The Challenges of Sustainable Rural Development towards Engineering Education

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Rural Problems and Sustainable Rural Development in Hungary

Since the Bruntland Report, which attempted to define sustainability as a complex concept, thus making it useable for rural development too, there have been several trends and models dealing with key problems of the rural areas. These include the changing role of agriculture, the environmental and natural protection and sustainability of rural landscapes, the aging, impoverishment and depopulation of rural areas, the almost complete disappearance of the traditional peasant society and lifestyle and different effects and problems originating from the above changes.

These rural problems showed up and influenced rural areas in various ways in different parts of the European Union, such as in Scandinavia, the Mediterranean or in East-Central Europe [1]. In Hungary, where rural areas account for 95% of the country's settlements, 87% of its territory, and 45% of its population [2], rurality can be equated with backwardness, a relative dominance of agriculture and depopulation over the national average [3].

Fig. 1. shows the state of development (from dark blue to red according to factor values) of micro regions together with the rurality index (based on population density of the area and indicated with a white circle). According to Fig. 1. there is no very developed (red) and only 8 developed (orange) rural areas in the country.

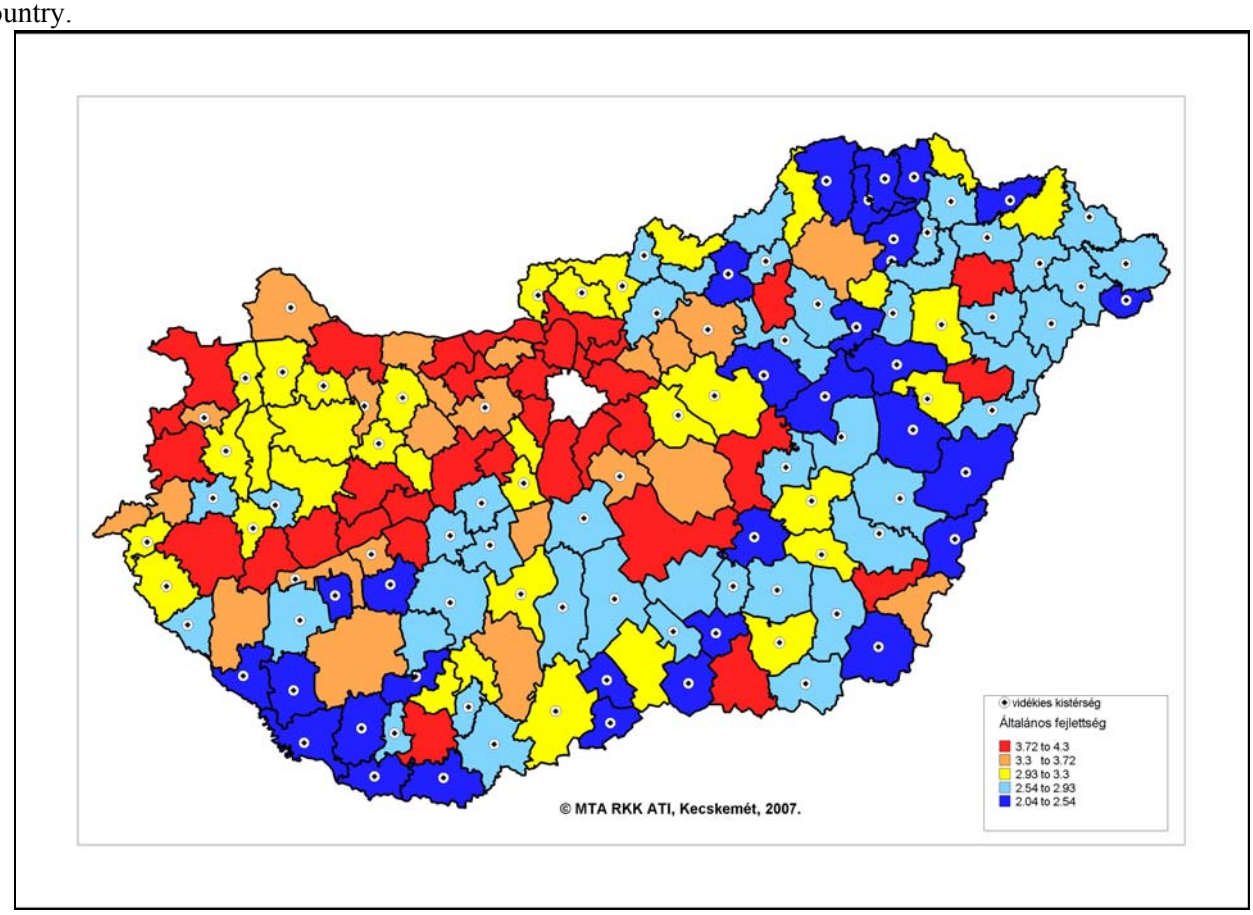

Fig. 1. State of development and rurality index of Hungarian micro regions [4]

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And at the same time, all backward (dark blue) micro regions have a rural character, described with high level of unemployment, high rate of workforce in the agrarian sector, low infrastructure density and poor accessibility.

Within these circumstances, engineers have a crucial role in the betterment of the rural situation. Whereas due to the fact that rural areas are also biological and societal territories, and that narrow rationality of modernization theory is incompatible with the complexities of rural societies, engineers need to possess a completely new frame of thinking and a holistic view, to be able to take part in the sustainable development of rural areas.

There are many definitions of sustainable rural development. In this paper, a definition from Scott is adopted, considering sustainable rural development as "the management and conservation of natural, social and economic resources utilising institutional and technological change to best advantage to meet the present and future needs of communities. Development needs to be economically viable and socially and environmentally acceptable incorporating principles of participation, equity and inclusion." [5] Fig.2. illustrates the integrated approach of sustainable rural development.

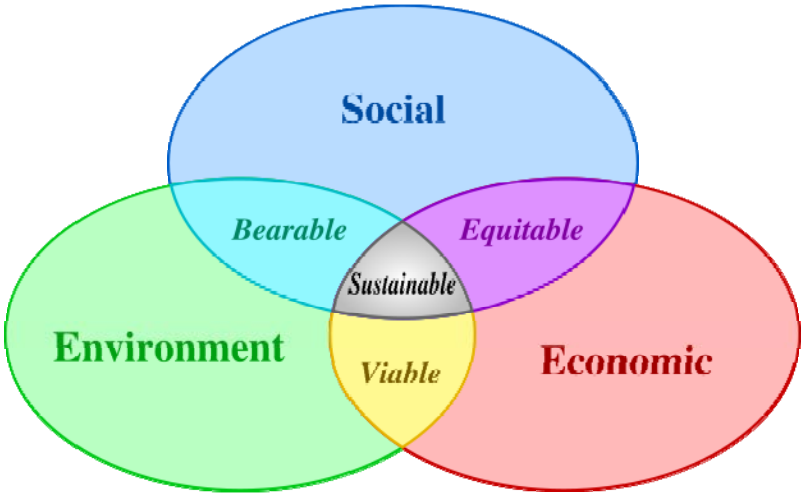

Fig. 2. Sustainable rural development [6]

The main principles of sustainable development, concerning the development of rural areas as well, are summarised in the National Sustainable Development Strategy of the Government of the Hungarian Republic [7]

- The principle of holistic approach. Things must be viewed as a system of inter-related elements, the elements themselves also being systems interacting with one another. Any intervention may trigger ripple effects even in remote systems. So local challenges can be adequately addressed relying on the knowledge of the wider environment and global trends alike.
- Principle of intra-generation and inter-generation solidarity. The interests of sustainable development are focused on people. The development and environmental needs of present generations must be addressed without compromising the ability of future generations to meet their own needs.
- The principle of social justice. The right to adequate conditions for living must be recognised and fundamental human rights must be guaranteed for all. All people should have equal opportunities for acquiring knowledge and skills required to become a worthy member of society.
- The principle of sustainable management of resources. Sustainable management of resources with a view to the limitations of the carrying capacity of the environment; by using natural resources in a prudent and thrifty way it preserves resources required for future development. Biodiversity is also a natural resource and we attach high priority to its conservation.

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- The principle of integration. In the course of elaborating, evaluating, and implementing sectoral policies, plans, and programmes, economic, social, and environmental considerations and their relationships must also be taken into account to ensure that they can mutually reinforce each other. Local, regional, and national activities must be coordinated.
- The principle of utilising local resources. Efforts should be made to supply the needs of communities on a local level, from local resources. Local features and diversity should be preserved. Preservation and sustainable utilisation of the man-made environment and the cultural heritage are also very important tasks.
- The principle of public participation. Adequate access to information affecting social/economic life and the environment, to information on decision making processes must be provided for all. People's knowledge about sustainable development, its social, economic and environmental implications, and about sustainable solutions and approaches must be clarified and enhanced. Public participation in decision making should be strengthened.
- The principle of social responsibility. To enable sustainable development and to make higher quality of life possible, unsustainable patterns of production and consumption must be changed. Businesses' social responsibility must be strengthened, along with cooperation between the private and the public sector.
- The principle of precaution and prevention. The precautionary approach means that wherever the possibility of severe or irreversible damage is perceived, lack of complete scientific certainty may not be used as an excuse for delaying effective action to prevent damage to the environment or endangering human health; i.e. action must be taken in view of the gravity of the perceived threat. Human activities must be planned and carried out in line with this precautionary principle and activities damaging or polluting the environment endangering natural systems and human health must be prevented and - where it is not possible – reduced, and finally, damages must be restored to their original state as far as possible.
- The polluter pays principle. Prices must reflect the real costs paid by society for activities involved in consumption and production as well as for their impacts, including the costs of using natural resources. Those engaged in activities damaging/polluting the environment must pay for damage caused to human health or the environment.

These principles must all be well-known and applied by engineers who have a strong influence on shaping the conditions of rural areas through their professional activities.

Well-Prepared Engineers

This has already been realized by actors feeling responsibility for engineering education. With the title of Engineering Education in Sustainable Development (EESD) biannual conferences are organized since 2002. On its second round in Barcelona, a Declaration was established [8] which defined the main challenges and objectives of engineering education in sustainable development. According to the Declaration, a different kind of engineer is needed today. One who has a long-term, systemic approach, and has a holistic understanding that goes beyond his or her own field of specialization. So, higher education institutions must not restrict themselves to generating disciplinary knowledge and developing skills. Universities need to prepare future professionals who should be able to use their expertise not only in a scientific or technological context, but equally for broader social, political and environmental needs.

According to the Declaration, today's engineers must be able to:

- Understand how their work interacts with society and the environment, locally and globally, in order to identify potential challenges, risks and impacts.
- Understand the contribution of their work in different cultural, social and political contexts and take those differences into account.
- Work in multidisciplinary teams, in order to adapt current technology to the demands imposed by sustainable lifestyles, resource efficiency, pollution prevention and waste management.
- Apply a holistic and systemic approach to solving problems and the ability to move beyond the tradition of breaking reality down into disconnected parts.
- Participate actively in the discussion and definition of economic, social and technological policies, to help redirect society towards more sustainable development.

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- Apply professional knowledge according to deontological principles and universal values and ethics.
- Listen closely to the demands of citizens and other stakeholders and let them have a say in the development of new technologies and infrastructures.

At the same time, an engineer is not born with the above mentioned abilities and skills, these must be created and developed through the education system. But it can only happen if the education system is ready and able to make it.

According to the Barcelona Declaration higher education including engineering education, must:

- Have an integrated approach to knowledge, attitudes, skills and values in teaching.
- Incorporate disciplines of the social sciences and humanities.
- Promote multidisciplinary teamwork.
- Stimulate creativity and critical thinking.
- Foster reflection and self-learning.
- Strengthen systemic thinking and a holistic approach.
- Train people who are motivated to participate and who are able to take responsible decisions.
- Raise awareness for the challenges posed by globalisation.

In Barcelona, the signatories agreed that in order to achieve the above, the following aspects of the educational process must be reviewed:

- The links between all the different levels of the educational system
- The content of courses.
- Teaching strategies in the classroom.
- Teaching and learning techniques.
- Research methods.
- Training of trainers.
- Evaluation and assessment techniques.
- The participation of external bodies in developing and evaluating the curriculum.
- Quality control systems.

Apart from the Bologna Declaration, another document, the Strategy of Education for Sustainable Development[*] worked out by UNECE–United Nations Economic Commission for Europe, also urges for the reassessment of the whole educational process in goals, in methods and in content at the same time, in regard of sustainable development.

According to Péter Havas, the theory of the pedagogy of sustainability is still in the rough, its practice is still evolving and the concept still needs to be clarified and defined. In his understanding, education for sustainability means establishing relationships between the three sophisticated subsystems to be able to understand the rules of operation of these relationships. This requires interdisciplinary, inter-subject and more integrated system approach, which is not easy for an educator society accustomed to rigid subject frameworks. Thus, a paradigm shift is needed both in the teaching-learning process and in the methodological culture of educators [9].

And this is the point where pedagogy of sustainability meets the efforts observable in Hungarian higher education, including engineering education. Linked to the so called Bologna Process [10] which aims to create a European Higher Education Area preparing students for their future careers and for life as active citizens in democratic societies, significant transformations are taking place here. A difficult component of this switchover in the engineering education as well, is the appearance of outcome regulations in the case of both Bachelor and Master level from one side, which can be considered a “Copernican turn” according to Iván Falus [11], and planning of learning outcomes defined in competencies from the other side. In our opinion education principle, system and application based on developing competencies require a completely new approach from both teachers and students.

Three elements of this switchover are especially important because of the differences of principles and the radicalism of their effects:

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[*] The strategy was adopted on a High-level Meeting of Education and Environment Ministries in Vilnius on 18 March, 2005.

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- Instead of courses to be taught, it defines competencies to be acquired by students during the learning process. In other words: it determines outcomes, the final goals of the education process. In this approach instruction of a course can be solely dependent on its contribution to the development of required competencies.
- It defines goals and requirements in a way that they contain both academic and labour market demands. Since the academic side is good at formulating competencies while the side of the labour market knows what kind of experts are expected from higher education.
- Output regulation at the same time does not limit the way and the means. In this way, a flexible education system can be created and unique solutions applied [12].

These inevitably mean that in engineering education, just like in other branches and fields of Hungarian "new style" education, learning outcomes are defined in the form of competencies. Definitions of what a student must know, understand and what actions he or she must be able to implement at the completion of a learning process are given. Application of the above in practice however, can not be realized according to the conception of closed education where goals, content, routine, method of organization, methodological solutions, applied instruments, requirements and their evaluation methods are defined by the teacher – deriving from his professional competence [13]. Sustainability can only be served by an open education, where students also have a crucial say in defining parameters of education mentioned above, on the basis that they are interested and competent in their own education and training, and where teacher-student-parent cooperation for the benefit of the student's development counts natural [14].

Another purpose of the Bologna Process is the switching into internationally accepted methods. The Qualifications Framework for the European Higher Education Area and the Report from Bologna Working Group on Qualifications Frameworks, list the six learning activities which can be required in order to achieve learning outcomes. These forms are: *lectures, seminars, practical work, private study, information retrieval, research and examinations* [15].

Their proportion, especially at Master and Doctorate levels, are regulated by forceful international expectations. Institutions not working this way, might find themselves in a peripheral situation in the medium run, diverging from the higher education centers. According to the Hungarian practice, two out of the six forms are used routinely: the lecture and the seminar, in engineering education the practical work. There is a strong prejudice that introduction of other forms might induce loss in number of courses and status of teachers [16].[1]

In engineering education based on competencies, *lecture* is a crucial learning activity. If it is used for the right purposes and it is not overused, lecture can be an effective education method [17]. A teacher must know however, that his role in the teaching-learning process is under a drastic change nowadays. He must create a working environment in which he accepts and encourages autonomy and initiatives of the students; accepts and utilizes the role of students' answers in directing the learning processes and in the modification of the educational content; stimulates teacher-student dialogues and the formulation of open questions together with developing original answers by the students; and feeds their natural curiosity. It effectively means that the teacher involves the student in the control of his own learning process [18].

The above mentioned learning environment is problem-centered where problems occur in a realistic context and students have the lead in solving them, by handling information according their own interpretation frameworks. Teacher should start from the assumption that in the professional and pedagogic communication, message and explanation are not decisive determinants of the outcomes – even in spite of best intentions of the teacher.

Among other learning activities the Report from Bologna Working Group on Qualifications Frameworks mentions the *seminar* that has reason for existence also in the engineering higher education. The Master level can be characterized with an intensive seminar activity. From the aspect of pedagogic efficiency, 15 students as a maximum per seminar are desirable. Seminar is considered as an involvement of students into directing their own learning control processes. It is not practical, especially on a regular basis, to use seminars in a supervising function (like written examinations, terminal examinations) [19].

[1] The new Act on Higher Education considers consultation, among others, as a learning activity counting into the working hours of the teachers.

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In applying the seminar as a learning activity, the most important is to educate students for autonomy which composed by the development of several skills. The first step is problem recognition (the development of problem sensitivity). The second step is the collection of information; the third one is orientation in the bibliography. The fourth step is the comprehension and differentiation of standpoints and the final step is the development of personal point of view [20].

The announcement of a seminar can have different goals. It can be targeted to supplement and deepen lecture material. In this case, seminars follow the lectures. It also assumes that students participate in lectures, arrive at seminars by being prepared according to previously given aspects, and that they become actively involved there in the common debate. A seminar can also have goals concerning professional socialization. This is neither the conventional special college nor the ordinary lecture. Students who undertake to engross in a topic and ready to write studies attend this kind of course. Research seminars are workshops of theoretical education and talent management but it can also be a framework for degree thesis preparation.

The European Qualifications Framework mentions *practical work* among suggested learning activities [21]. The concept of practical work includes activities conducted on curses having the intention to show how knowledge is applied. In the Framework skills are defined from a cognitive (application of logical, intuitive and creative thinking) and a practical (manual skills, methods, application of materials, tools and instruments) angle. Competencies are formulated from the aspect of responsibility and autonomy.

Practice includes the action and the reflection which are in interaction. Students encounter a series of different situations during their practical activities. By solving them, students have to show that they possess high level skills proving professional security and innovation, which are needed for solving complex and unexpected problems in a specialized field of work or study. If problems occur, the situation must be consciously analyzed and decisions made, without letting the action to be stopped. Occasionally there are also need and way for a deeper analysis following the action and reviewing possible modes of the solutions. Professional development of the student is a result of the series of these reflective processes. It mainly depends on practice-based knowledge [22]. In the case of practical work, location is not an essential part. The transformation of theoretical knowledge into practical one can happen in a classroom, a laboratory, a study shop, study plant, on a field work or traineeship as well.

According to Iván Falus and János Setényi, in the Hungarian higher education requirements are approached from the side of knowledge. Competencies and attitudes are intended to be developed in the so called “intellectual modules” [23].

The European Qualifications Framework lists *private study* among learning activities that may be feasibly required for the achievement of the learning outcomes [24]. Private study is the learning work performed by students independently, outside contact classes, including study time in the examination period. This does not demand continuous contribution from the teacher; it is the student who takes the responsibility to his decisions. The proportion of private study (reading, research, essay writing, presentation) increases at the Master level, comparing to the Bachelor level where the input competencies needed for this type of the learning activities must be developed.

From the aspect of sustainability, it is an especially important role of the teacher to help students to develop their self-regulatory learning skills which means that the student sets his own learning goals, motivates himself, and plans, structures and controls learning activities responsibly, independently and autonomously [25]. This requires due foresight since it can be only successful with proper dosage of the curriculum, with the assurance of continuous feedback and motivation and with the active participation of the students. However, the teacher can not ignore personal attributes, development level, previous knowledge and experiences of the students as he also needs to consider features of the curriculum and his own possibilities [26].

The European Qualifications Framework lists *information retrieval* among learning activities that may be feasibly required for the achievement of the learning outcomes [27]. Requirements of knowing one’s way in the dumping of information accessible through the net, are especially valid for students studying in the higher education cycles.

According to a survey made by the University of Debrecen students canvassed used web and email facilities most frequently. However, only few students use opportunities provided by free word search engines for defining information needs accurately and for filtering results. In spite of this, most of them

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consider his searching skills good or as the average. A notable result of the survey is that students learn information retrieval from the web by themselves or by reclining upon their peers. One fifth of the surveyed students claimed that his teacher played a role when they were learning how to search properly. An experiment by the author of the above study proved that after teaching information retrieval from the web, searching skills developed significantly. As a conclusion he emphasized the importance of increasing teachers' role in the development of students' searching skills [28].

Research is another learning activity that may be feasibly required for the achievement of the learning outcomes according to the European Qualifications Framework. This activity aims at developing professional commitment and responsibility in students. The concept of research can be used both in a narrow and in a broad meaning. In the first case, the concept is attached solely to the application of scientific method in the traditional sense [29]. Research competence presumes the presence of different systems of partial competencies regarding knowledge artefacts, attitudes, views and skills. Students must acquire knowledge, skills and competencies needed to understand that research is a systematic process of collection and analysis of information in order to increase comprehension of the studied phenomenon. If research is considered as a process, it can be viewed as series of steps from the development of an idea to the finalization of the complete study. The challenge for a researcher is to contribute to the comprehension of the phenomenon and to communicate it to others. The European Qualifications Framework considers research with a broader meaning, listing different activities under one label. These activities are usually connected to some field of knowledge and have the common feature to be based on systematic interpretation of knowledge and critical reflection.

The final type of learning activities that may be feasibly required for the achievement of the learning outcomes according to the European Qualifications Framework is *examination*, a form of supervision containing evaluation regarding the acquirement and acquisition of knowledge, skills and competencies. Studies and Exams Codes accepted in the engineering higher education, accurately define different types, forms and procedures of examinations. It is important to note that even after introducing the Bologna System, exam-centeredness still has a strong presence in Hungarian higher education (including engineering education). While Hungarian higher education makes only two types of the six suggested learning activities operate in practice (lectures and seminars), periodic interrogation has a preference over the assessment of students based on their continuous work. According to László Zrinyi, the implicit overlap between the interests of one part of teachers, students and employers sustains the "exam fetish" and creates the illusion that certificates and not knowledge and competencies are what count [30].

Concerning applied learning activities, it can be beneficial to review the solutions of the high prestige (Anglo-Saxon) higher education institutions [31]. Henceforward, an interesting form of oral exam, the *synopsis exam* is introduced from the University of Copenhagen [32]. It differs from the traditional oral exams in that it is based on a short essay prepared and handed in by the student – as an admission – one or two weeks before the exam. The lecturer provides the class with a collection of source material, expectations as to the content and form of the synopsis as well guidelines to the oral exam. The synopsis may be prepared individually or in groups and must be a summary of a selected subject.

The oral exam must be initiated on the basis of the synopsis. The synopsis should influence the type and level of difficulty of the oral questions asked during the first part of the exam, but not necessarily the evaluation of the student's performance. The exam must contain questions on matters not covered by the synopsis but by the required reading. During the exam issues which are not covered in the course-required readings may be touched upon if they have been discussed on the basis of literature or material in the synopsis, and if they are relevant to the problem in question. Required reading materials and other materials may be brought along to the examination.

Oral examinations are open to the public. However, a student who has prepared a synopsis together with a fellow student (in a group) or who has written a synopsis on the same subject as another student, is only entitled to witness such other student's exam after having been examined himself.

The synopsis exam means a great challenge and has a serious influence on the views, attitudes of both students and teachers; as well as on the teaching-learning process and content and quality of the study. It sets definite requirements and is connected well to the content of current courses.

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If all the above mentioned learning activities take over and operate in the Hungarian higher education (including engineering education) according to its role, sustainability will have a much grater chance to prevail.

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