplinary Teaching: The New Challenge

Although new teaching methods allow by default the didactic application of teamwork within the learning process (e.g. project seminar or laboratory studies), a new problem arises when searching for multidisciplinary solutions in the entrepreneurial context. Marketing education itself requires multidisciplinary teaching skills that cover different knowledge domains such as psychology, communication, art, mathematics and logic. Even so, marketing today is regarded as mono-disciplinary knowledge. Yet under closer examination marketing is not such an isolated mono-discipline. The conventional 4P marketing shows explicit overlapping with other knowledge disciplines, primarily with information and communication technology (ICT) [22], social media, cloud computing. Moreover multidisciplinary trends like on-line marketing, viral marketing, mobile marketing and neuromarketing have emerged. Marketing experts now have to be familiar with much more than economics.

This emerging reality presents a challenge for a monothematic-oriented economic university which, given the demand for real business marketing solutions, faces a structural mismatch due to self-imposed intellectual limitations on mono-disciplinary knowledge. Although the professional background of the teaching staff may be partially multidisciplinary, the most serious problem is that the students probably will not be able to form a multidisciplinary working team. In that case a multidisciplinary education would be confined to theoretical, pencil-and-paper case studies rather than reflecting business reality, and produces inadequately qualified graduates. In addition to explicit knowledge communicated to students, tacit knowledge is formed in seminars, laboratory exercises, etc. Tacit knowledge consists mainly of skills, such as the optimal way to approach a problem or communicate in a professional group. Therefore, the tacit knowledge needed to cooperate efficiently in a multidisciplinary group can only be formed if multidisciplinary group work occurs in the course of the curriculum.

We recognize the fact that economic disciplines, particularly in management and business administration, marketing and innovation management, will increasingly have to interface with applied natural science. While many production plant managers claim to be able to turn an engineer into a marketing expert but not vice versa, such transformations cannot be the overall objective of a multidisciplinary education. Multidisciplinary education must be geared to preparing professionally trained students to create and work in and with multidisciplinary teams. The creation of such teams, which are capable of solving multidisciplinary tasks and communicating the solutions to all stakeholders, is the proper target of multidisciplinary education [41].

It is a tough job to create a multidisciplinary education scheme [40] under the current restrictions of monothematic-oriented universities and curricula. We can look enviously across the ocean to Mexico's Tecnologico de Monterrey (TMU), which is offering a standard education scheme under which attractive projects are successfully assigned to multidisciplinary student teams. At a joint workshop with the Economic University in Bratislava a group of visitors from the TMU presented teaching methods for project management and innovation management. The teacher assigns a project for the development of a new product to a team of students who come from marketing, IT, design and mechatronics. If the multidisciplinary team completes the task within six semester-weeks, its next project is to create a business model for the newly developed product.

A similar working design is applied by the new start-up teams, participating in a Start-Up contest offered by Plug-and-Play Ltd. in California. The teams design an ICT product with a realistic business model and defend their results in a five-minute pitch to a jury. The success of a pitch is based on efficient analytics, solid IT and marketing expertise, and excellent training in pitch communication. For the past five years a similar education design has been applied by TU Wien and WU Wien for technology marketing.

Common introductory education for several or all university curricula, such as the 'tronc commune' at France's 'grands écoles', is another approach aimed at narrowing the MD communication gap.

3.4. First Results with Multidisciplinary Teaching at the University of Economics in Bratislava

We have carried out several experimental projects at the University of Economics in Bratislava (EUBA) focused on multidisciplinary design in academic teaching. Two of the projects are described below:

3.4.1. The "Creative Business" Project

The project brought together EUBA marketing students and design students from the Academy of Applied Arts Bratislava (VSVU), who were assigned to revitalize a health and wellness village in Slovakia [42: p. 2]. This is a problem-solving approach starting from two diametrical viewpoints – art and business – with a very clear assignment from the client: "What measures shall be planned and carried out by the local village administration to ensure the wellness services for new target groups?" During the one-year process, both the advantages of multidisciplinary solutions and significant organizational obstacles became clear.

- The advantages lay in the solution procedure: Marketing students analyzed the market potential of the new target group and defined the qualitative attributes and needs for modern wellness services. Based on these results the design students added design concepts of new furnishings, architectural designs for the wellness village, and an internal information system. These design concepts generated an added value because they focused on the needs profile for the new target group which had been worked out by the marketing students. This example shows a successful application of the variables PU and PEoU for health and wellness services. So far the project was successful.
- When it came to the project implementation, several obstacles arose as a result of the separated university structure:

  a) Syntax/semantics. We found that students from the two universities used different terminology for problem solving, and this caused misunderstandings with the local wellness administration at the final presentation. The client's management used its own terminology, which led to the creation of a "communication dictionary" tool for bridging different semantic content and pragmatic views [37]. For a possible approach, see [33: p. 62].

  b) Pragmatics. Design students produced their own solutions without "how to put into reality" implementation plans and relied on the marketing students. The decisive impact came from the available management budget. As a result, some of the design concepts were not applicable due to higher quality levels of material or shortage of regionally available supply of services (missing material, unavailable technology or resources). This reflects the physical and social layer of data quality dimensions (see Chapter 1.3).

c) Timing. Each university has its own time schedule for diploma work, which hinders the synchronization of the students' team work. Some work sections require synchronously working in parallel, while other work sections require serially shifted execution of work. An important organizational and legal barrier is the legal restriction, that a diploma work can be presented and defended only by one student, thus formation of teams impeded and depends on the modularity of the project order.

3.4.2. Multidisciplinary Interegio Project: A Picture as a Means of Communication

The multidisciplinary project "Interegio" was carried out by architecture students and economics students to solve the reconstructing of communal infrastructures. In this case the multidisciplinary approach had a very high impact.

Local councils show a complex formation of opinion. Representatives of different political parties predominantly defend their own political concerns or even private interests, both of which reduce the chances of finding a political compromise. Whenever we participated with our project management students in communal assembly meetings, we were always confronted with a group of hostile council members who tended to quarrel over a virtual problem due to the lack of a realistic visualization. To accomplish anything in this environment we had to use a new medium for communication [17: p, 9]: "one picture instead of thousands of words." We tasked the architecture students with developing sketches of possible alternatives for the reconstruction work. At the next communal assembly meeting all the hostile council members were peacefully united because they were confronted with practical pictures. It was no longer about defending political interests. Instead, the discussion focused on "Which of the two pictures is the right solution for the wellness village?" The subsequent steps for implementation were much easier and faster because the improvement and further development of the visible, illustrated alternative was the goal. The picture proved to be a highly efficient communication device for solving conflicts, and it also facilitated the budgetary planning argumentation and the allocation of funding in 25 villages.

4. CONCLUSION

4.1. Multidisciplinary Education

We base our future conclusions on our numerous experiments with multidisciplinary student teams. We connect the focus of a marketing curriculum with technology-oriented teaching content that would offer our future marketing experts a suitable and realistic environment. To achieve this aim we developed a structure of technical and professional "theme clubs" where the matching between innovation and marketing can take place. The following theme clubs were set up in the summer 2012 semester at the Faculty of Commerce at the University of Economics in Bratislava:

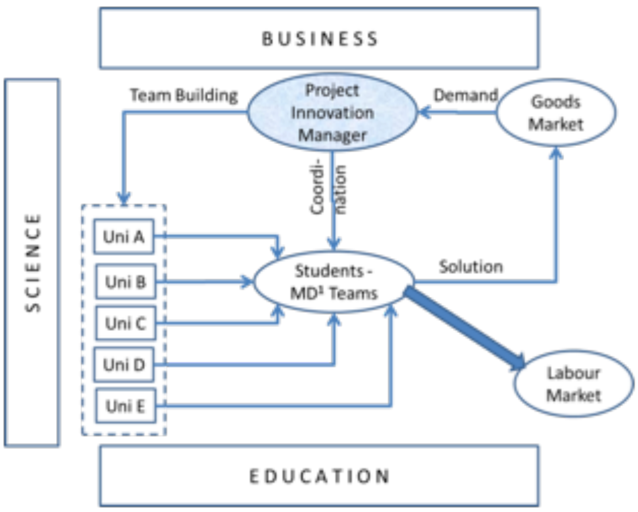
- Pharmarket Club. Includes pharmacological and medical R&D of products and technologies, health technology assessment, and micromarketing studies for improved analysis of consumer behavior of prophylactic and therapeutic products and services.
- Agro-bio Club. Sets up a special marketing test bed for B2C enterprises by developing a procedure for high-speed sensor-based product analysis of innovations in the food and nutrition sector, as well as marketing studies for a majority of innovations in the agricultural sector, e.g. plant nutrition and plant-protecting agents.
- Online Club. A platform for further development and studies of online marketing methods, hardware and software innovation, mobile applications and robotic-oriented studies.
- Mat-in Club. For marketing studies of innovative materials predominantly in the B2B market as automotive, electric product and construction material.

The club structure offers an open meeting space where experts from the different disciplines can come together and help one another surmount the inherited barriers for MDC in the diversified Slovak university landscape. The next step will be the implementation of multidisciplinary curricula for innovation and marketing at the University of Economics in Bratislava.

4.2 Requirements of a Multidisciplinary Network of Science – Education – Business

The network of science – education – business requires multidisciplinary players for generating an added value to MD Innovation Management. The chart below presents one MD approach as a flow system between science, education and business:

Fig. 2 Flow System of Science, Education and Business



The first empirical results in MD education in Slovakia and comparable results with Austrian MD academic education at the TU-Wien and WU-Wien, as well as at Campus 02 in Graz/ Austria show the importance of MD projects in the innovation marketing context. The project innovation manager (see Fig.2) is the most important interface between Business, Science and Education.

There are weak signals that efficiency in MDC can be achieved by applying at least two of the three MDC options: "accepted black boxes" (Option B) by applying the cognitive principle of relevance, and "modular MDC by applying a design structure matrix" (Option C). Future research will show the applicability of these efficiency criteria in the context of high-tech innovation marketing.

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