Teaching methods and science communication

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The purpose of this module is to highlight the roles and objectives of higher education, and to discuss aspects of teaching and learning. It provides examples of teaching and examination methods, as well as discussions on research supervision, science communication, evaluation of courses and curricula, and how to promote educational development. The module addresses university/college teachers and scientists teaching animal breeding in developing countries, but large parts of the contents are general and useful also for others teaching in higher education institutions. There are references and links [burgundy] to various parts of the Training Resource, such as exercises, case studies, discussion questions, module texts and compendia, which may be useful in teaching animal breeding. There are also links [blue] to Web resources.

Contents

Citation

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1 Capacity building-Role of higher education

The world is presently going through a period of rapid changes among which the increasing globalization, the high pace of knowledge creation and the use of new information technologies are the most apparent ones. This offers great opportunities, but may also result in an increasing gap between developed and developing countries, unless capacity building at all levels and access to the global knowledge are successfully addressed. Higher education and the teachers/researchers involved are facing great challenges that require vision and initiative, and also support at governmental and institutional levels.

1.1 Role of higher education in developing countries highlighted in World Bank report

Higher Education, including research, has fundamental importance for capacity building and development, not least in developing countries. A report, `Higher Education in Developing Countries: Peril and Promise' was published in 2000 by the World Bank. The report highlights the role of higher education in supporting and enhancing the process of economic and social development. Higher education promotes income growth and poverty alleviation; it contributes to labour productivity and entrepreneurial energy; it strengthens civil society, and it promotes democratic governance. Increasing globalization, information revolution and rapid expansion of *new* knowledge further emphasize the importance of effective higher education.

The World Bank report emphasizes that, in spite of their role, the higher education institutions in many developing countries are chronically under-funded, and must still meet the needs of increasing numbers of students. Faculty may lack motivation as they are usually poorly rewarded. Absence of a vision about the nature and magnitude of the potential of higher education to development is one major obstacle. Other obstacles are lack of political and financial commitment, as well as low critical mass of teachers and scholars, and losses of highly demanded faculty and scholars to rich countries.

Recommendations to overcome the obstacles in developing countries focus on the needs both for increased resources in higher education and for more effective use of existing resources, such as physical and human capital. It is urgent to:

- satisfy the need for good quality higher education
- improve management of higher education
- improve educational infrastructure, including access to new information technologies
- implement new curricula and academic programmes, and improve the teaching methods
- recruit, retain, motivate and offer long-term development of well trained faculty
- conduct more and better science education and research, both basic and applied.

1.2 Animal genetic resources often given too little emphasis

Conservation and sustainable use of animal genetic resources in developing countries is an example of an area where teaching and research is given too little emphasis worldwide, or is even neglected. This results in low awareness of the needs to develop animal breeding programmes for various conditions and environments in order to reduce losses of animal genetic diversity. Furthermore, the necessity to improve production per animal to meet the increasing demands for food from livestock and poultry is not stressed enough. Animal genetics, with special emphasis on breeding programmes and animal genetic resources, needs to be given increased attention in university curricula and in research. Moreover, the teaching methods need attention; animal genetics is a topic that students quite often experience as theoretical and difficult to understand. It is a challenging task to find the best approaches to facilitate students' understanding of the topic.

2 Link research and teaching in higher education

Ideally, teaching and research should always be linked to each other in higher education. This is often the case, but there are also many universities, especially in developing countries, where teachers have limited opportunities for research; the research is usually done at research institutes, where the scientists might not be involved in teaching.

Insufficient links between teaching and research may not only reduce the level and quality of higher education, but may also hamper recruitment of new scientists and reduce the understanding and support for research and capacity building in society. It is, therefore, important to provide opportunities for university/college teachers to be active both in teaching and in research, and to

involve scientists at research institutes in teaching and supervision of students.The ideal process of capacity building, with links between universities and research institutes, and with the agricultural sector is illustrated in Figure 1. Universities are national engines for capacity building. Their output is people trained for qualified jobs, as well as research results for application. The latter is the role also of research institutes, but their contribution is enhanced when their scientists participate in university

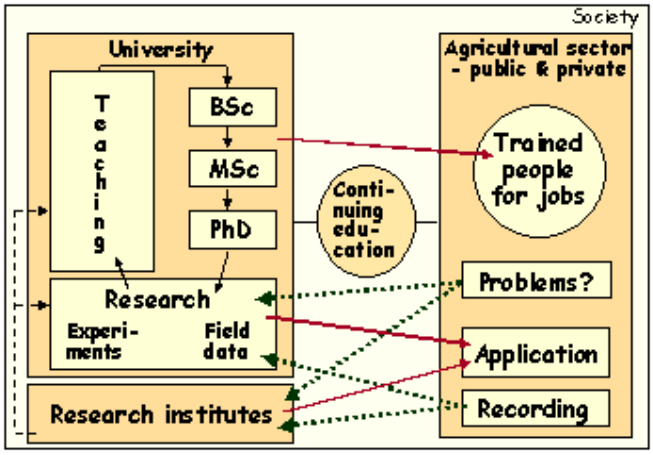

Figure 1. *The ideal process of capacity building.*

teaching. For best use of existing resources, universities

should be significant partners in national research programmes, especially when financial resources and access to qualified teachers and scientists is highly limited.That would also benefit quality of higher education, and make good use of students as a resource in research through BSc, MSc and PhD thesis research.

For research results to be implemented, it is necessary for researchers to have good communication with those who can make use of the results. Such communication will also help focus research on essential problems; it facilitates use of field data in research (such as data from livestock recording), and it may give opportunities for students to get a better understanding of how they can contribute to agricultural development in their country.

3 Objectives of Higher Education - a challenge to fulfil

University education is directed by distinct objectives. Students in science, for example, should acquire:

- knowledge and skills based on the forefront of science in the subject areas of their studies
- capability to identify, formulate and handle scientifically complex problems, as well as to critically evaluate information and to formulate possible solutions
- skills to communicate knowledge at theoretical as well as at applied scientific levels, and
- ability to co-operate and to develop management/professional skills.

Fulfilling these objectives in university education is a great challenge; it imposes specific demands, not only on scientific content but also on teachers and teaching methods. Teaching must stimulate students to learn, to seek information and to critically synthesize information and knowledge, and also offer possibilities for applying their acquired skills. This means that a variety of teaching methods needs to be applied.

Defining objectives for the whole educational programme and for each individual course is essential and the objectives given should be used actively by teachers, as well as by students. The objectives should not only focus on subject knowledge, but also on the skills to be acquired. Students must become aware of what they need to learn to succeed, and teachers should reflect upon what and how to teach to best stimulate the learning process, and how to evaluate it. It is essential to evaluate how well the objectives have been fulfilled.

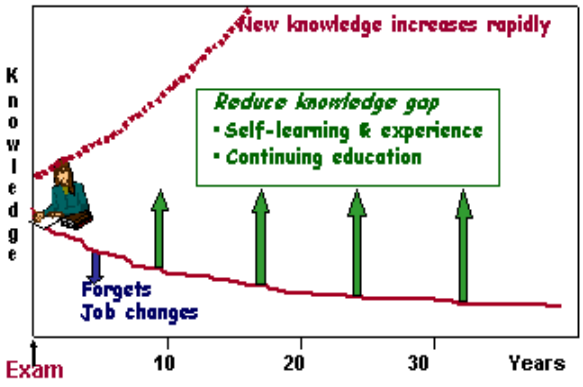

Figure 2. *Life-long learning is essential.*

When discussing objectives in university education, it is necessary to keep in mind the rapid growth of *new knowledge* (Figure 2). A student completing a university degree within a subject area will have acquired a certain amount of knowledge, but this will only be a fraction of the total knowledge available at that time. Quite soon the former student will start forgetting parts of what he/she learnt, and at the same time new knowledge will become available. A *knowledge gap* arises, a gap that will increase rapidly if not counteracted.

The knowledge mass in science and technology is doubled every 10 years! All individuals with a degree from higher education will need to keep their knowledge up-to-date. This will, to a large extent, be through *self-learning*. University curricula, therefore, must be designed to provide students with tools for life-long learning, i.e. learn how to learn and to gather knowledge. Training in using information and communication technologies is essential. Moreover, higher education institutions need to offer opportunities for *continuing education*. Such education will often need to be given as *distance education*, where new technology-based tools will play an important role.

4 Aspects on teaching and learning

Teaching is not effective unless it results in learning. As teachers, we must always think of what our students need to learn, and what changes in their understanding we hope will occur. Some basics in teaching for learning are illustrated in Figure 3.

First of all a safe learning climate is needed. Students must feel comfortable, and so must the teachers. Both parties must also feel motivated - students to learn, and teachers to facilitate student learning. Clear objectives are also important.

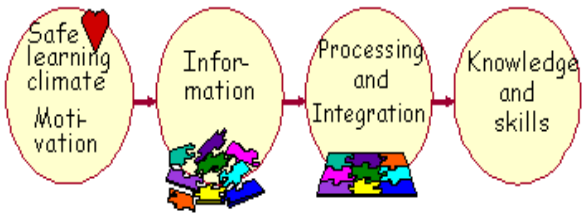

Figure 3. *Some basics in teaching for learning.*

Quite often, teaching consists of answering questions that students have never raised, not even in their thoughts. Doing it the other way around will be more effective; making students curious and stimulated to think about what they want to get an answer to will motivate them to search and receive information. Information, however, will not necessarily result in raising their knowledge. For that to happen, students need to reflect upon and process the new information, as well as to integrate it with their previous knowledge and frames of reference. They also need to put it into a larger context, see how it fits into the whole. It's like doing a puzzle; having seen a snapshot of the whole facilitates putting the pieces in place and stimulates the search for additional pieces to insert. In teaching it is important, therefore, to place any new topic in a holistic perspective before splitting its contents into pieces, and to relate the topic to the students' background and experience.

4.1 Relate to students' frames of reference

When teaching animal breeding, for example, a good introduction can be to talk about the importance of livestock and animal genetic diversity, and the need for sustainable breeding programmes for livestock improvement. The main components of a breeding programme [see Module 3, Figure 2] should also be discussed briefly, *before* going in detail into the basics, such as various types of inheritance, the molecular background, genotype-environment interactions, genetic relationships, heritability, methods for genetic evaluation, selection principles, models for cross-breeding, etc. When also the details are in place, it will be important to discuss breeding strategies and alternative breeding programmes in depth, as well as their impact in short- and long-term perspectives.

As a teacher, do your best to find out what your students know about a topic *before* starting to teach it, and remember that discussions with students and diagnostic tests might be helpful. Also make sure to arrange situations in teaching where students *discuss, process and apply* the information provided. The case studies, discussion questions and exercises available in the Animal Genetics Training Resource can be useful for this purpose. It is important that theory and application are closely linked, also in time.

Educational research has shown that a good university teacher has:

- subject knowledge and enthusiasm to share it
- ability to structure the topic and relate it to students' background and experience
- commitment and ability to stimulate student learning and development of skills
- social competence and good contact with students, and
- a personal philosophy on learning and teaching.

Teachers who regularly check student understanding and improvements and also give positive feedback frequently have the best impact on student learning.

4.2 Learning styles vary

Different individuals can have different learning styles. Learning styles may be classified as:

- *Visual* - understand from seeing pictures and other illustrations.
- *Auditive* - good listener, good ability to transform words into pictures.
- *Read/Write* - learn through reading and writing.
- *Kinestetic* - emotional, wants to touch, learning by doing.

A person might use all these learning styles, but one style usually predominates. There are tests through which students can "find out" something about their learning style(s). The [VARK test] (Fleming 2001) is one example. The results might not "fit" totally for each individual, but doing such a test make students reflect upon their learning style(s), and what study techniques might suit them best.

In teaching it is important to satisfy all learning styles. Using a variety of teaching methods is a good solution.

5 Teaching methods

For the objectives of higher education to be fulfilled, it is important to put emphasis not only on scientific content but also on the teaching methods (Figure 4). Employers of university graduates do not ask just for subject knowledge; they also ask for ability to search for information, to critically analyse and make syntheses, to deal with new situations, to manage projects and problem solving, to co-operate, to communicate information and knowledge, and to have a global perspective.

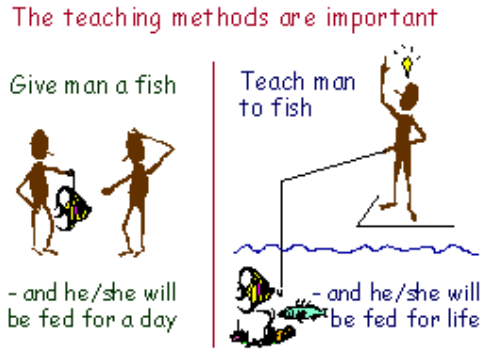

Figure 4. *Ineffective versus effective teaching.*

There is a pool of teaching methods and activities to choose from, such as: lectures, exercises/labs, assignments, computer labs and use of information technology, group work, cross-group discussions, seminars and tutorials, problem-based learning, case-studies, role play, study visits, internships, projects, research activities, literature reviews and self studies. Furthermore, various examination forms, which influence student learning, can be used.

Using a variety of teaching methods in university programmes and courses is often a good way to encourage students to seek and acquire knowledge and skills. The focus should be on

student learning, understanding and development of skills. Overloading students with information, leaving them no time to think about, integrate and work with the content, is not an effective way of teaching. It is essential to use teaching methods that stimulate student activity and participation and make them feel responsible! Students need training in finding, interpreting and validating information and research results; they also need training in various forms of science communication. Furthermore, students should be regarded as a resource in teaching and research.

In the following sub-sections some teaching methods are discussed.

5.1 Lectures

The lecture is one of the oldest and, maybe still, the most widely used teaching method. A committed, inspirational lecture can be effective for structuring, linking and transferring information, and for generating interest in a topic. However, lecturing should not be the only teaching method used in a course. Lectures seldom leave enough opportunities for students to digest, integrate and deal with the information provided. Sometimes, a lecture is merely a process where the lecturer's notes become the notes of the student. If this would be the case, it might be more effective for the teacher to just provide the written notes, or leave students with a textbook, if that is available.

Giving a good lecture is an intellectual and emotional challenge that should be worth real effort. Some essentials of a good lecture are illustrated in Figure 5.

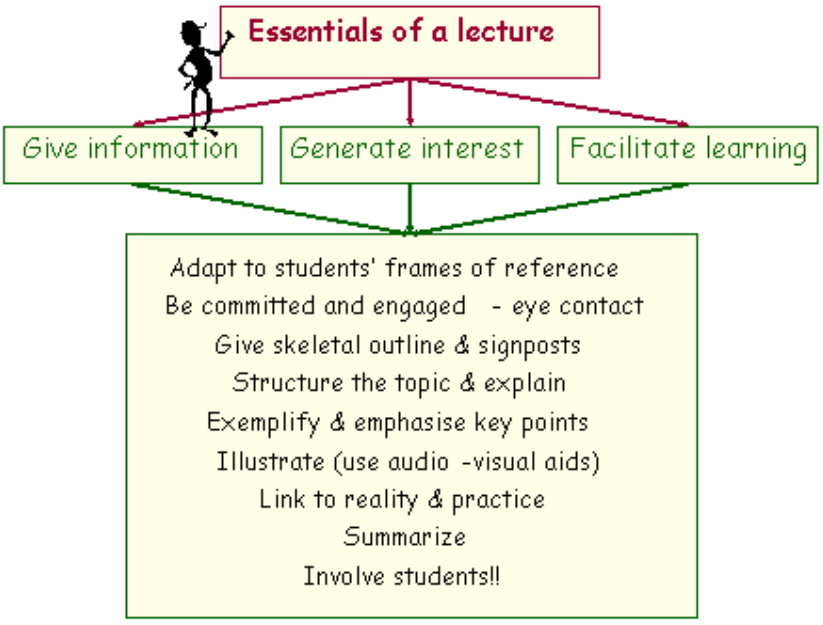

Figure 5. *Essentials of a good lecture.*

Do your best to make the topic understandable and alive for students, and keep in mind that your main task is not just to give information, but also to motivate and facilitate their learning. Make sure that what you say is heard and what you project on the screen can be seen from the last row of seats in the lecture room. If you are not certain of the font size needed in visuals, make a few test examples and go to the lecture room and to have a look at them from the last row. A general recommendation can be to use font size 24 points as a minimum, but preferably larger.

The benefit of a lecture is enhanced if the students are involved during the lecture. Leaving time for questions and discussion is one way to achieve this. One method to stimulate activity is using *buzz-group discussions.* You make a short break in your lecturing and ask the students to take a few minutes to discuss or analyse an issue using the content of the lecture, or ask them to compare their notes. The students may do this two by two, where they are seated in the lecture room. This usually causes intense student activity and should improve their understanding of the topic. The buzz-group discussion might be followed by a short class discussion. Several buzz-group discussions can be included in a lecture. Another option for stimulating questions and discussion could be to start a lecture by giving a short summary of the previous lecture in the same area, and then give the students an opportunity to ask questions on things they have not understood.

Note taking during a lecture is a form of student activity that should be encouraged. It increases students' attention, and gives them something to go back to afterwards. As a lecturer, think of how you can facilitate for students to make good notes. Start your lecture by giving the skeletal outline and some signposts for the content, make clear transitions and links as you move along in the lecture, make frequent summaries and highlights of essentials, and give students some possibility to reflect upon the information given.

Visuals are useful in a lecture, but presenting lots of visuals at high pace will make it impossible for students to take effective notes; it may just cause frustration. When you build your lecture on visuals, it will be more effective if you at the start of the lecture provide a handout print (e.g. six slides/page) to your students; this will form a "skeletal" in which they can make additional notes (there will be some more space for notes if the visuals in the handout are not framed). If you plan to talk a lot around a visual you can insert one or two blank slides next to it to give some extra space for students' notes in the handout.

For some brief advice on oral presentation and visuals, see compendium [Science Communication] and [PowerPoint Guide]; these two tools are provided in the Animal Genetics Training Resource. Further advice is given in a book by Malmfors et al (2004).

5.2 Group work and discussions

Group work can be applied in many different situations in teaching; it is useful for developing the students':

- communication and discussion skills

- co-operative ability
- self-confidence
- responsibility for learning.

Within a small group, students are more willing to reveal what they have not understood, and also to try to explain things to one another, rather than asking the teacher. This is an important aspect of group work; teaching and explaining to others is often considered to be the best method for learning. The teacher then has the role of a supervisor or tutor; a person who encourages and supports students and the group process, and provides help when needed. It is important that the tutor does not dominate the discussions. Students often learn more from each other than they do directly from the teacher!

Cross-group discussion is a group activity that is useful to improve students' learning and understanding. It can be used as a follow-up of a section that has been taught recently in the course, for example, and it can also be used for other purposes. The principle behind this teaching method is illustrated in Figure 5.

Students are seated in groups (in one or several rooms) and are provided with a set of questions, each one fairly extensive. Every group discusses one question (group 1 - question 1, group 2 - question 2 etc) and all students in the group take part jointly in the discussion and make notes of the answers. The tutor(s) circulate to give supervision. They should also do a brief check of the answers of each group by reading the notes; this is important to do before the groups are split (see Figure 5).

After about one hour, groups are split and cross-groups are formed. This is done in such a way that the full set of questions will be covered in each cross-group. Students start teaching one another and the tutor(s) help to clarify issues, but only when needed.

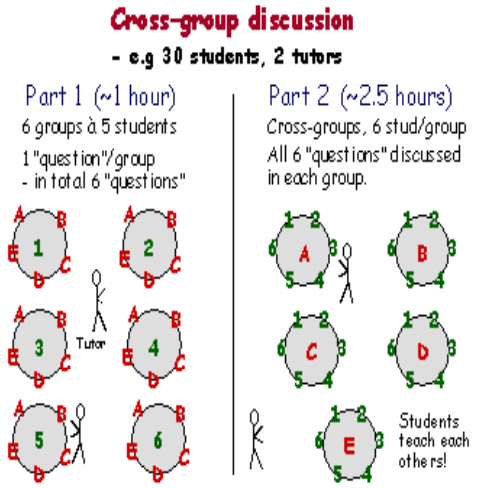

Figure 6. *Illustration of how groups are formed in the two parts of a cross-group discussion.*

Cross-group discussion is normally highly valued by students. It is an efficient exercise; every single student needs to be active. It can be done at low cost, and it can be used also in quite large classes (e.g 60-80 students), but then more teachers are needed, at least for the first part of the group discussion. Several groups can be given the same question, if needed. Some examples of questions for [Cross-

group discussions] used in an animal breeding course are presented in the tool "Exercises" in the Animal Genetics Training Resource.

Plenary or class discussions are other forms of discussion that can be beneficial to include in a course. Those might include external participants, such as collaborating researchers, teacher colleagues, extension specialists, farmers, representatives from NGOs or industry, as well as consumers; such contributions can add to broadened perspectives. Students often need some stimulation to take part actively in plenary discussions; you might ask them to prepare questions for the discussion. Seating is also important; sitting in u-form or in a half-circle is usually beneficial. The discussion sessions can be chaired by students or by the teacher. The main issues of the plenary discussion should be structured and summarized by the chairperson, and the discussion climate should be open and friendly, making students feel confident to take an active part in the discussion.

5.3 Exercises, assignments and labs

Practical work has a critical role in science education. Different types of exercises and assignments can be used to help students get a better understanding of concepts and methods covered in a course. Exercises/assignments can be scheduled and supervised, or given as homework, or even be optional. The type of exercises needed varies, of course, with the topics taught. Being a teacher in animal breeding, you might find it useful to use numerical examples dealing with gene frequencies, heritability, breeding values and genetic progress. Some [Manual Exercises] for use in animal breeding courses are available in the tool "Exercises".

Laboratory teaching is valuable for training manual and observational skills in subjects like chemistry, physiology and molecular genetics. It can also be helpful for developing understanding, assuming the lab practicals are not just carried out according to a "cook book" recipe. Lab work can be time consuming and expensive, so it is important to get the most out of it. Written instructions must contain the objectives of the experiment, clear instructions for the lab work, as well as some questions on the experiment or its implications. Students' learning is enhanced if they write lab reports.

5.4 Computer labs

Computers, software and the Internet are powerful teaching and learning tools in higher education; they are efficient for activating students and they provide tools for life-long learning.

Computer software can be used in teaching and research for a vast number of purposes, such as data management, calculations, statistical analyses, simulations, word-processing and presentation;

there is also software for interactive learning. Students having access to the Internet can find huge amounts of information, and also quite a lot of free software. A number of free search engines are available on the Internet (for examples, see [Section 14.3] of this module); possibilities for quick and easy information search stimulate student activity and curiosity. By use of the Internet, teachers and students might communicate through e-mail, course home pages and virtual discussion groups; this also gives great opportunities for distance education.

Limited access to computers, software and the Internet might be a constraint for using a full range of computer labs, but teachers should use these tools where possible. Building infrastructure to improve access to the Internet will probably be given high priority in many countries, so the situation may change in the near future. Furthermore, important information, software and databases, for example, can be made available in a CD, which does not rely on Internet access. The Animal Genetics Training Resource CD, where you found this text, is an example of such a computerized tool.

The use of information technology in higher education might influence teachers' role. Students can find information themselves to a larger extent than before, but need the teacher as a supervisor and coach in their learning process. Moreover, the major part of the information found in the Internet has not been peer reviewed before entry; it is important, therefore, to discuss quality and validation of such information.

In the following some examples are given on software and databases useful in teaching Animal Breeding. For brief highlights on each item, as well as for more examples, see the tool [Web Resources] in the Animal Genetics Training Resource.

5.4.1 Examples of computer software useful in teaching animal breeding

- for web-addresses, see [Section 14.1] of this module.

There are software packages available to support teaching in animal breeding; some of those can be downloaded *free* from the Internet. One example is GENUP (by B. Kinghorn) designed to help students to master concepts in quantitative genetics and its application in animal breeding. Other examples are PEDIGREE VIEWER (by B. & S. Kinghorn) to display pedigree structures and calculate inbreeding coefficients.

Some useful interactive computer-assisted learning (CAL) programs are available on CDs for purchase. One example is [Animal Breeding: an introductory tutorial] (Roden et al. 2001); it includes modules on inbreeding, heritability and selection. The tutorial helps students to get an introduction to basic concepts and their meaning, and there are a large number of interactive exercises, as well as self-tests, included. The modules also contain links to GENUP. By using computer-based tutorials students can explore a topic at their own pace.

Software such as Microsoft Excel can be used in various types of calculations and for production of graphs. Excel can also handle matrix operations in small data sets and be

helpful in numerical exercises dealing with matrices. A brief [Excel Guide] is provided under "Compendia" in the Animal Genetics Training Resource.

Two examples of using Excel in computer exercises in animal breeding courses are available under "Exercises" in the Tools menu of Animal Genetics Training Resource:

- [Prediction of breeding values]. In this exercise students are presented some situations for prediction of breeding values; they are asked to set up the BLUP equations in matrix form and to solve those by using Excel.

- [Optimization of breeding plans]. In this exercise Excel has been used to pre-produce a sheet where different parameters and other numerical information can be entered to generate the genetic gain achieved for a given situation. For example, students can study the effect on expected genetic gain when they change population size, heritability, percent selected animals, testing method and amount of information in breeding value estimation. The exercise is based on dairy cattle breeding in tropical countries, but may be used also for other species.

Software useful for *statistical and/or genetic analyses* in students' research projects might be downloaded *free* of charge from the Internet or through a named contact person. Some examples are:

- GenStat Discovery - free version of GenStat for use by not-for-profit research organizations, charities and educational institutes based in the developing world. GenStat Discovery Edition 2 (2005) includes e.g. basic statistics, calculations and manipulation, linear regression, analysis of variance, and REML analysis of mixed models.

- R Statistical package written in S-language - can be used for a vast range of analyses, including also mixed models and estimation of variance components.

- VCE, PEST, WOMBAT, ASREML - software packages for estimation of variance and covariance components, and/or for prediction of breeding values.

- SelAction - predicts response to selection and inbreeding for practical livestock improvement programs (available free for teaching purposes).

- Microsoft Access - not a free software, but users of MS Office might have it installed with the other packages. MS Access is a useful database management tool to store, view and retrieve data. An [Access Guide] is included in the tool compendia.

For more examples of software, see tool [Web Resources] in the Animal Genetics Training Resource.

5.4.2 Examples of useful information sources in teaching animal breeding

- for web-addresses, see [Section 14.1] of this module.

There are several information sources in the Internet that can be useful in teaching animal breeding. Some examples are given below (those available also as a CD are indicated by *):

- FAO (Food and Agriculture Organization)*
  From this website, lots of information can be retrieved, such as Statistical databases with agriculture data (including livestock data), software, publications and various types of news and links within the area of agriculture.
- DAD-IS (Domestic Animal Diversity Information System)*
- LEAD (Livestock and Environment Toolbox)*
- ILRI (International Livestock Research Institute)*
- DAGRIS (Domestic Animal Genetic Resources Information System)*
- Breeds of Livestock (Oklahoma State University)
- OMIA (Inherited disorders in animals) and OMIM (Inherited disorders in man)
- OCOA (Cytogenetics of animals)
- Informatics (Mammalian homologies and comparative maps)
- ArkDB (Animal genome database) and Anubis (Animal genome maps).

5.5 Problem Based Learning and the Case Method

Using problems or cases from real life in teaching is effective for motivating students and enhancing their learning and development of skills. Problem Based Learning (PBL) and the Case Method (CM) are two methods used quite frequently, but also other alternatives of problem-oriented teaching exist. In this type of teaching, students are usually presented a situation, a case or a problem as a starting point. From there they search for the information and knowledge needed to explain background and context, or to identify and analyse factors and causes of importance, and to suggest solutions when applicable. The role of the teacher is to be a "manager of a process", not to give the answers.

CM is used both in small and large groups of student, and a teacher usually chair the discussions. Normally a joint seminar session is included, where students from different groups get together. A case might be analyzed from the perspective of different stakeholders, and role-play might be included. The [Case Studies] available in the Animal Genetics Training Resource can be useful in this type of teaching.

In PBL the students are split into groups of maximum 7-10 students; the students normally chair the meetings, and the teacher acts as a tutor to support the group process. PBL is based on a series of steps that each group of students follows (Figure 7). The first step is for the

students to do brainstorming and thereafter decide what they need to learn to deal with a situation/problem. The next step is to search relevant information from different sources, such as reference people, the library, lectures, exercises, and study visits, CDs and, where possible, the Internet. Each group of students summarizes its findings and conclusions. The way of reporting can vary. Reports might be done in writing, orally (e.g. in cross-groups) or as posters.

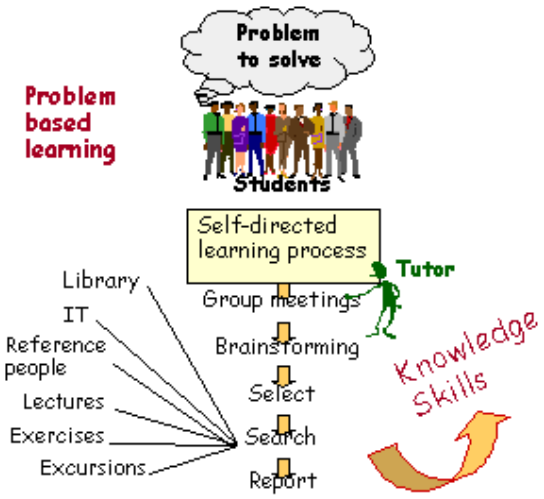

Figure 7. *Some steps in problem based learning.*

The subject knowledge gained by students is considered to be about the same for PBL/CM as for traditional teaching methods,but it seems that critical and creative thinking and skills in problem solving are better developed when PBL/CM are used. Students learn how to use and integrate knowledge from different sources, and they "learn how to learn" effectively. Furthermore, they practice working with others. The outcome of these teaching methods, however, largely depends on the suitability of the problems and cases presented.

5.6 Field work, internships and field visits

Contacts with farmers, extension specialists and industry will add much to the relevance of an education programme. Students need to get professional identity, and it is essential that they experience and become familiar with problems and conditions in practice. That will help to put theories into a context, to see practical application of knowledge, and to integrate knowledge from different disciplines; this increases students' understanding and motivation. Field experience gives students frames of reference, and will awaken questions in their minds that promote active learning; it also helps them to become acquainted with, and to appreciate, indigenous knowledge.

Field experiences can be achieved in different ways, through study visits and excursions, field projects or through an internship period. Students in animal science/animal breeding can learn a lot from visits/projects/internship at various types of livestock farms, national parks, AI stations, livestock and breeding organizations, education and research institutions, feed

industries, abattoirs, dairy plants, extension services etc. Livestock experimental herds may also offer good opportunities for practical exercises, for projects, and for MSc thesis research. Funding might be a major constraint, especially for study visits, which usually require travel. Considering the value of field experiences, it is worth trying hard to make these visits possible. When it comes to projects and internships it is important to emphasize that here university students can be a resource to people in the livestock industry.

It is important to set clear goals to maximize the outcomes from field experiences. Students should always be informed or asked to reflect upon what they should observe, analyse, document and learn from these activities; and also to produce some kind of report.

5.7 Projects, literature reviews and research tasks

Training students in performing projects, literature reviews and research tasks is vital; such activities are our best tools to help fulfil the objectives of higher education and they give students supervised experience of how to:

- formulate and analyse problems, explore an area deeply, and draw conclusions
- apply and integrate knowledge acquired during the education, and search and evaluate any further information needed
- do research in the form of experiments, field studies etc (e.g. for the BSc and MSc degree projects)
- communicate research results through scientific and popular science writing, as well as oral and poster presentations.

Projects etc. help students get contacts with scientists and/or representatives from the farming community, extension service or the industry. Furthermore, students' curiosity and motivation increases, and they develop ability for life-long learning.

Projects, literature reviews and research tasks can be performed in groups or individually. In both cases, however, it should be under supervision. The degree projects give students a real opportunity to go in-depth into an area of their own interest, and to apply and display their knowledge and skills. These projects usually include a research task to be performed and reported individually by the student. The supervisor plays an important role in giving guidance, but without telling too much what to do. Examples of free software for statistical and genetic analyses of research data were given in [Section 5.4.1] of this module.

Minor projects and literature reviews should be included as parts of most courses. These projects can be performed in small groups so that students train to co-operate in solving a task. Specific literature reviews, on the other hand, might be better to do individually, thereby making it possible for a student to select a topic of own interest and to train in writing and presenting.

A minor project in animal breeding could be, for example, to let students (in groups) work with the various components of a breeding programme continuously during a course. They can be given a data set with phenotypic and pedigree information from a model population of animals and, thereafter, use computers to estimate genetic parameters, economic weights of different traits, breeding values and their accuracy, genetic progress, farm revenue and profits etc. Doing each step in direct connection with the teaching provided gives the students motivation to learn and adds to their understanding of the subject. Such a project can be done at hardly any additional cost, assuming computers are available.

Another project task could be to make a plan for a village of smallholder farmers to produce milk, meat, eggs and other commodities, both for own consumption and for sale at the farm gate, as well as to dairy cooperatives, butcheries etc. Students could consider, from the farmers´ point of view, all important aspects of the chosen production, such as species and breeds to use, herd size, climate of seasons, available farm labour, management systems, feed stuffs, feed production, manure handling, breeding programmes, recruitment of breeding stock, production and health control programmes etc. Simple calculations of economic revenues can also be included. The production system should be sustainable and include considerations for environmental health. Different groups of students might focus on different types of production, and each group may present its results both in writing and orally, or as a poster. The value of the project will be enhanced if some representatives from the livestock industry or extension service are present at the oral/poster presentations.

Most [Case Studies] available in the Animal Genetics Training Resource identify knowledge gaps. Such gaps could be used as starting points for various projects in teaching.

Literature reviews can be separate tasks or parts of research projects. *Literature searches* can be done manually in libraries, or more efficiently, by use of computers. The latter requires access to bibliographic databases. These are available in many libraries, but not everywhere. Some bibliographic databases on the Internet provide free literature searching, e.g. [AGRICOLA], [AGRIS] and [Ingenta]; for web-addresses, see [Section 14.2] of this module. For further literature databases, see [Web Resources] in Tools menu of the Animal Genetics Training Resource, and for some full text documents see [Library].

5.8 Self studies

Reading textbooks, compendia, scientific papers, reports and other types of literature is important in the learning process. Unfortunately, lack of literature is a constraint in many universities; not only because modern textbooks are often not available in the libraries, but also because students cannot afford to buy them.

Literature available in the Animal Genetics Training Resource can be useful in courses. Examples are the module texts, case studies, full papers, and the compendia. Furthermore, Internet links to some lecture notes in animal breeding are given in the tool [Web Resources]; most of those notes can be downloaded and/or printed. More lecture notes etc. can be found

by exploring websites of different universities; for web-addresses to universities, see the reference "Universities Worldwide" in [Section 14.4] of this module.

5.9 Learning portfolio

Students can be asked to continuously document (e.g. weekly) what new things they have learnt, as well as thoughts they might have concerning these issues, and how their new knowledge can be applied. This makes students reflect upon their new knowledge, and to find out what they have not fully understood. They will then also better retain the knowledge. The procedure might best fit MSc students.

5.10 Supplemental Instruction

Supplemental Instruction (SI) is an academic assistance program built on scheduled, out-of-class study sessions related to a specific course (module). Students meet in groups and each group is assigned an SI-leader: an "older" student who already passed the course and who received training in group facilitation techniques. During study sessions, students compare their notes from the course and discuss readings; they try to explain things that everybody in the group has not understood, and they discuss strategies on how to study effectively for the course. The role of the SI-leader is not to give answers to the students' subject specific questions, but to facilitate the meetings and to give advice on study strategies. The teacher(s) in the course get feed-back through regular reports from the SI-leaders.

Students who regularly attend SI sessions usually improve their understanding of the subject and earn higher course grades; failure rates, therefore, are reduced. To learn more about SI, see e.g. the UMKC SI website; for web-address, see [Section 14.1] of this module.

6 Examination methods influence learning

Examination is an important part of higher education. The examination methods and questions have a large impact on how and when students study and what they learn. Examination should not only be used as a control that a student is qualified, but also as an educational tool to influence the learning process (Figure 8). If the assessment is mainly for factual knowledge, the students will primarily learn, memorize and recall facts and details.

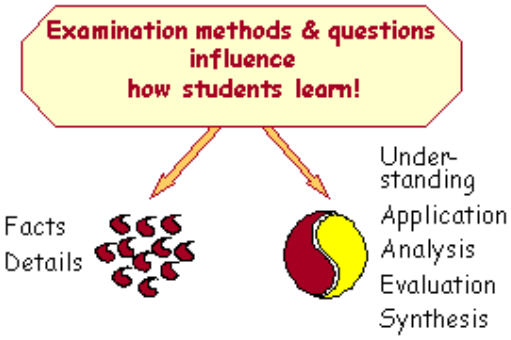

Figure 8. *The learning process is influenced by the type of examination.*

Such tests may have a high reliability, i.e. are easy to grade, but the validity might be low. For measuring that the aims and objectives of higher education have been fulfilled,

assessments need to include tests of understanding (such as ability to interpret, exemplify, summarize, compare and explain), as well as ability to apply, analyse, evaluate and synthesize; assessment of skills, such as ability to communicate, should also be included. When students know that all this will be examined, they will extend their learning and gain useful and enduring knowledge and skills.

Students should be given the opportunity to learn from the examination, and realize what an answer should have covered. Furthermore, the students' answers are of value for the teacher to reveal what has been difficult for students to understand or to apply, and thus identify modifications needed in the teaching.

6.1 Examples of examination methods

Various forms of examination and assessment might be used. Some examples are:

- *Written exams, including short-answer and essay questions*

Short-answer questions are usually easy to judge and grade, but mainly test how students recall specific facts. In subjects involving quantitative manipulations, it is suggested to include numeric tasks for the students to elaborate on, as well as some questions on explaining the meaning of concepts and the results in words. It is also recommended to include essay questions in the written examination; those will give a better assessment of how students have understood a subject and their ability to apply their knowledge and do analysis, comparison, evaluation and synthesis. The grading of the essay questions could also include how students outline and express their answers in writing.

In order to make students learn from the assessment, one option can be to give them 10 exam questions, for example, and ask them to answer 7 of those during the examination (different students can make different choices). Each student is also asked to deliver answers to the 3 questions omitted, but then as a take-home exam.

- *Open-book exams*

In an open-book exam, students are allowed to use their textbooks and possibly also other materials during the examination session (commonly used in Biometry). This examination form can be helpful to test students' understanding and ability to apply knowledge, as well as to select relevant information. A limitation might be lack of relevant textbooks or that students cannot afford to buy the books.

- *Multiple-choice tests*

In multiple-choice tests, the students select the answer from several alternative answers (usually 4-5) for each question. These types of tests mainly focus on detailed knowledge and are not very effective at measuring and stimulating learning for understanding, analysis, synthesis and application of knowledge. The tests are easy to judge and grade, but to construct good multiple-choice questions with realistic alternatives is difficult and time-

consuming. Multiple-choice tests might be found useful for examination in very large groups of students, or as a guiding quiz in continuous assessment. They should be combined, however, with other examination methods.

Multiple-choice tests could be used early in a course if, for example, the students are asked to read some simple texts to get an overview of the subject area before going into the individual parts. Knowing that there will be a test might motivate them to read, and the teacher can quickly check their answers.

- *Computer-based assessment*

Computer tests can be based on multiple-choice questions, but might also involve more interactive events where students are presented a case or a problem to elaborate on at the screen. An advantage of computer tests is that students get an immediate feedback on their answers; the tests can also be used for continuous self-assessment. Lack of computers in sufficient numbers might limit the use of this examination method.

- *Take-home exams*

In a take-home exam, the tasks or questions can be distributed to students in the morning, and at the end of the following day they deliver a written short report to be judged and commented upon by the teacher(s). Take-home exam can be a good way to test students' understanding and ability to apply knowledge, and to select and synthesize relevant information; the method might best fit MSc students. Reports delivered can be compared to check that they have been produced individually.

- *Oral examination*

Oral examination is useful to test the students' knowledge and understanding of a topic, as well as their ability for application, analysis, integration and synthesis. The direct feedback in oral examination provides opportunities for students to learn from the examination, and for the teacher to realize what problems students are facing in grasping the topic. It is also a good training for students to express themselves orally, without extended time to think about the answer. Such situations will occur in their professional careers.

Oral examinations can be done in groups and still grade each student individually. Performing an oral examination in a group of 3-4 students (during 1-1.5 hours) can have several advantages; it is less time-consuming than examining all students one by one, and the discussion within the group can be fruitful. It might be wise to have two teachers per group of students in these examinations, especially if many groups are examined in a day. A comprehensive question, problem or case might be used as a starting point.

When examination is done in groups, it can be recommended that teachers do not direct their questions to a specific student; directing the questions will hamper the discussion and increase anxiety. It is better to tell the students that they must all take an active part in answering and discussing to pass the examination; questions should be directed only if a

student is too quiet. An experienced teacher can quite easily grade the students into the categories fail and pass, and usually also pass with distinction; it might be difficult, though, to do a very detailed grading.

- *Report writing and oral or poster presentations of tasks performed*

Parts or all of the assessment of students in a course might consist of reporting of projects, practicals (field and lab), literature studies or problems/cases dealt with during the course. Examining students on their ability to perform tasks and apply knowledge to unfamiliar situations, as well as to write and present the outcomes is important; it will also test their capacity for application, analysis, synthesis etc. Projects are often performed as group work; they test students' ability to co-operate, but some testing also of each student individually might be needed.

6.2 Use a variety of assessment methods

So, what examination methods should we choose? The best answer probably is: Use a variety of assessment methods, if possible within each course, but at least within the education programme. Diversifying the assessment is beneficial. That gives students opportunities to display their full knowledge and skills in the area(s) studied; it extends their learning, and it prepares them for their professional careers. Testing students for detailed, factual knowledge alone will not achieve this. Remember that the assessment methods should be related to the aims and objectives of the course and of the education programme.

Because examination has such an impact on student learning, it is essential to do *continuous assessment* during a course. If examination is only at the end of the course, most students will postpone their studying until the end. This is not good. Knowledge obtained in a short period is usually not well retained; furthermore, it will not be applied during the course! Continuous assessment can be done through the types of examination discussed above, but also by including compulsory activities that require studying throughout the course; for example, assignments, cross-group discussions, case studies and problem-based learning activities, or study questions covering a wide range of the course contents. Such activities are vital to help students check on their understanding and to identify their knowledge gaps. The results from formal continuous assessment should count in the final exam, either fully or with a weight of 25-50%, for example. When parts of the course content are examined continuously, it is important to include some main issues from these parts also in the final examination so that students get the holistic view.

Whatever type of assessment is used, the teacher must give *feedback to students* on their progress in studies. Students learn from their mistakes and a student who fails in an examination should be given another chance within a reasonable time.

6.3 Using a detailed grading system has advantages and disadvantages

The systems for grading examination results vary. Some universities/colleges apply only pass or fail; some use also pass with distinction, whereas others do the grading on a more detailed

scale. Having a detailed grading system has advantages, and disadvantages. Students get credits for good results, which might help them to get a job, and also increase their efforts in the studies. However, a detailed grading might make teachers use examination methods and questions that are easy to grade, i.e. written exams with questions on facts and details, which, as discussed earlier, can have a negative impact on student learning and the fulfilment of the objectives of higher education. Detailed grading might also increase competition between students, make them less willing to co-operate with one another, and possibly promote cheating.

6.4 Minimize cheating

Cheating can sometimes be a problem in written examinations and other written tasks. To avoid cheating totally is difficult, but the risk for it to happen can be reduced. The most important might be to show trust in students - and to make them feel that you do that! Study counselling is also important; students need to realize that they should learn for life, not for the exam, and if they cheat they will "fool" themselves. They should also be informed about penalties for cheating.

Common practices to minimize cheating are close watching of students during examinations and not letting them bring anything except allowed materials. In addition, students can be seated randomly in the room; one way to do this is to label the seats to be used in consecutive order, and also write these numbers in a list, but then in *random order*. When the students enter the room, they write their name on the list, starting from the top line, and go to the seat assigned through the list. This prevents students to choose where to sit, and next to whom, and the teacher decides exactly which seats are to be used. The teacher will know (from the consecutive numbers) which students' have been sitting next to each other, and can check for similarities in answers in case cheating is suspected. If examination occurs simultaneously for students in different courses the students can be mixed, so that those who write the same exam are not seated closely. In a multiple-choice test the order of the questions could be different for students sitting next to each other.

The risk for cheating is smaller when essay type questions are used in written examinations. It might happen, though, that a student claims to have been given too little credit for an answer. If the graded answers are given back to the students, it can be wise to keep a photocopy, at least of the answers from students who failed the examination; it can then be checked that nothing has been added afterwards. Other forms of cheating, such as copying text from other sources, are discussed in [Section 10.6] of this module.

Making good examinations in higher education is a challenging task, and teachers should take the opportunity to exchange ideas on examination. The system with external examiners that is used in many universities may contribute to such exchange, in addition to having an impact on the quality of examination.

7 Supervision of post-graduate students

In successful post-graduate training the aim should be to prepare the students for careers in basic and applied research and extension, for teaching and administrative duties at universities/research institutes, and for careers in the business world, as well as in the public sector. This is valid for PhD training, and to a large extent also for MSc training. To widen job opportunities, students need training not only in their own specific research area; they also need training to obtain a broad base of general competence and skills (Figure 9).

Figure 9. *What a PhD student should attain.*

To achieve the required knowledge and skills in a limited time, every PhD/MSc study needs to have a clearly defined research task and a time plan for the research, courses and any other activity to be included; there should also be a plan for the financing. A valuable tool for the study is to have an [Individual study plan]; it should be prepared by the student together with the supervisor(s) and, where appropriate, with the student's employer. It is essential to discuss the respective expectations and roles, and that all parties involved agree on the content and time schedule. The study plan should be revised regularly, every half year, or at least yearly; research, courses and other activities performed should then also be recorded.

Quite often, MSc and PhD students do their research work at national or international research institutes, away from the university where they are registered. It is then essential that the university supervisor visits them regularly and that the work is jointly discussed with the host institute supervisor and the student. Being the university supervisor you will then better understand what your student is doing and why he or she maybe cannot do everything that you considered important. It may also help the supervisor contribute to and maybe come to the defence of the student in the final research project examination.

To obtain the maximum benefit from supervisory meetings with your research students, the meetings need to be well planned and structured. Each meeting requires that you are actively listening, questioning, responding, explaining, providing feedback, and summarizing. It is

often a good idea to ask the student to write minutes of every meeting. Furthermore, the students should make regular written reports on their work. Such reporting benefits both supervisors and students; it sets out progress, identifies problems and forms a basis for work plans for the next period. Students should also be required to present regular seminars.

Research supervision is a complex form of teaching. The academic experiences and skills of supervisors and of students are the major factors affecting the research training. For supervising research students, however, it is not enough to be an effective researcher. You also need to be an effective supervisor. As a supervisor, you can adopt a range of possible roles, e.g. director, facilitator, advisor, criticizer, supporter, friend and examiner. The roles you take have implications for the roles of the research student and should be influenced by the needs of each student. For example, if you act like a guru, your student will act like a disciple, whereas acting like a guide and friend will make the student an explorer. As in all teaching, a safe learning climate is vital in the supervisory process. Research students usually characterize the "ideal" supervisor as being knowledgeable, available, helpful and stimulating.

8 Evaluation of courses, teaching and the education programme

Higher education needs to be under continuous revision and improvement not only to satisfy the needs of a changing society, but also to attract students. Regular evaluation of study programmes, the individual courses and the teaching is crucial. Evaluation can be done in different ways, e.g. by students, former students, employers or experts from other universities; a self-assessment by the education institution itself might be done as well.

8.1 Student course evaluations

Students are the "consumers" of higher education; it is important, therefore, to get their evaluation of the teaching. The aim of teaching is to promote effective student learning, and students usually give positive evaluation if they have learnt from the course, and the teaching has facilitated their learning.

Student course evaluations should be done in every course (module) included in the education programme. There should be a course evaluation at the end of a course, and preferably there should also be a mid-course evaluation, giving students the possibility to have an impact on the course they are taking. It is important that the issue of course evaluation is discussed with course faculty, departmental head and students so that everyone understands and agrees upon the purpose, process and outcomes -otherwise such evaluations might be seen as a threat.

Course evaluation can be done through questionnaires to be filled by each student (or by groups of students), and it can be done through oral discussions. Course evaluation questionnaires often focus on assessment of an individual teacher as a basis for decisions about promotion and salary increases. Such evaluation might be needed, but should not be the main purpose of student course evaluations; these should, first of all, aim at *improving* the

courses and the teaching! The students' ratings and comments will help to identify what could be changed in a course, e.g. in content, methods for teaching and examination, teaching materials, as well as in course organization and administration.

The issue whether written course evaluations should be anonymous or not is important, and the answer is both yes and no. By making them anonymously, students feel at less risk of being "punished" if they are critical. However, if these evaluations will influence a teacher's possibility for promotion or salary increase, it seems fair that the forms are signed by the students; but that requires that someone not involved in assessing and grading the students administers and transcribes the course evaluations. An option could be to let students do evaluation in groups; the extremes are then usually balanced out. In all cases, however, it is important that students are told also to comment upon *what* was good or bad, and *why,* as well as *how* things could have been done better.

Some questions in a course evaluation questionnaire could be the following (leave space for comments under each question):

	Rating scale ranging between:
What is your overall impression of the course?	(very bad - very good)
Do you find the course objectives relevant and meaningful?	(not at all - fully)
Were the objectives of the course fulfilled?	(not at all - fully)
Questions specific to various parts of the course.	(very bad - very good)
What do you think of the teaching methods used?	(very bad - very good)
How were connections between theory and application?	(very bad - very good)
Opportunities to reflect upon and process the topics?	(very bad - very good)
What do you think of the examination?	(very bad - very good)
Did you do your best to learn from the course?	(not at all - very much)

How was the workload in relation to the course credits?	(too low - too heavy)
How was the course organization?	(very bad - very good)
What do you think of the course literature?	(very bad - very good)
How do you feel that your understanding of the subject:	
was before the course?	(very bad - very good)
is now, after the course?	(very bad - very good)
What was the best with the course?	(comments only)
What would be the most important improvements to make?	(comments only)

The rating scale might, for example, range from 1-5 or from 1-9. Choosing the latter scale means that the ratings easily can be grouped into three categories if desired (1-3, 4-6, 7-9) when data are compiled.

Evaluation results should be compiled; Microsoft Excel, for example, can be used to [Summarize ratings], whereas students' comments, might be summarized manually. The evaluation results should be distributed to the teachers involved in the course and to the department head / director of studies. Nasty comments about an individual teacher might be better to give just to the person concerned, and possibly also to the department head / director of studies. Most people getting an unfavourable evaluation will become better teachers only if the criticism is handled with care; otherwise it might rather have a negative impact on their teaching. One should also keep in mind that there is no reason to worry too much about negative evaluation results unless they are repeated in several years. Students should also be notified of the importance to give *constructive* criticism.

Student course evaluation results should not only be compiled but also be interpreted. Analyse *why* students reacted negatively on specific parts, and discuss whether, and what actions are required. It can be useful to write a [Course Report] (1-2 pages) giving some background information about the course, plus summarizing the students' evaluations and the teachers' experiences of the course, as well as providing suggestions for improvements. The report can be distributed to students, to teachers involved, to department head / director of studies, and to the teaching committee for the education programme (if there is such a committee). The report will be useful when planning the next year's course; it also

demonstrates to students that their evaluations are considered. Teachers could also do a self-evaluation of their teaching and compare that with the results from the student evaluations.

8.2 Evaluation of the education programme

It is important to evaluate not only individual courses, but also the education programme as a whole. This is necessary in order to see that the education objectives are fulfilled, that the individual parts fit together, that important parts are not missing and that the programme is in phase with changing demands in society, nationally and internationally. Programme evaluation can be done at different levels: by students, former students, teachers and employers, by peer-reviews and at ministry or other authority levels. The individual university teachers are usually involved in parts of this evaluation, and should also actively consider the results.

8.2.1 Continuous evaluation by graduating students

Evaluation of the education programme can be done continuously by the students completing their BSc or MSc degree, for example. Such an evaluation might contain a large number of questions to be graded and commented on by students, who can also be asked to give suggestions on how the study programme could be further improved.

Some issues to include in student evaluation of education programmes could be:

- fulfilment of the objectives of the education programme (plus questions on specific parts of the objectives)
- length of the education programme in relation to the content
- teachers' commitment, subject knowledge and teaching skills
- amount of compulsory courses, and possibilities to elect courses
- co-ordination between courses (in content, in schedule etc)
- demands in relation to credits assigned
- thesis work and supervision
- internships and professional insights
- internationalization
- multi-disciplinary approaches
- study counselling
- facilities and social environment
- tools for life-long learning

- overall impression of the education programme
- the best aspects of the programme
- suggestions for improvements.

The only cost for this evaluation will be the labour required to [Summarize ratings] and comments regularly.

8.2.2 Follow-up evaluations by former students

It could be worthwhile to do follow-up evaluations of the study programme by former students who have been working for 1 or 2 years after completing their degree. They are in a good position to tell what knowledge and skills gained through their education were the most useful in their jobs, and also what they have been lacking.

8.2.3 Periodic evaluations

In addition to continuous evaluations by students, more *thorough evaluation* of an education programme is needed at regular intervals, e.g. every 5-10 years. The decision to do such evaluation is often taken at ministry level, and it might include a self-evaluation performed by the education institution (involving students, teachers and employers), as well as national and international peer-reviews. Important areas to cover might include the following:

- *Background information*, e.g. *i*) objectives, formal contents and organization of the education programme, *ii)* numbers of student applicants per seat and their age, sex, social and ethnic background, as well as fulfilment of prerequisites, *iii*) access of teachers, their qualifications and possibilities/incentives for developing those, *iv)* facilities and financing.

- *Implementation of the education programme*: such as *i*) contents and their academic and professional quality, *ii)* teaching methods, *iii)* examination methods, *iv*) links with research, *v)* national and international co-operation with other academic institutions and with industry, *vi)* physical and social working environment as experienced by students and teachers and *vii*) study counselling, *viii*) student influence, responsibility and systems for student evaluations. , e.g. *i)* fulfilment of objectives, *ii)* examination results, *iii*) results from students' evaluations, *iv)* percent students completing the degree in the time allocated, *v)* internationalization achieved, *vi)* percent students getting a relevant job, *vii*) employer satisfaction and *viii)* tools for life-long learning.

- Results

An evaluation of the education programme can preferably include analysis of strengths, weaknesses, opportunities and threats (*SWOT*). It is also important to discuss the relevance of the education objectives and the tools to reach them, as well as the efforts for continuous quality improvement of the education programme. The evaluation should give suggestions for

improvements. It is essential, though, that these suggestions are discussed with faculty, students and stakeholders before the final evaluation document is produced.

9 How to promote teaching skills and educational development

Effective higher education is crucial for development in a country, but all university/college teachers are not automatically skilled in teaching or active in educational development.

9.1 Requirements and incentives - both are needed

Educational efforts and skills need to be stimulated, both through requirements and through incentives. This can be achieved if governments and higher education institutions, e.g.:

- Give opportunities and set requirements for educational training of university/college teachers. Training in teaching methodologies and research supervision for 8-10 weeks can have a very favourable effect; this training might include topics such as the learning process, teaching methods, tutoring, computer assisted learning, distance education, examination methods, course evaluation, research supervision etc. The training can be a requirement for employment and promotion. It might be beneficial for the institution to have its own educational unit to provide this training.
- Value and give credits to teachers showing educational skills, i.e. let this give merits for promotion and salary increases, just like research efforts do.
- Stimulate activities where teachers from the same or different departments come together periodically to discuss specific educational topics.
- Establish a distinguished award for educational skills.
- Provide the physical facilities needed for efficient teaching.
- Fund research related to the teaching and learning process in specific subject areas (e.g. animal breeding); this research should be performed and published by the university/college teachers. Money from the fund could also be used to test new teaching methods and related activities.

9.2 Document your educational efforts and skills

Being a university/college teacher, you need to document your educational efforts and skills. This can be done in a teaching dossier, often called *Teaching Portfolio*. Keeping records continuously of your educational achievements is not only useful for promotion and salary discussions, or when applying for a new position, it also helps you to reflect upon and to improve your teaching. The portfolio should contain information both on your teaching activities *and* their effectiveness. For detailed information on what to include in a teaching portfolio, explore the website "DeLiberations"; for web-address, see [Section 14.1] of this module

In brief, a teaching portfolio might include:

- your philosophy, objectives and strategies for effective teaching/learning and educational development
- your own education (if any) in this area
- your past and present teaching activities (extent, academic level, teaching and examination methods used etc.)
- your contribution in developing curricula, courses and teaching or examination or evaluation methods, and in fulfilling the education objectives
- your efforts in linking education to research and to professional life, as well as your contribution to internationalization of education
- research supervision
- teaching materials you have produced (and reviews/evaluation of those if available)
- experiences in education planning and administration, and participation in teaching committees etc.
- study counselling and your contribution to the students' learning climate
- participation in research/projects on the teaching and learning process
- results from student course/teacher evaluations
- statements from others about your contribution to education and your skills as a teacher and supervisor (e.g. from colleagues, department chair, educational experts, alumni)
- educational awards, honours, grants, stipends etc. that you have received
- national and international invitations for you to present a report on teaching and learning.

A teaching portfolio should not be too long; a length of maximum 8-10 pages is sometimes recommended (remember to include a content list). Some appendix materials might be attached, but don't overload the portfolio.

10 Teaching Science Communication

Writing and presentation skills are vital in most professions for which students train and such skills are ranked highly by employers. At all levels of university education, it is essential to include training in various forms of science communication, and to help students understand why this is important. They need to realize that research results must be communicated effectively to contribute to knowledge and development. It should also be stressed that communication skills are tools for life!

This section focuses on some essentials in *teaching science communication*, including scientific writing, popular science writing, oral presentation and poster presentation. Examples are given to illustrate how such training can be incorporated into a university curriculum, and what to emphasize in teaching.

As a help for students a compendium, *"**Science Communication: A brief guide**"* is included in the Animal Genetics Training Resource; see "Compendia" in Tools menu; or click this direct link: [Science Communication].

This section and the compendium are based on ideas and advice in "Writing and Presenting Scientific Papers" (2nd ed., 2004) by B. Malmfors, P.C. Garnsworthy & M. Grossman, published by Nottingham University Press, UK. The book addresses scientists, teachers and students; it covers more topics, in more detail, than this module or the compendium.

10.1 Communication skills in the curriculum

Training students to improve their communication skills, such as scientific writing and presentation, should be a continuous process throughout curricula at all levels of education. Students need time to develop communication skills; it is a maturing process. Training can be delivered in specific communication courses, but that should not be the only training provided. Communication skills should be taught also within most of subject courses. Linking communication training to specific topics within a subject course will give students better motivation to improve their writing and presentation skills. Furthermore, it will enhance their learning of the subject.

There are some general skills that students need for science communication:

- *Computer skills* for writing and presentation, such as word-processing and production of visuals. Students often know the basics, but they will gain from learning more details. The [MS Word Guide], the [PowerPoint Guide] and the [Excel Guide] provided in the training resource might be useful; these tools are included under Compendia: Software manuals.

- *Library skills* for literature searches and Internet searches. This should be taught at the start of the studies, and throughout courses. Literature databases requiring subscription might not be available in all university libraries, but there are some free literature databases on the Internet. See: [Web Resources: Additional Information Sources].

- *Critical evaluation* skills to assess sources of information. This is essential to teach to students, especially because non-refereed sources sometimes are used (e.g. Internet). For advice on evaluating sources of information, see e.g. OWL at Purdue; for web-address, see [Section 14.1] of this module.

- *Referencing skills* to keep track of relevant literature found. Bibliographic software exists, but might not be available to students. Students can be taught, however, to

record in a spreadsheet of word processor (or by hand) all information required for a reference list. In addition to the reference they should include the abstract, if possible, plus additional comments and keywords set by the student.

10.1.1 Specific science communication courses or teaching events

Specific courses or teaching events on writing and presentation might be required when students are doing their degree projects (BSc, MSc, PhD), but students also need some introduction to science communication at the beginning of their studies. Students need to become aware of the features of scientific writing. They also need to learn essentials of preparing and delivering oral and poster presentations. Details and depth of teaching will differ according to education level.

In addition to lectures, a science communication course should include exercises (for individual students or groups). Some possible *exercises* for students might be to:

- Review published abstracts, tables and figures, or full papers, and give suggestions for improvements. The teacher should select papers where improvements are needed.
- Find mistakes in a "mini-paper" (constructed by the teacher) containing lots of errors and breaking rules of scientific writing. This should be followed by a thorough discussion on how papers should be written correctly.
- Write a brief popular science article based on a scientific paper.
- Prepare and deliver a short oral presentation, and answer questions from the audience. A specific topic might be provided as a 1-2 page "summary" of a scientific paper/report, giving brief text under the headings Introduction, Materials and Methods, Results (including a Table) and Discussion. The oral presentation should be reviewed in a constructive manner by the presenter, by other students, and by the teacher. The exercise is even more useful if the presentation can be videotaped.
- Design on a computer a poster that is reviewed and discussed.

10.1.2 Training in communication skills within subject courses - some examples

In relation to specific topics within subject courses (e.g. Biochemistry, Animal Physiology, Animal Breeding, Animal Nutrition) students can be given individual or group tasks to improve their communication skills. Some examples:

- Write lab reports, as well as reports from study visits.
- Deliver an oral presentation about results of group work.
- Prepare and deliver seminars (oral presentation on a topic relevant to the subject course).

- Carry out a project as part of the course, write a project report and present the report orally or as a poster.
- Form a "journal club", i.e. groups of 2-4 students, to read a paper published in a refereed journal, write an abstract in their own words, and prepare and deliver a 15-minute oral presentation, including 5 minutes for answering questions. Measures should be taken to ensure that other students will ask questions.
- Write a review paper on a topic relevant to the subject course, and present the paper orally. Allowing students to choose the topic increases their motivation. The review paper should be based on published scientific papers. Students could find relevant papers, or papers can be provided. Students writing a review paper should be assigned a supervisor. Oral presentations can be assessed by fellow students as well as by a teacher.
- Write a popular science article by summarizing some scientific papers for a non-specialized audience.

In the following sub-sections the focus will be on some specific issues to emphasize when teaching science communication.

10.2 Accurate, brief and clear

It is important that students understand that science communication means sharing knowledge, and that the ABC of written or oral communication means that it should be accurate, brief and clear!

Emphasize that for effective communication it is not enough to think only of the topic and the message to be delivered; one must also consider the frames of reference of the audience and the questions they might have concerning the topic (Figure 10). When preparing to write or to make a presentation, students should ask themselves the questions "Who? - Why? - What? - How?". For example: "Who do I address?; Why do I communicate this?; What do I emphasize?; How best do I deliver it?".

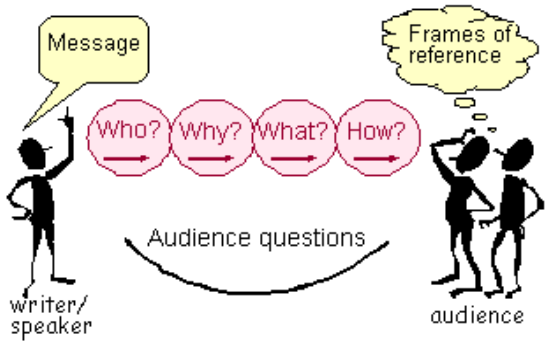

Figure 10. *Some components of effective communication.*

Science communication takes many forms, such as papers in journals,

reports, conference abstracts, review

papers, theses, research proposals, popular science articles, oral presentations and posters. The various forms have a lot in common, but they also differ with regard to purpose and audience.

10.3 Scientific writing

Written documentation of research results requires precision. This includes providing a logical structure, distinguishing new results from old, citing original sources, differentiating and interpreting facts, and giving sufficient information for others to repeat or check what was done. In the compendium [Science Communication] students get brief advice on the different sections of a scientific paper/report/thesis; they also get writing tips and advice on tables and figures. Students who write their text and tables in Microsoft Word may have use also of the [MS Word Guide]; and the [Excel Guide] as well (if they make graphs).

10.3.1 Sections of a scientific paper

Students need to know that scientific papers, reports and theses usually follow a standard format, with *sections reflecting the research process*. The following main sections usually are included: Abstract, Introduction, Materials and Methods, Results, Discussion (or Results and Discussion), Conclusion (not always under a separate heading) and References. In a report or thesis, there is often also a separate section - Literature Review. In a scientific paper, a brief review of literature is included in the Introduction (and in the Discussion). In a review paper, however, the sections on Materials and Methods and on Results are replaced by a Literature Review split into suitable sections.

Students should learn about the main purpose of the sections of a scientific paper/report, and some essential details about each of those sections. Students also should learn about the need for the title to be relevant, informative, specific and concise. Explain also that the tense used in the text varies; in general the past tense is used to describe materials or methods and results (own and others'), whereas the present tense is used to write commonly accepted facts, e.g. in the introduction and in the conclusions.

Emphasize the need always to give a reference to the source when using text, tables, figures or ideas from other people. This must be done also when students summarize in their own words the work of others (see also section 10.6, this module).

10.3.2 Tables and Figures

Science research results are presented mainly in tables and figures, so it is important to give students some instruction on this topic. Students should realize that tables and figures must be clear and easy to understand, without reading the body text of the paper/report, and that there must always be a reference in the text to each table or figure. They should also learn that the same result should not be presented both in a table and in a figure, and realize what might

influence the choice. Furthermore, some instruction is needed on what a table or a figure should look like, as well as some details on making tables and figures.

10.3.3 Writing a popular science article

Science is communicated also to non-specialized audiences, so students need some training on this issue; it is a necessary skill in their professional careers. As part of their training in science communication, therefore, students might be given the task to write a popular science article.

Stress the need to adapt the popular science article to the knowledge and experiences of readers, to simplify, to put things in context, to give examples, and to emphasize conclusions and possible implications. Also stress the need to use language that is easily understood, to use illustrations and to make an attractive layout.

10.3.4 Some writing tips for students

Whether writing a scientific paper/report or a popular science article, students need advice on how to get started and how to improve their writing. Some advice is given in the Science Communication compendium, e.g. that it is important to make an outline, to start writing the easiest parts, to emphasize the most important, to make the text easy to read and to review and revise the text. Further advice on how to get started and to improve one's writing is given in Malmfors et al. (2004).

10.4 Oral presentation

Giving an oral presentation is a great opportunity to communicate ideas and facts - you are in contact with your audience! Emphasize that to your students. Explain also that successful presentations can be done in many ways, as long as the message gets across. The ABC of science communication, i.e. being accurate, brief and clear, should be fulfilled, and the presentation must be adapted to the audience. Remind students of the questions "Who?-Why?-What?-How?" (Section 10.2, this module). Some advice on oral presentation and visuals is given in the compendium [Science Communication]. For further advice, see Malmfors et al. (2004). Some important matters to emphasize when teaching oral presentation are given in the following sub-sections.

10.4.1 Preparing a presentation

The contents of a presentation depend on the main messages to be delivered and the frames of reference of the audience. Students should be encouraged to anticipate questions from the audience, which helps to adapt the presentation to the audience.

Using visuals in an oral presentation helps audiences to understand and to retain the contents. The type of visuals to use depends on facilities available; it might be slides for an electronic presentation, transparencies for an over-head projector, or slides for a slide projector. In a small room, it might be possible to use a flipchart or white/black board. All types of slides

can be created on a computer using presentation software, such as Microsoft PowerPoint, but students might need some training on how to use it. The [PowerPoint Guide] included under the tool "Compendia" in the training resource can here be of help.

Emphasize the need to make slides brief and clear, to make a good contrast between text and background, to use a large font size, and to include illustrations (photos, clip art, graphs etc.) that support the text. Moreover, if electronic presentation is used, some advice on animation of slides might be required. Many animation effects are available, but using too many can distract from the message; using the simple option "appear" is nearly always the best animation.

Students need to be realistic about the number of slides to use in a presentation. Tell them to rehearse (preferably using a timer) before finalizing the slides. Underline that rehearsal is a key to a successful presentation, and that several rehearsals are needed to "fine-tune" the talk and to ensure the students stay within the time allotted. Make students realize that being well prepared is also the best way to cope with nerves.

Tell your students to talk as "freely" as possible when delivering an oral presentation. If they use a manuscript to aid their memory, it should be based on key-words only, and not a full text; key words can be written on a "handout print" of the slides.

10.4.2 Performing an oral presentation

Students should learn some basics for performing a successful presentation:

- Show interest and enthusiasm.
- Keep eye contact with your audience.
- Speak so that you are heard and understood.
- Use only visuals that can be seen clearly and that support your talk.

Eye contact between speaker and audience is essential, so room light should be *on* during presentations. Instruct your students to make slides with colours and contrasts that allow for that. If the room is dark, then the audience can't see to make notes and easily gets tired. Tell students that if they point at something on the projection screen, they should keep the pointer in the hand nearest the screen to avoid turning their back on the audience.

Also train students to ask brief questions (when being in the audience) and to give brief answers (when being the presenter), *and* to speak up so that everyone in the audience can hear the questions and answers.

10.5 Poster presentation

Poster presentation is used widely, and some training on designing posters should be included in university education. Some advice for designing and making posters is given in the compendium [Science Communication]; further details are in Malmfors et al. (2004).

Emphasize that a poster should be attractive, audience-adapted, brief and clear. It should focus on the main messages, and it should not be overloaded (details can be given in a handout). The poster must be seen easily from a distance to attract viewers; it should have large text, and have illustrations that support the message. The background should neither distract from the message nor make the text difficult to read.

Students can design and create posters on a computer, using MS PowerPoint, for example. They might not have access to a poster printer, but they can produce and print posters in pieces, which can be mounted on a unifying background. A simple exercise might be to let students design a poster on the computer and then review and discuss each poster, either from the screen or from a printout.

10.6 Copyright and plagiarism

Students should be informed that it is plagiarism if they use other peoples' ideas, text (exact or re-phrased), tables or figures in their writing or presentations without giving reference to the source. They should also know that materials from others are usually copyright protected; copyright is established as soon as an original material is created in a form that could be copied. A copyright (©) notice might be placed on the work to identify the copyright holder, but the work is protected even without that. Students should be told that plagiarizing or infringing copyright can carry serious penalties. At the same time, it can be emphasized that students themselves gain from giving references to sources; it shows that they have read world literature.

Plagiarism increases with availability of materials on the Internet. Search engines can be used to check for plagiarism, e.g. on key words or a string of words. However, more efficient electronic search tools exist for teachers to detect plagiarism from electronic materials. These tools can be found on the Internet. Some tools are free, but many require subscription. It might be wise to inform students that their teachers have these tools. For a discussion on anti-plagiarism strategies, see e.g. Harris, 2004; for web-address, see [Section 14.1] of this module

Plagiarism might be unintentional if students do not fully understand the rules on when and how to give a reference to the source. Some advice to students on this topic is given in the compendium [Science Communication].

10.7 Feedback and progression

Training in science communication should be progressive: simple tasks can be assigned at the beginning of university studies and more advanced tasks later. Early tasks might be performed in groups, whereas later tasks might be individual.

At each stage of training in science communication, it is important that students get feedback on their performance in writing and presenting. This feedback should be constructive: students should be told what they did well and what could be improved. Constructive suggestions will help them develop their communication skills.

Detailed advice on reviewing written papers, oral presentations and posters is given in Malmfors et al. (2004).

11 Writing a research proposal

A research proposal is written with the purpose to convince a sponsor or donor that you have come up with an interesting idea, and that it is worthwhile to finance your research project. You thus need to make a real effort in making a good research proposal and to clearly convey the message why the research is important. A research grant proposal should be accurate, brief and clear; it should tell why the planned research is needed, and it should give evidence that you and your possible collaborators have the competence to do the job. Your proposal should also match the purpose and goals of the funding organization.

Most granting sponsors have *guidelines* telling what should be included in a research proposal, as well as formal requirements such as maximum number of pages with a specified font size, line spacing, number of copies to be submitted etc. Make sure to follow these guidelines in every detail! You will not be happy if your project is not even considered for further evaluation because some formalities were not fulfilled in your application.

Your research proposal will usually be reviewed and graded by a number of referees, where some of the people might be specialists in your particular research area, but several of them may not be very familiar with the area. This further stresses the need for your application to be accurate, brief and clear and emphasize essentials. You cannot expect the graders to realize that your project is important unless you manage to convince them that it is!

11.1 Essential components of a research proposal

Writing a research proposal is partly similar to writing a scientific paper; you need to define the problem, the objectives, what is known and what is not known about the problem, as well as give your research plan. Instead of presenting results, you describe the expected outcomes. You also give a time plan with short milestones and present a budget for the project. Your (and your collaborators') qualifications are verified in a "C*urriculum Vitae*". Make sure you make a structured and logical proposal with suitable headings and an appealing layout.

When writing a research proposal, it is also wise to check the criteria that will be used for grading the applications. Such criteria might be relevance, scientific quality, qualifications of applicant(s), research collaboration, plan for dissemination of results, and budget in relation to project plan and funds available.

Some essentials to include in a research proposal are summarized in the box and briefly discussed below. For more detailed information, see e.g. a [Manual for grant writing] available in the internet (Reid 2000).

Essentials of a research proposal

- Title and Summary
- Justification & Background
- Objectives & Expected outcomes
- Research plan
- Time schedule & milestones
- Dissemination of results
- Budget
- Collaborating institutions
- Literature references
- Competence of applicant(s)

Title and Summary. Those give reviewers a first impression of your research proposal and should be informative, brief and clear. Summarize the key information of your proposal; tell what problem you wish to address, and also give the objectives, the significance and the potential contribution of your proposed research, and a very brief description of the methods to be used. The summary might also include a few words on your and your organization's ability to carry out the research, as well as the resource needs of the project. The allowed length of the summary is usually stated in the sponsor guidelines.

Justification, background, objectives and expected output. Define the problem and emphasize the importance and relevance of your proposed research project, and tell what is unique in your approach. Present a brief literature review (and a coherent *Reference list)* to show what is done already, and also identify information gaps. The objectives might be split into major and specific objectives, and also be put in a broad framework. Specify the expected outcomes and possible applications of your research.

Research plan (including equipment), time schedule and milestones. Describe the research methods and materials to be used, including methods to analyse the materials or data collected (e.g. laboratory or statistical analyses). State the facilities and equipment needed, which of these your organization can provide, and what requires funding within the research proposal. Describe the research methods so that the scientific quality of the proposal can be evaluated, but avoid describing the methods in too much detail. Relate the experiment/study to the objectives. Present a time schedule for the activities to be performed and milestones to be achieved, e.g. as a time-delivery flow chart of achievements and outputs. Note that an ethical approval might be needed for animal experiments.

Dissemination of results. Scientific results must be communicated to relevant audiences. Obviously, scientists aim for publication in scientific journals, and at international and national conferences. In applied areas of research it is as important that the results are also, but not only, communicated to the industry and various authorities outside the scientific community. Such publications must be kept in a popularized form. Many funding

organizations require a good plan for publication and information of results to approve an application.

Budget. Many sponsors provide a specific budget format that you must follow, but there might be the possibility to add more details elsewhere. The budget should be credible and realistic, and clearly reflect your research plan. Some items might need specific justification. Indicate whether your organization, or maybe other donors, will cover part of the research costs. If that will be the case, your chances for a research grant might be improved; cost-sharing/matching funds are sometimes a precondition.

Collaborating institutions. Performing the research in collaboration with other institutions might strengthen your proposal, and also indicate a multi-disciplinary approach. Across-country collaboration is sometimes a requirement. Costs for the collaborating institutions may need to be considered in the budget. Evidence of collaboration, i.e. letters of support from collaborating institutions, should be included as an appendix.

Curriculum Vitae (*CV*). It is common to add a CV as an appendix to the research proposal. Alternatively, if kept short, it may be incorporated at the end of the application. The main purpose of the CV is to provide the reviewers with such information that they can form an opinion whether the applicant(s) have the competence required to carry out the research described in a proposal. The qualifications and abilities of the principal investigator(s) are most important to describe, although CV*s* may also be required for the collaborating scientists. A CV must be kept brief and clear; include essentials of relevance for the application! Organize the information into categories, such as personal facts, academic education, relevant positions, main research topics, relevant publications, awards or honours received and other skills or experiences that might be of relevance for carrying out the research project. Scientists sometimes overdo the CV and harm themselves by writing a longer CV than the research proposal itself!

A CV is also required in many other situations, e.g. in applications for academic positions. The focus on research, teaching and administration or leadership merits may vary depending on the type of position and the tasks to be performed. Instructions and examples for writing a CV and related letters are easily found on the Internet.

Before delivering a research proposal, also let someone who is not in your area of discipline read it and give you her/his comments. And, remember to make a final check that all requirements set by the sponsor organization are fulfilled (including signatures required)!

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Several ideas presented on teaching, learning and examination have been introduced to the author in courses and other educational activities provided by Nils Trowald and Bengt Ekman, educational experts at the Swedish University of Agricultural Sciences (SLU). Their contribution in this respect is highly acknowledged.

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13 Literature for further reading

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14 Websites

The listing includes examples of websites useful in teaching animal breeding and in research projects. The websites are all referred to in the text, and were accessed on June 2006.

Many of the websites in the list are described in more detail in the tool [Web Resources] in the Animal Genetics Training Resource.

14.1 Websites to databases, software, literature, teaching and communication

Anubis - Map Selector (animal genome maps). Roslin Institute, UK.
http://www.thearkdb.org/anubis

ArkDB - Animal Genome Database. Roslin Institute, UK. http://www.thearkdb.org

ASReml. http://www.discovery.genstat.co.uk/products/asreml

Breeds of Livestock. Breeds database at Oklahoma State University.
http://www.ansi.okstate.edu/breeds

DAD-IS (Domestic Animal Diversity Information System). FAO. http://www.fao.org/dad-is

DeLiberations. *Teaching Portfolios*. Links to websites on what to include in a teaching portfolio. http://www.lgu.ac.uk/deliberations/portfolios/

Effective Presentations (by Radel, J.). University of Kansas Medical Center. On-line tutorial series.
http://www.kumc.edu/SAH/OTEd/jradel/effective.html

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Fleming, N.D. 2001.VARK: a guide to learning styles. (VARK materials are free for use in student or teacher development with attribution, but permission must be granted; see the VARK website). http://www.vark-learn.com

GENET. La partie commune de GENET. Les modules en ligne (Animal Breeding course notes in French). Downloaded free for printing at: http://www.univ-tours.fr/genet/

GENUP (by Kinghorn, B.). Computer aided learning for quantitative genetics. Univ. of New England, Dept of Animal Science, Armidale, New South Wales, Australia. Software downloaded free at: http://www-personal.une.edu.au/~bkinghor/genup.htm

GenStat Discovery. Free version of GenStat developed by VSN International for use by not-for-profit research organizations, charities and educational institutes based in the developing world. http://www.discovery.genstat.co.uk/products/

Harris, R. 2004. Anti-plagiarism strategies for research papers. http://www.virtualsalt.com/antiplag.htm.

ILRI (International Livestock Research Institute). http://www.ilri.org

Informatics - Mouse Genome Informatics. The Jackson Laboratory. http://www.informatics.jax.org

LEAD (Livestock Environment and Development). http://www.fao.org/lead

Microsoft Clip-art Gallery (clip-art that can be downloaded by licensed Microsoft users http://office.microsoft.com/clipart

OCOA (Online Cytogenetics of Animals). http://www.angis.org.au/Databases/BIRX/ocoa

OMIA (Online Mendelian Inheritance in Animals). Database compiled by Nicholas, F.W., Brown, S.C. and Le Tissier, P.R. Univ. of Sydney, Dept of Animal Science, Australia. Location: http://www.angis.org.au/Databases/BIRX/omia

OMIM (Online Mendelian Inheritance in Man). National Center for Biotechnology Information. http://www3.ncbi.nlm.nih.gov/entrez/query.fcgi?db=OMIM

OWL at Purdue. Evaluating sources of information. Purdue University, USA. http://owl.english.purdue.edu/owl/resource/553/01/

PEST (software used for prediction of breeding values). Contact Eildert Groeneveld, e-mail: eg@tzv.fal.de

PEDIGREE VIEWER (by Kinghorn, B. and Kinghorn, S.). Software downloaded free at: http://www-personal.une.edu.au/~bkinghor/pedigree.htm

R (Statistical package). Software downloaded free at: http://cran.r-project.org

Reid, P. 2000. Handbook for preparing and writing research proposals. 164 pp. International Union of Forest Research Organizations. Handbook in pdf-format; also a PowerPoint presentation. http://www.iufro.org/science/special/spdc/training-resource-centre/proposal-writing/

Roden, J., Andersson-Eklund, L., Strandberg, E. and Garnsworthy, P. 2001. Animal

Breeding: an introductory tutorial. Version 2.1. MERTaL™ Courseware. Univ.of Aberdeen, UK (purchased from MERTaL™ Courseware, e-mail: clues@aberdeen.ac.uk , fax: +44 1224 273752). http://www.clues.abdn.ac.uk:8080/mert_idx.html (see: MERTal Courseware Modules)

SelAction. Software for optimization of breeding programs. For information, contact Pieter Bijma (Piter.Bijma@wur.nl) at Wageningen University, The Netherlands.

UMKC SI. Supplemental Instruction website at University of Missouri-Kansas City, USA http://www.umkc.edu/cad/si/

VCE (by E. Groeneveld). Software used for variance component estimation. Downloaded free at:
http://www.tzv.fal.de/~eg/

WOMBAT (by K. Mayer). This software will replace DFREML. Released in Aug 2006. Homepage: http://agbu.une.edu.au~kmeyer/wombat.html

World Bank Report. 2000. Higher Education in Developing Countries: Peril and Promise. Task Force Report. http://www.tfhe.net

14.2 Websites for literature search (Bibliographic databases free of charge)

AGRICOLA. (AGRICultural OnLine Access). Bibliographic database of citations to the agricultural literature created by the National Agricultural Library and its cooperators. http://agricola.nal.usda.gov/

AGRIS. International information system for the agricultural sciences and technology. Created by FAO in 1974. http://www.fao.org/agris/

Ingenta. Free literature searching of academic and professional journals. Summaries often provided. http://www.ingenta.com

14.3 Websites to search engines

Examples: www.google.com ; www.ask.com ; www.altavista.com ; www.yahoo.com ;

http://search.msn.com

Combining several search engines: http://ixquick.com ; www.dogpile.com

14.4 Websites containing useful links

Universities Worldwide. Links to home pages of universities all over the world. http://univ.cc/

Quantitative Genetics Resources (Listing of websites to literature, class notes, software etc. Compiled by Lynch, M. and Walsh, B.) http://nitro.biosci.arizona.edu/zbook/book.html