METHODS OF TRANSFER: SCIENCE MAKING AN IMPACT FOR SUSTAINABILITY

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Abstract

The reasons, objects, means and methods for a transfer of scientific results to society are analysed in the article. Among this, knowledge transfer - especially technology transfer - and on projects, especially joint projects with the aim of creating or transferring knowledge are concentrated upon. Success factors for bringing science to support socioeconomic development also receive attention.

Keywords: Knowledge transfer, Academic knowledge, education for sustainability.

1.   PREFACE: TRANSFERRING KNOWLEDGE TO SOCIETY

Sustainable development is ubiquitous in this paper since universities have the responsibility to support the quest for sustainable development. Knowledge is not a value on its own, it should be used to make this world better; but this notion of a "good" or "better" state of the world is not a scientific term, it's an ethical and normative matter.

Besides their basic role in education, the strategy for universities is based on two tracks: active transfer (mostly associated with training activities) and joint projects (mostly associated with research or development). The main difference lies in the initial purpose: while transfer is knowledge-oriented, projects are result-oriented.

There is a wide range of methods and ways to transport knowledge, results and scientific method to society, the extreme points given by one-way-training and joint projects. We reflect on the experiences and success factors for knowledge transfer and projects based on several projects, for example from the Steinbeis network in Germany and from students´ projects in Engineering Management. We concentrate on the question of how and why to transport the research results in order to foster innovation and socioeconomic development in society.

As an initial issue we consider the reasons for this transfer. Unless we understand the full range of reasons for this transfer we cannot evaluate the different means. Pure research can do surveys on the ways of technology transfer, but even there we should consider the reasons and motivation. Even more importantly, when we consider ourselves as researchers, it is important to think about the reasons for doing or changing something.

The main part of the article is dedicated to the different ways of knowledge transfer. We analyse a wide range of methods, especially concentrating on transfer and projects. Being researchers, as well as part of society, we accept the challenge to look at these issues from an academic point of view as unbiased as possible.

2.   WHY

The first step in any planning process should be to reflect on the reasons for the activity and the aim of the enterprise. Unless we understand the full range of reasons for this transfer we cannot evaluate the different means. Science or knowledge is not a value on its own. It should be used to make this world a better place to live in. Among the main reasons for transfer, we point out:

- Normative reasons going back to the organisation and individual's ethical motives.
- The classical university mission (duty) to do research and create knowledge.
- The paradigm that knowledge creates better decisions and a better society.
- The contribution to sustainable development increasing the quality of life for forthcoming generations and the chance to preserve human culture for the future.
- Customer orientation as a consequence of modern market oriented thinking at universities.
- Pragmatic reasons from creating income to increasing the individual or corporate reputation.

The latter arguments can be derived from a utilitarian point of view while the others can also be derived from duty or responsibility ethics.

2.1   Knowledge as a University Product

A good starting point for the analysis of reasons and motivations for bringing research results to society is the analysis of the products of a university. To adhere to this marketing based approach, we start with the analysis of the various "customers" of a university.

Of course, we have to differentiate according to the different products (here the analysis becomes circular) and the roles within a university. Nevertheless, we can identify the most important stakeholders of a university that perceive themselves as customers of a university.

- *Students:* They (or their parents …) pay tuition fees. The more important aspect is: they invest several years of their lifetime to get a qualification. Products: Education, knowledge, qualification, degree.

- *Scientific community:* They cooperate with the university researchers exchanging scientific results. They expect the university to contribute to the state of the art of science.
  Products: Scientific results, publications, academic knowledge.

- *Industry/Business:* Industry is a customer of research results, transfer and joint projects. As far as students are concerned, companies are employing them, but they don't "buy" them from university. Industry must rely on the formal qualifications and degrees issued by the university.
  Products: Knowledge and technology transfer, support and consulting, students, formal qualifications.

- *Society and administration:* Society contributes to university funding directly or indirectly (e.g. via tax). Administrations (e.g. Departments of Higher Education) give the money to the university and see themselves as representatives of the society (or taxpayers) with the mission to ensure efficient use of the money. Society wants a high number and quality of graduates and a contribution to welfare, innovation and sustainability.
  Products: Graduates (qualification), knowledge, contribution to the development of society

- *Local and regional Government:* They support the university and expect university and university staff to contribute to the development and welfare of their region.
  Products: Education, projects, staff expenditures in the region, staff contribution to social life

2.2   Sustainable Development

The first mentioning of the concept of sustainability goes back to German forestry in the 15th to 18th century. The notion of sustainability can also be traced to the so-called Brundtland report (World Commission on Environment and Development, 1987) where it was described as: "Sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

The vision of sustainable development was stated in the Rio 1992 declaration of the Agenda 21. Sustainable development has an economic, ecological and a social component. The full implementation of Agenda 21, the Programme for Further Implementation of Agenda 21 and the Commitments to the Rio principles, were strongly re-affirmed at the World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002.

The Rio 1992 declaration, also called the Agenda 21, states the components of sustainable development as the three pillars of sustainable development.

Figure 1: The three pillars of sustainable development

1.1.1   Sustainability

Sustainable development is an anthropocentric concept. It's not on conserving nature for nature's sake but on keeping the world in a state that makes life worth living for future generations. Sustainable development means to preserve human culture for future generations. Here, we mean by culture all the objects and systems that were created by mankind. The notion of culture is not restricted to arts, but it means all things created by humanity – science and critical thinking, the cultural landscape and the responsibility for nature, the economic system creating wealth and welfare, social and political systems that give freedom and self-esteem to all people, peace and order within and among generations.

Sustainability seems to be based on conservationism and to represent a static concept. But sustainability is a highly dynamic concept since our current system is far from being sustainable. Hence, efforts must be made and innovations are necessary, to transform the present state of the world to a more sustainable one. This will rather be a process of continuous improvement and an ongoing struggle then a finite horizon project.

Even if and when sustainable development should be reached, it will be a dynamic (possibly a stable) but not a static system's state. Sustainable development means that ongoing innovations have to take place to ensure the ability of future generations to meet their own needs. Innovation, research, design and development are the basis for a sustainable development replacing qualitative growth by quantitative growth.

1.1.2   Agenda 21

The Rio declaration Agenda 21 is aiming to improve the social, ecological and economic status of the World and to fight the ongoing deterioration in these areas. One of its main focuses is to integrate economic and environmental aspects. "Prevailing systems for decision-making in many countries tend to separate economic, social and environmental factors at the policy, planning and management levels...

New forms of dialogue are also being developed for achieving better integration among national and local government, industry, science, environmental groups and the public in the process of developing effective approaches to the environment and development." (UN, 1992).

Universities and the scientific community are addressed implicitly and explicitly. "Scientific and technological community: The scientific and technological community and policy makers should increase their interaction in order to implement strategies for sustainable development on the basis of the best available knowledge... Scientists and technologists have a special set of responsibilities which belong to them both as inheritors of a tradition and as professionals and members of disciplines devoted to the search for knowledge and to the need to protect the biosphere in the context of sustainable development." (UN, 1992).

1.1.3   Sustainability and innovation

Sustainability does not mean to stagnate, but to evolve quantitatively. Innovation is the basis for decoupling wealth from resource consumption. Ideally the situation depicted in Figure 2 below should result.
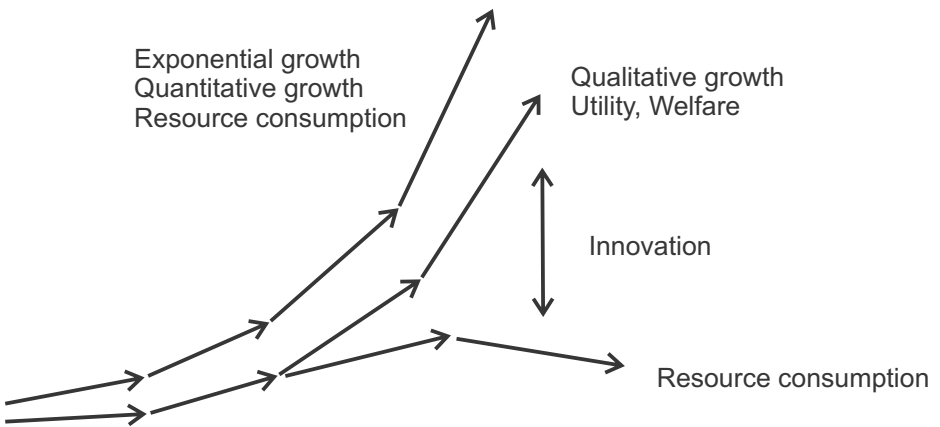

Exponential growth
Quantitative growth
Resource consumption

Qualitative growth
Utility, Welfare

Innovation

Resource consumption

Figure 2: The ideal future relationship between development and resource consumption.

2.2.4   The educated society

The most ambitious task is to bring scientific thinking to society. This means much more than bringing some knowledge to society; it's a matter of scientific, critical and rational thinking and the implementation of the ideas of the enlightenment. Enlightenment is according to Kant (1784) "man's emergence from his self-imposed immaturity". This means that people will not only be able, but also be willing to draw conclusions on their own and to act according to rational conclusions.

It's also an important educational issue to ensure and to communicate that science and innovation is part of the solution, not the root of the problem.

3.   WHO – WHAT – WHERE

The transportation (or transfer) process can be analysed in the same way as any transportation or communication process is analysed. (A detailed analysis would include flow in the opposite direction, too. This could integrate feedback and the information about demand and the present state.) The object and potential receivers (customers) have already been discussed.
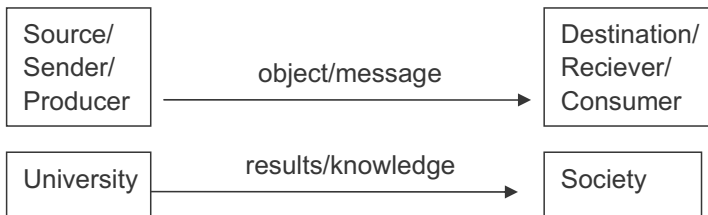
Figure 3: Communication model of the transfer of scientific results

3.1   The producer

Knowledge is generated not only at the university but also at all partners that are enabled to use knowledge for producing new knowledge.
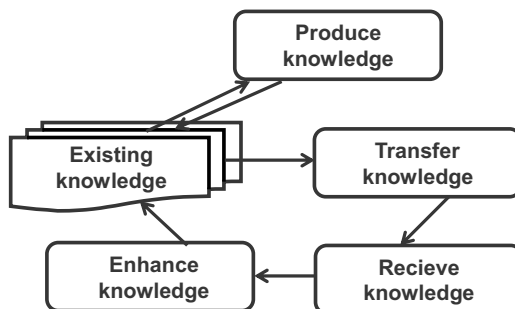
Figure 4: Production of pure and applied knowledge

Within the considerations of this paper, the word university has two meanings:

- The university as an institution that owns the resources and pays its staff. It takes action according to the decisions of its council but is also a self-organising system.
- The members of the university: they have an impact that is independent from the formal role in the university and they also have a life outside this institution.

3.2   The receivers

The potential receivers (customers) of this transportation process have already been discussed. Here we look deeper at the question who is that "society". Society consists of and can be represented by

- Individuals (any person),
- Groups (any group of persons),
- Cultures (a group of persons with a common way of living and set of values),
- Organisations (a group of persons that have a common goal and some formal structure).

4.   HOW

4.1   Methods

There is a broad variety of methods of transporting knowledge from one object to another. The sender and receiver of knowledge may be individuals or groups, but we also can represent knowledge on computer systems or networks. The main methods for transferring research results are:

- Education
- Publication
- Planning games
- Transfer
- Projects

4.2   Publication

Publication of research results is also a core competence of the University that may include:

- Primary literature communicates within the scientific community
- Secondary literature makes results available to non-researchers
- Popular books make results accessible to the general public
- Newspaper articles bring basic information to the general public.

- Multi-Media-Communication: Radio, TV, Internet, Mailing lists, Podcasts.

4.3   Broad Publication

A press release is an effective way of taking results out of the ivory tower to the public. Press releases can be sent directly to the local, regional, national or international press. A press release or publication in a general journal is quite different from publishing a paper in a scientific journal. A big advantage of publication in the general media is that press releases can increase the impact of your work and the visibility of your project and your team tremendously. As a research manager you should also bear in mind that this can help you to access potential research partners and sponsors.

In preparing press releases, you have to keep in mind that a press release has several target groups:

The future reader of the paper. This is your most important audience. The AIDA formula well known from presentations also applies here:

- *Attention:* A headline that makes the reader take a closer look at the document.
- *Interest:* Immediately showing the relevance to the reader.
- *Desire:* The intended impact on the reader (e.g. to know more, to use the results).
- *Action:* The immediate activity by the reader (e.g. to get in touch with you).
- *The editor:* Your press release will never be published if the editor thinks that it does not match the policy of the paper or the interest of the target group.
- Your own press officer: He/she will help you, but you must show clearly why the publication of this result at that time in these journals is beneficiary for your university.
- *Your peers:* They will also critically read the final article (note that this may be an abbreviated version of your press release, omitting the lengthy phrases about the relevance of statistical data).

Ceteris paribus – this also applies to publication on the Internet – either on your university´s homepage, on an edited page run by a newspaper or organisation, on your own homepage or in some social media. The Web 2.0 is changing the world from a producer-oriented (the printer decides what will be published) to a consumer-oriented one (the readers decide what will be read and followed, and what will be ignored).

A press release should be short and concise; 300 to 700 words. Longer texts should only be provided upon request.

Some hints:

- Please be aware that you are (re-)presenting your working group as well as your university and your project partners. You have to bridge the gap between grasping attention and being an exact and reliable scientist (see Imperatives 3 and 6).
- The author (including the contact data) and affiliation (including the contact data of the press office) as well as the date must be included.
- As the text may be abbreviated, the structure will vary greatly from that of a scientific paper which develops a subject: most important statements come first; then towards the end, some details and background information can be added.
- With the result as a central issue, the scientific paper tells the other scientists why this is valid. The press release, on the other hand, tells the readers why this is relevant for them. Hence, press releases to different newspapers also will look different.
- The headline must grab attention. It can be formulated in a provocative way but must reflect the statement of the paper.
- The headline and the statement must be correct. You have to make sure that there is no misinterpretation of statistical data.
- Additional headlines can improve attention-getting and can also help the editor to compile an adequate headline.
- The first sentences will inform the reader and the editor: WHO has achieved WHAT and WHERE, and WHY this is valid and important.
- One message at a time. If there are several results, you have to find an adequate general motto.
- Make sure to mention all participants. Especially (local) project partners will be important. You may also add personal statements or cite some of the participants.
- Pictures (two or three) should be added as JPG files. Every picture comes with a title, a description that also shows the relevance to the paper and the full names of all persons depicted.
- Diagrams can be used to visualise results. Pie charts are easily understood, and bar charts can illustrate more complex results. In all cases, keep in mind that the diagrams may be reproduced in one colour. Make sure that diagrams do not lie – either willingly or unwillingly.
- Statements or testimonials by experts, people well known to the public or stakeholders involved in the project can make a text more vivid and authentic.
- Before you send the document, take a break, read it again and have a second person read it. Be careful of lack of, or implicit information, jargon, possible misunderstanding, and formulations that may be interpreted as an accusation or attack on or by anybody.
- Be available for questions from you PR officer and the editors. Depending on the timeline, make sure that you can respond immediately (within an hour), and rather give your (mobile) phone number in addition to an email address.

4.4   Education

According to the overall effect for society, education seems to be the most important method of transferring knowledge from a university. Well-trained academics and an education that encourages innovation and entrepreneurship are the most valuable contribution of higher education towards economic sustainability and success.

To support this, academic education should comprise not only the teaching of knowledge and facts but also a variety of skills and attitudes. In order to encourage innovation and entrepreneurship, adequate methods of teaching and training are necessary. Among these, projects and planning games play an important role.

Students' projects must be driven by the skills and competencies students have to acquire. This means that a lot of didactical competence, project management experience and preparation labour is required to come up with a rewarding project. For a rewarding outcome, two aspects are necessary: a challenging project that gives the opportunity to learn and a successful project that provides a visible result and positive feedback from the project partners in order to give students the feeling of not having wasted their time and efforts. This means, that projects have to be prepared carefully. The same is true for planning games where the training success depends on the preparation and the setting in scene of the planning game as an event.

The complete knowledge transfer process to students can be represented by the following diagram, with students being exposed to formal lecturing, followed by industrial exposure including specialised training. Highly trained, skilled individuals can become involved in either more creative/innovative or alternatively production/maintenance activities. Whilst the likelihood is better that the former will contribute by the creation and transfer of knowledge via new innovations, the latter can also contribute to sustainability by their behaviour in production or maintenance activities. The realistic expectation is that responsible graduates from universities will contribute directly and indirectly to furthering the sustainability agenda of a modern society.
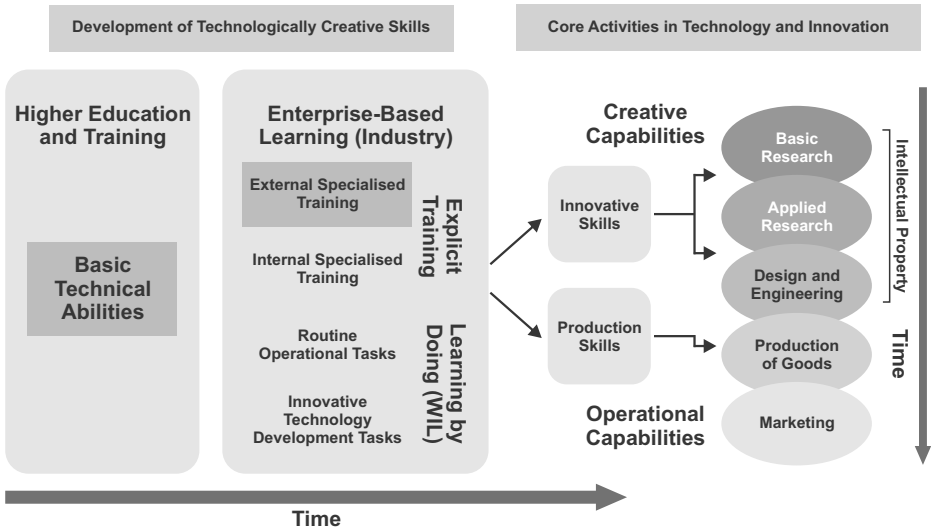
Educate for Innovation

Figure 5: A representation of the involvement of graduating students in the development of a sustainable society.

As mentioned above, one of the most important prerequisites for innovation is abstraction - to see the problem in a wider field of view. Entrepreneurship needs planning abilities – to have a clear vision or model of the future. Hence, modelling skills are necessary for both aims. University training is highly model-oriented and should stay on this approach. Curricula should be based not only on short-termed training towards "what industry wants now" but also on a long-termed and basic education towards "what society may need in future" and the ability to adapt to future ideas and paradigms. Basics such as mathematics give not only the abstraction and modelling competence but also the ability to acquire and understand complex knowledge and structures.

4.5   Transfer

Sustainable development has an economic, ecological and a social component. Innovation and entrepreneurship can play an important role in the sustainable development of an economy, a region or a country. We consider the ways in which universities can support innovation and entrepreneurship and we outline some of the supporting structures and methods. The following results are based on one of the authors' experiences mainly in Germany as a researcher, lecturer, engineer, manager and consultant.

4.5.1   General considerations

There are different ways for a university to support and encourage innovation and entrepreneurship. Although the aims and effects of innovation and entrepreneurship are quite different, universities have to support both in order to achieve a sustainable development of industry and society.   Important aspects comprise motivation, modelling and management. The most important ways of support are given by the triad of education, research and direct support. Nevertheless, we must never forget that people are the most important component in innovation and entrepreneurship. Hence, motivation, information and networking play an important role.

Technology Transfer can be

* Pull: demand-driven "we need" from the customer
* Push: result-driven "we can" from the research organisation

Effective technology transfer from a university to enterprises and the community needs a supportive infrastructure with respect to

* Marketing and acquisition
* Project administration
* Accounting and billing
* Legal framework

Within a university a variety of activities to support knowledge transfers are typically found:

* Education
* Institutes
* Steinbeis Transfer Centres
* Training institutions
* Citizens' engagement
* Privately run activities of professors, assistants and students e.g. privately-own companies.

4.5.2   Factors of a transfer system

The following considerations on the optimal design of a transfer system are based on the German experiences and consulting in several countries.

4.5.2.1 Trade-offs

Implementing a formal framework for transfer requires control, especially when dealing with pubic resources.

This control is in the interest of those contributing the money, as well as in the interest of the manager that is responsible for the use of other people's money. This control is the core issue of any managing or accounting system. Since complete control can never be achieved and will lead to disengagement (cf. the experiences from the planning economies before 1990), any managing system must be balanced and adapted to the specific tasks in order to avoid the two main faults (in statistics known as the error of the first and second kind):

- Frustrating and disengaging people by a too intensive planning and control system and by an extensive accounting workload – especially on projects under market conditions.
- Enabling fraud by neglecting control or by inadequate accounting systems - especially in externally-funded projects.

A solution may be a differentiation between projects and a corresponding differentiation of the form and level of control and reporting.
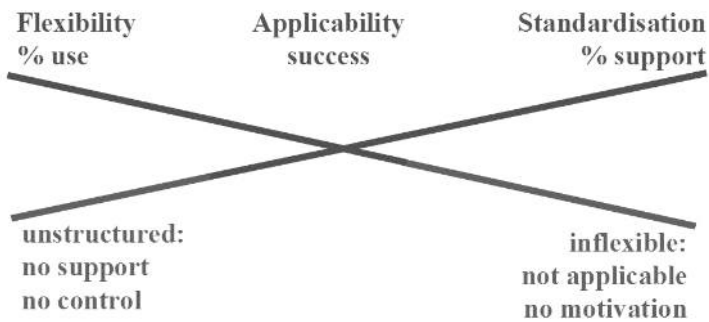
Figure 6: Concept of the optimisation of a transfer system between flexibility and supportiveness

4.5.2.2 Organisation

The main consideration within a formal organisation is the role which the individual parts play. The parts of the system may be rather independent organisations or subsidies of a central unit. The amount of individual freedom of decisions granted to a manager will depend on the amount of risk he is willing to bear or his superiors are willing to afford him.

A shareholder that provides money or a central unit that has full responsibility will have the power to control the limits of the manager´s decision-making powers. A university will want to have control over and account for their staff, rooms and equipment. On the other side, an entrepreneur that runs a centre with no external money, have his own staff and equipment and workspace rented on the free market, will be able to decide independently.

4.5.2.3 Portfolio

Each centre has a spectrum of potential activities, which is its portfolio. Within the two dimensions geographic range and technology breadth there are several possibilities for any Transfer Centre (TS): Since the capability and capacity of a TS is limited, two general strategies can be identified:

*   A narrow focus research-oriented capability leading to a small density of potential customers and to a global area of operation.
*   A wide focus in technology (even down to low technology consulting), leading to a high density of potential customers and a locally restricted area of operation.

Atypical combinations can also be found:

*   A narrow focus concentrating on a locally concentrated specialised branch. (e.g. tourism, agriculture, automotive, manufacturing),
*   A wide focus in technology and widely spread expertise concentrating on special aspects of knowledge and special types of service.
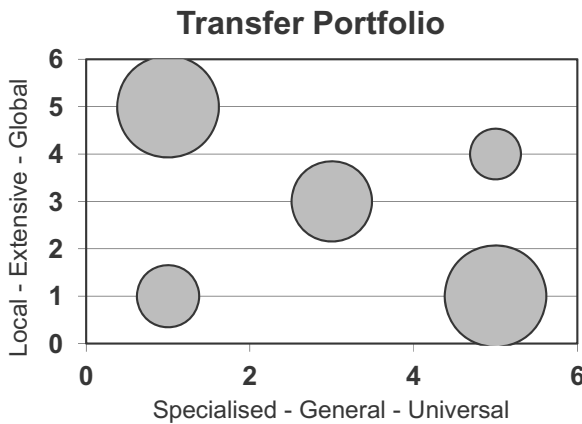
Transfer Portfolio

Figure 7: Potential transfer portfolio(s) of a Transfer Centre

4.6   Projects

Within this paper, projects are considered as a method of transferring research results to potential customers. Projects are also a means of producing and enhancing knowledge. The production of knowledge in projects can also be seen in the context of mode 1 and mode 2 knowledge (Gibbons et al, 1994)
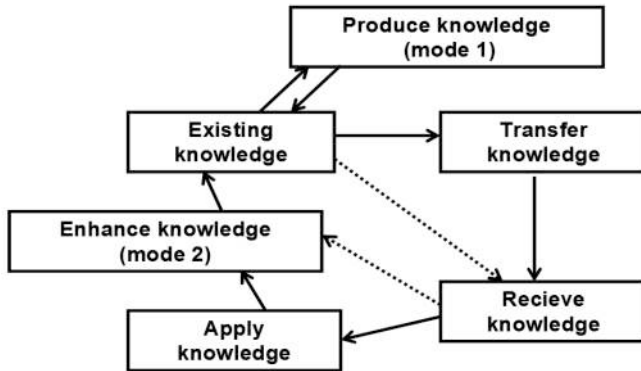
Figure 8: Production of knowledge in projects in the context of mode 1 and mode 2 knowledge

4.6.1 Projects as education and transfer activities

In University education, projects are seen as a means of training to:

- Encourage the students to perform a project starting with initial investigations and ending with the documentation and presentation of the results.
- Urge the students to apply the knowledge which they acquired beforehand or within the projects to solve a given problem.
- Create new knowledge within a research project (the knowledge may even be the answer to the question of whether and how some theoretical result can be transferred to reality).

The outcome of a project may be twofold

- To produce a defined set of deliverable items – documents, products, prototypes. (In some cases, the deliverable item may be a training unit as a document or as a service that is delivered once or several times).
- To enable the project partner or customer to learn through the project and to acquire knowledge from the university or to help the partner/customer to derive relevant knowledge on their own.

4.6.2 Customers and Partners

External partners or customers for projects are important since they give a sense and challenge to the project. Unfortunately it is seldom possible to do realistic, applied projects for customers.

There remain two types of partners:

- Industry can provide tasks to improve the design of a product or processes. Real industry projects are mostly critical in time and resources; moreover, confidentiality imposes severe restrictions on the project documentation. These projects are typical for industrial placements, final theses or commercial transfer projects.
- Government, public organisations and non-profit organisations (including universities and parts thereof) often have a lack of staff; especially of staff experienced in project management. Hence, project management itself and a lot of standard competencies such as marketing and modelling can be applied. Moreover, the problems would not be addressed otherwise and hence can be matched to the semester schedule.

There are several ways of cooperation between university and government:

- Formal cooperation is based on an agreement between the university or some of its organizational bodies on one side and government or a company unit on the other side.
- Informal cooperation can be initiated and conducted by individual persons. This kind of cooperation works between persons within the framework of teaching and research.
- Students can work for an organization and combine this with a university project (if agreed to by the supervisor).
- A commercial project can be handled via an official framework. If this is to be combined with students' projects, severe restrictions and rules have to be obeyed.

Universities can take advantage from government support and funding; while government and community will get support from the university as an institution or from individual members by methods, knowledge and manpower. This will lead to successful projects and to more effective and efficient decisions.

4.6.3 Action oriented learning and goal setting

In action oriented learning, projects are defined by the supervising lecturer, and an external customer (more often it is more a stakeholder than a sponsor) is identified. The details of the project have to be agreed upon between the team and the stakeholders. This challenges the communication and cooperation skills of the students, since they get a coarse outline and a person acting as a customer instead of a well-defined list of criteria. The students must define the project vision and scope, expected outcome and deliverable items, resource allocation, timelines and the way of publication. This must be communicated to and agreed to by the customer and the supervisor.

In this type of experiential learning, the students learn facts and skills such as planning, use of management tools, documentation and scientific work. But even more important are the "soft skills" such as leadership, self-esteem and confidence and communication skills. These skills cannot be acquired within a classroom lecture, but the practical project urges the students to communicate amongst each other and with other groups of people. They must come up with common goals and a common plan and must co-operate with other students. They must also think about the consequences of their actions and the possible outcomes of a project for other people.

5.   SUMMARY

Within the wide range of methods for transferring research results to society, there is neither an optimal one nor an optimal recipe. Diversity in the structures, methods, and tools and responsiveness to the individual customer´s requirements and the needs of society enable the universities to support this transfer in an optimal way.

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