Just in Time Education[1]

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Abstract

Based on experiences with advising and teaching agricultural students in three countries, we observe that conventional building block approaches starting with basic science courses and ending with specialized applications do not serve all students well. We propose a flexible strategy that individualizes the program based on each student's prior experience and places each course into context of farming and food systems and community. Building relevance and connections within courses helps link theory to practice; students are more motivated when specific subject matter is taught "just in time" to help them solve practical challenges and bridge the gap between knowledge and action. Specific examples are provided from the undergraduate program at the Swedish Agricultural University (SLU in Uppsala), the Agroecology MSc program at the Norwegian University of Life Sciences (UMB in Ås), and the College of Agricultural Sciences and Natural Resources at University of Nebraska (UNL in Lincoln). Our proposed approach helps students develop deep knowledge related to integration of systems components through inductive learning, one that heightens student motivation and cultivates greater confidence during academic programs.

Introduction

Undergraduate education programs at agricultural universities could be re-conceptualized and courses sequenced in ways that would make the learning process more logical and motivating to students. A revitalized program would also focus on skills that better address the individual goals of students as well as future job demands on graduates from such universities, and attract and retain a wider range of students in this time of shrinking enrollment in agricultural universities. This conceptual paper is based on personal experiences from the authors, who have a cumulative teaching and advising experience in agricultural universities of more than 70 years, on discussion with students and undergraduate advisees, and on new research in pedagogy and university teaching. Although we have no data, nor detailed qualitative evaluation, there has been opportunity to test alternative methods of learning including changing the sequence of courses. We consider it imperative to challenge the conventional programs where most basic courses are taught as foundation to all students in the first two years of undergraduate education, and that one size fits nearly all in the university schedule. We present a flexible, just-in-time alternative approach to professional agricultural education.

Background

The concept and historical roots in action research and education have been summarized by Schubert (1995), who suggests that we recognize and promote "students as necessary and neglected curriculum inquirers, thus action researchers."

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Schubert describes the early work of Francis W. Parker (1894) who saw children as "experiencing a continuous process of acquiring knowledge, an ever-growing and ever-changing appreciative mass," and who defined "the child's continuously evolving outlook, [that] should be the organizing centre for the curriculum." The logical conclusion from Parker's work is that education is a continuing and comprehensive process, and that the evolving context in which an individual is enmeshed should provide a framework for further study. Schubert further cites the work of Dewey (1929), who called for a collaborative learning environment involving teachers and students, as well as studies by Corey (1953) who focused on how teachers could design classroom assignments to promote reflection and inquiry. Current applications of this practical approach to education are being organized under the theme of "service learning" (Schine, 1997). Such changes do not come easily in an established and conservative university (Francis et al., 2001).

Another inspiring source for looking on the education system from a learning environment perspective has been the pedagogical research summarized in Marton and Booth (1997) and processed into university teaching practice recommendations in Bowden and Marton (1998). Their concepts of a surface approach and a deep approach to learning, and their research findings on the importance of relevance [obvious applications of information] and variation [stimulation of multiple senses] for a good learning environment, provide an intellectual and experiential foundation for what we are calling just in time education. This is parallel to the "just in time inventory" approach used in manufacturing and business to acquire component parts only as they are needed in the assembly process, based on the experience that it costs to create and maintain storage of information. Manufacturing and business also recognized that some stored components that should fit into bigger systems could soon be out-of-date and thus no longer fit into larger systems that develop and change.

A conceptual framework for introducing greater relevance into education in universities by changing the structures of departments and programs has been proposed by Lieblein et al. (2000b). In their models, department lines are blurred and courses are taught by teams of faculty who can integrate materials and present them in the context of the farm and the food industry. Their proposed curricular time frame would make sense to students and provide immediate applications. They propose moving much of the applied research in agriculture and food systems off the university campus, onto farms and into communities. In these settings, students would interact closely with both current faculty and actual practitioners who are in farming, food processing and marketing, government regulation, and advertising, and students would learn as well through interviews with consumers.

The context of farm and community provides a compelling reality to both learning and research, brings new perspectives and information through a broader array of teachers, and exposes students to many and diverse ways of learning and knowing. The practical context can create a learning environment that introduces both relevance and a variation that appeals to multiple senses. The proposed new learning environment makes it possible for the student to start from their present knowledge base and a real life situation to create their own questions to be explored together with the teachers/facilitators. Experience creates a need, or demand, for new information that is now seen as important because of this experience. The real-world context also provides incentive to retrace the academic steps, to learn what more is needed, and to be ready to focus on academic subjects that are vital to understanding the current situation. Within this real world context, we propose the need to provide the students with a dynamic curriculum for "*just-in-time education.*" The ongoing and successful MSc program in Agroecology in Norway described later is one example of how this theory has been applied.

What are Some Current Problems of Agricultural Universities?

Lack of Perceived Relevance

Most agricultural universities, regardless of language and culture, organize their agronomy and other educational curricula in a similar way: general basic chemistry as a foundation for physiology, physiology as a foundation for crop/animal production, and sometimes production knowledge as a basis for study of farming systems. With respect to systems, traditional curricula are heavily loaded with specific topic courses such as soil fertility, cereal and legume crops, and soil microbiology, and often do not include integrative systems courses.

Many years of experience teaching in basic science and applied science at agricultural universities have convinced us that there is a discrepancy between this concept of how agricultural sciences and experiences are currently organized and the real impacts or outcomes that such education strategies are designed to achieve. We have observed that most students have difficulties recognizing appropriate contexts and when this basic knowledge should be applied. The current study plans often do not start with, nor build on, each student's perspectives and experiences. A frequent situation is that students in the third year, when they are being introduced to practical production perspectives, begin to understand the relevance of physiology and sometimes parts of the chemistry classes: "Aha, now I understand why we were supposed to learn about …!" Almost all former students we have asked have also described the following experiences: "In the first or second semester I took (or had to take) a course in statistics. But not until my thesis work in the eighth semester did I understand why and how I should use these tools, and then I had to take the course once again or read the course content on my own."

In our university teaching we have also found that as educators we often answer questions none of the students ask, probably because many issues we consider important in class are far away from the students' experiences and learning contexts. Although we need to expand learning beyond their prior experiences, it helps to provide grounding or connections to the contexts from where they arrive. The current teaching approach generates another consequence -- students study for the examination instead of integrating new information into their existing experience base and "learning for life." A frequent question is: "What shall we read for the examination?"

We have also recognized, and students are not hesitant to point out, that many of the facts that we teach in basic courses (chemistry, mathematics, statistics and physics) are not used in the other applied level courses (production, environmental and farming systems courses), mostly because they may have little relevance for solving problems at that level. Much of this knowledge becomes a kind of "trivial pursuit" or accumulation of facts to pass exams. We also recognize that preparing students to face future challenges requires much more than tools to solve today's problems, and that it is critical to provide basic concepts and develop problem-solving skills that will serve them well in a complex and changing world.

At times the current approach to teaching is both inefficient and frustrating to everyone. Students don't learn what we teach. Students don't learn to use knowledge, but rather to copy information. Motivation must be developed as an effective incentive for learning, at all levels, since lack of motivation leads to inefficient learning or none at all. Strong foundation for motivation is found in curiosity and relevance. One of our incentives to provide an alternative curriculum is observing students who postpone requisite courses, e.g. chemistry, until they take these courses "just in time" to graduate. We think that the new and flexible approach to sequencing of courses will appeal to students, yet we fear that faculty advisors who are unfamiliar with this new approach may cling to the traditional sequence of courses that has always been in place and was, after all, a successful curriculum for them.

Lack of Linking Theory to Real Life Situations

We recognize the many trade-offs in priorities and opportunity costs when a student decides on courses. Taking a set of courses in one area in a given semester precludes taking other courses at that time. Working toward a broad appreciation of principles and applications in a number of subject matter areas makes it difficult to become a specialist in depth in any one of these. Yet students and graduates who can fit pieces together from many disciplines are badly needed to confront and solve tomorrow's complex challenges. These graduates could be called systems specialists, or systems integrators. There is increasing evidence that lack of knowledge is not the main problem today, rather the problem is the gap between knowledge and action (Pfeffer, 1998). We know many things, but our capacity to apply them is hampered by an inability to place information in context and to know where a given set of principles may apply. Service education with students active in the community provides one solution to this challenge (Schine, 1997). Levin and Greenwood (2001) summarize the importance of action research in learning communities, and why this is so difficult to introduce in current universities.

The challenge was obvious in a series of recent interviews with students in their last semester at the Swedish University of Agricultural Sciences (SLU). Many students expressed an anxiety of not being prepared to use their knowledge in a real world situation, even though the teachers in their applied subjects recognize that they have quarried a large store of relevant knowledge (Lagerkvist, 2000). With the disappearance of general agriculture courses and farm practice in the university curriculum, we have evolved our programs into a collection of highly specialized pieces of a complex puzzle. Often students are not sure how these pieces fit together to form a useful picture. Facts and principles are often presented from a series of different disciplines that can only be fit into very different puzzles, or the pieces can be viewed only from one angle at a time.

The anxiety expressed by SLU students is demonstrated in the frustration of many agriculture university graduates who are often uncomfortable with the idea of meeting a real farmer and discussing crops or livestock production. They suddenly realize how little they really know and understand about the reality of the farm and the current agricultural context, and may return to academia for more specialization or to some completely different job rather than expose their ignorance.

We think that providing context for learning is an essential part of the learning itself. Meaningful learning is not context-free. Therefore, when students are ready to learn specific concepts in a given area of study, it will be most important and relevant for them to integrate this knowledge with what they know from prior courses and experiences and to apply the sum of the learning to practical problems in the field or in the community. This must be done when the time is right.

Lack of Context, Integration, and Deep Focus

When creating structure from information and patterns in the complex world, we most often organize using a hierarchical model. In agriculture: atom level, molecule level, physiology level, whole plant/crop/animal level, production unit level. But when searching for structure, we start from our present situation in knowledge, perspectives, values, and attitudes, and try to organize new information into this framework. Although learning styles differ, for most of us when these new concepts or facts are too far from our present perspective of the complex world, new information tends to be stored as "trivial" knowledge, something to be used in games and crossword puzzles (or university exams).

Lack of integration has been summarized by Marton and Booth (1997). They describe how one could identify two general types of students, facing a new unknown text in an experimental recall situation. "Some of the participants described how they saw reading as an imposition and made sense of the given task accordingly, treating learning as something external to themselves, as a task of performance for later recall. They adopted what we have called a surface approach to the learning task, focusing on the text as such, and ending up mainly with the sequential kind of understanding …. In contrast, others seemed to see reading as a means of finding out about the world around them. They saw text rather as windows to reality, and they treated the text in the experimental situation accordingly." The authors call this latter situation a deep approach to learning (Marton and Booth, 1997; Ramsden 1992). In current terminology, this could be considered a difference in learning styles between experiential learners and reflective learners.

We find, in our teaching experiences, that a curriculum approach based on the idea that the student should be "guided" through the sequences from atoms to farm systems by teaching basic principles as knowledge to "store" for later recall and relevance, represents the study style that Marton and Booth (1997) call "a surface approach to the learning." In the literature, surface focus is related to external motivation and to such terms as resistance to learning and fear of failing at exams. The deep focus is more related to engagement and challenges, with the joy of learning something based on genuine interest, on an inner motivation (Entwistle, 1988; Ramsden, 1992).

The context within which the students do their studies can be called a learning culture. Jacobsen (1999) describes two extremes: the culture of fixed answers and the culture of curiosity. The culture of fixed answers is connected to surface knowledge, negative emotions, and low level of cooperation, whereas the culture of curiosity is connected to a deep focus, positive feelings and high level of cooperation. In the culture of fixed answers, learning is viewed as information processing, where the student is expected to find the information in lectures, books and others texts. Reproduction of facts is more valued than individual production of meaning and of finding new solutions. The level of autonomy is low. In the culture of curiosity, learning is viewed as the construction of meaning. Based on available information, the students are expected to solve problems, or at least develop their own understanding of the phenomenon. The activities will have a high level of autonomy, students will have a deep focus, and new and original solutions are valued. Most classroom and field trip activities foster the fixed answer approach, with students learning from instructor or farmer, while what we propose is a discovery process where students build meaning. Education of course is obviously some mixture of both.

What Alternatives Do We Propose?

Our main idea with "*just in time education*" is that basic concepts and tools should be presented at times when students are ready and ask for them. Sometimes we as teachers and researchers are in situations where a concept, methodology, tool, or perspective would be very useful to organize a complex structure into a simpler model to highlight certain properties or functions. From the bases of pedagogical research (Marton and Booth, 1997) we believe that for students the new concepts, methodologies, tools and perspectives should be introduced in the context when they make sense for students and when they are ready to integrate them into their own knowledge base. The idea is to expose students to such concepts, methodologies, tools, and perspectives in situations where they are delving into a complex system with certain goals. We can help build that context.

Education needs to be more relevant to students and timelier than our conventional approach of delivering of a big 'tool-bag' in the first semester and expecting them to trust our judgment that those tools are the relevant ones for future problem solving. If the concepts, methodologies, tools or perspectives are introduced in situations where we think they make sense to solve a problem, students could also give quick feedback on how relevant these perspectives really are. That feedback could also help us to continuously update our curriculum, instead of teaching subjects "by tradition" or by pure personal interest in special topics or narrow approaches in which we are competent. We think that educators at agriculture universities could make this reformation of their curricula by:

(1) *identifying what concepts in "basic subjects" really are important* to include in the education program, from the perspective of application, and from there go down in the hierarchy of scale into details that are relevant for solving problems typical of each professional area;

(2) *identifying where and how these concepts could be integrated* into the more "applied" subjects and with students' prior experiences;

(3) *creating interdisciplinary teacher teams that would cooperate and expose the students* to those perspectives and integrated approaches that seem relevant from the students' present situation, and in a way that it fits into the context where the students are likely to work in the future;

(4) *implementing these steps* in an environment of "real life" cases that will motivate students to search for new knowledge and perspectives. Such real life cases will further show that there are no given or fixed answers to (1) and (2). The phenomenon is illustrated by the cases and given priority over only isolated theory in textbooks. When dealing with real life cases, learning can be restored as a genuine researching activity. Teachers and students will engage in a joint process to find answers. In such a climate the deep approach to learning will dominate.

Implementation in Agroecology: Three Models of Application

As examples, we present this concept and approach in integrated and practical education programs in agroecology that are either proposed or already implemented in three universities. As a basis for such programs, agroecology has been defined in a broader sense by Nordic teaching staff as "an emerging field that bridges the studies of ecological processes and agricultural production systems. It is becoming more broadly defined to include economic, environmental, and social variables and their impacts on agricultural production and food systems" (Francis et al. 2003). In summary: agroecology is being defined in this program as the ecology of food systems.

Agroecology provides an excellent arena in which to test the concept of just in time learning. Agroecology as the study of natural resources, agricultural production, and food systems provides the integrating framework through which students can connect with the world outside academia. This can be done in the current university context only by moving the students out into the field and community, or bringing those practitioners into the classroom and laboratory. By changing the university learning paradigm to one of experiential activities, it is possible to move both faculty and students out of the cloistered environment and into the practical world to work within the current context of agriculture and food. There both faculty and students can discover what is relevant, while working together, and teachers and students will be highly motivated to acquire what is needed to improve individual learning (which will be different for each student and teacher) in order to help farmers improve their current situation. This we can call action research in learning.

Proposed Implementation in a BSc Program in SLU (Sweden)

Much of the education at SLU is currently organized into learning modules. We believe that a logical, systems-oriented approach could be successful in providing an opportunity for action education in place of the conventional BSc programs currently found in the region. In this example we explore the potential for developing an Agroecology BSc program based on the concept of just in time education.

(1) *Structure*. The proposed curriculum structure and course modules are shown in Table 1. Students begin with an introduction to the real-world case and the context in which it operates. They also are given an overview of the farming and food system to provide further relevance to current and later studies. As they move through the semesters, there is an accumulation of the tools and methods needed for their specialty, yet they maintain a breadth of appreciation of the whole system so that these tools take on a new relevance that is difficult to achieve when they are taught within a single discipline. Toward the end of the BSc curriculum there are activities in synthesis, including the BSc thesis.

(2) *Course elements*. Descriptions of content and activities in the different course modules in Table 1 are described in Table 2. This table clearly shows the differences between the proposed just in time education and the conventional university curriculum. Also, much of the current material in courses could be converted into this new organizational

Table 1. Proposed 3-year BSc in Agroecology, implementing the approach of just in time education, at Swedish Agricultural University (SLU), Uppsala, Sweden.

Semester	Course modules (numbers are course elements found in Table 2)
Autumn Semester 1 (fall first year)	(1) Meeting your case I, Introduction to the case that will be the students' 'real world' references during the first year. (2) Overview of the food & land use system I - different systems perspectives - Systems ecology and socio-economic perspective. (3) Tools for reading the context of farm and landscape
Spring Semester 2 (spring first year)	(4) Overview of the food & land use system II - different systems perspectives - different stakeholders' view. (5) Professionals' terminology and perspectives - First specialization section where students get to know their chosen specialties and ways of structuring the complex food system.
Summer 1	Practitioner period I
Autumn Semester 3 (fall second year)	(6) "Meeting your case II" - Introduction to the case that will be the students' real world references during the second year (7) Tools and models for specialists I - Second specialization section where students are exposed to tools and models used by their chosen specialty area.
Spring Semester 4 (spring second year)	(8) Synthesis practice I - Examining the cases with different perspectives - challenges and problems. (9) Tools and models for specialists II - Third specialization section where students go even deeper into tools and models used by their chosen specialty area.
Summer 2	Practitioner period II
Autumn Semester 5 (fall third year)	(10) Synthesis practice II, - project work, including project planning and leading. (11) Tools and models for specialists III - Fourth specialization section where students use their specialization skills and practice them in different cases.
Spring Semester 6 (spring third year)	(12) Synthesis practice II, - 'Reading a context' exercises in groups. (13) BSc-thesis.

model, and we can maintain the quality of instruction on components and through disciplines, but provide these within a systems context.

(3) *Chemistry example.* As an example of one important discipline and foundation course, where should chemistry be taught in this model structure? This seems to be a key question when we suggest reorganizing the BSc level teaching system according to the proposal described above and detailed in Tables 1 and 2. Chemistry has a central role in the present teaching system in the first study year. The central point in our argument is not that chemistry knowledge is of no relevance, but that chemistry is most often taught separately from its relevant context. Our suggestion is to integrate central chemistry perspectives into a teaching situation where it helps to organize a complex system. Below we give examples of where in the block model described above the central chemistry concept could be provided to students and in what ways they could make sense of this information from the student perspective. We recognize, of course, that some students can generate their own context and will find chemistry meaningful in the first study year, but the proposal is for flexibility and design of a unique program for each student. Here are examples of where chemistry enters the curriculum:

(a). Course module 2. *Overview of the food and land use system I - different systems perspectives - Systems ecology and socio-economy perspective:* In the systems ecology model, perspectives on fundamental driving forces and processes will be introduced. This includes the energy flow and material flows in the eco-systems and social-systems, and the role of water as transport agent and as a solvent, and also its role in temperature regulation of the planet. This will give a natural context to concepts such as: acidification - pH, solubility, complex formation, chemical equilibrium, all practical applications of chemistry.

(b). Course module 7. *Tools and models for specialists I - Second specialization section where students are exposed to tools and models used by their chosen discipline area:* Many central chemistry concepts will here have a relevant connection: chemistry analysis tools, deeper study of solubility, complex formation, equilibrium.

(c). Course module 9. *Tools and models for specialists II - Third specialization section where students go even deeper into tools and models used by their chosen discipline area:* Plant and animal physiology will give a natural context for some basic biochemistry and organic chemistry. But, instead of starting from the simplest hydrocarbons (methane, ethane, propane ….), we have a vision of starting from plant and animal structures, and from physiology functions and energy transformations in plants and animals. This should be structured in a way that the chemistry and biochemistry concepts will provide important answers to questions about structures and functions. For example, one principle will be found in the soils arena: to start from a geology and living systems perspective on soil formation, and from there introduce chemistry and biochemistry concepts that make sense to model the complex soil system and its many important properties that need to be managed in sustainable food and land use system situations. These are practical ideas of how chemistry can be imbedded in the context of the system, rather than being taught in a context-free environment that is difficult for some students to understand.

Table 2. Description of course contents in Agroecology BSc course modules.

Course modules	Examples of course contents
(1) Meeting your case, I - Introduction to the case that will be the students' real world reference point during the first year.	Students get to know a special case situation: a farm, processing company, or municipal administration that is involved in food & land use systems.
(2) Overview of the food & land use system I - different systems perspectives.	Students are exposed to basic concepts of systems thinking, human context, ethics and perspectives from systems ecology as well as economics.
(3) Tools for reading context.	Students have the opportunity to meet perspectives from hard and soft systems methodology.
(4) Overview of the food & land use system II - different systems perspectives - different stakeholders' view.	Students and staff members analyze and describe different stakeholders' views by using systems perspectives and tools from models 2 and 3.
(5) Professionals' terminology and perspectives - First specialization section where students get to know their chosen discipline's way of structuring the complex food system.	Students begin to specialize with an overview of their disciplines. Crop production students get an overview of the crop/soil system, for example.
(6) Meeting your case II - Introduction to the case that will be the students 'real world' references during the second year	As in module 1, the students are introduced to a new case, meeting people in the field and community and work with a case facilitator.
(7) Tools and models for specialists I - Second specialization section where students are exposed to tools and models used by their chosen discipline area.	Students are exposed to models and tools used by their different professions. Crop production students will for example practice soil analyzing tools, crop models, and techniques for monitoring crop disease.
(8) Synthesis practice I - Looking on the cases with different perspectives - challenges and problems.	Students with their different specializations come together and start to look on new small cases, create a rich picture of the cases and identify emergent properties when analyzing the case from different perspectives.
(9) Tools and models for specialists II - Third specialization section where students go even deeper into tools and models used by their chosen discipline area.	Crop production students for example start to look on the crop system at a plant physiology level and on the soil system at a geology, microbiology and soil structure level.
(10) Synthesis practice II - project work, including project planning and leading.	All students are exposed to a case with a formulated task to solve over a fixed time frame. Students are introduced to project planning tools and project management.
(11) Tools and models for specialists III - Fourth specialzsation section where students use their disciplinary skills and practice them in different cases.	The students are exposed to cases together with professionals from their specialization area, and together with those external professionals analyze different cases.
(12) Synthesis practice II - Reading a context exercises in groups.	This module contains excursion, where the students in small heterogeneous groups analyze different situations in depth.
(13) BSc-thesis.	Individual thesis writing.

Current Agroecology MSc Program in UMB (Norway)

The agroecology post-graduate program organized at the Norwegian University of Life Sciences was initially promoted under the banner of NOVA (Nordic Veterinary and Agricultural) University, a regional virtual organization that encourages cooperation among member countries in the Nordic Region. Now under direction of the AGROASIS (Nordic School of Agroecology/Ecological Agricul-ture) the program in 2005 is in the sixth year of implementation with an intensive two-module, full-time semester course of study and an option for students of continuing for a complete four-semester MSc program. The goal is to bridge ecology and agriculture and to provide a practical systems-oriented experience for students interested in ecological agriculture and food systems. The schedule for the two-year program is summarized in Table 3.

The heart of the program is the first semester in UMB, Norway that includes two eight-week modules, *Agroecology and Farming Systems* (PAE 302) and *Agroecology and Food Systems* (PAE 303). This was initiated as a prototype course in spring semester of 1999 with four students, and the full course has been running with 14 to 20 students each fall since 2000. The first module on farming systems includes an initial farm stay on an organic dairy to establish the context for study, and in-depth analysis of four nearby farms by student teams. During the eight weeks students have some lectures, many discussions, library and community discovery exercises, and a major team project that involves multiple farm visits and development of a farming plan that will help the operator and family to achieve long-term goals. There is a written team project report and oral presentation, an individual learner's document to reflect on the educational process and experience, and an oral exam with faculty. There have been students from 20 countries over the first five years of the course. Half of the students enrolled for the one semester as part of a study plan at another university, and half have continued for the two-year MSc degree.

An eight-week *Introduction to Agroecology* (PAE 301) modular course available by distance was introduced in 2004, and continues to be available for students unfamiliar with the topic or wanting a refresher before starting the MSc program. It includes a team project using a practical case study of an organic dairy farm in Denmark. Experiences and a pedagogical concept for the course design of this web-based course has been published by Lieblein (2005).

Table 3. Course of study for 2-year Agroecology MSc program at Nowegian University of Life Sciences (UMB), ?s, Norway.

Semester	Description of Modules and Courses
Summer distance course PAE 301 (optional)	Introduction to Agroecology, offered by distance to students from any country, 5 ECTS
Autumn semester 1 (fall first year) PAE 302	Agroecology and Farming Systems, intensive full-time eight-week module with lectures, discussion, practical exercises, and major team project working with farmers on conversion to ecological agricultural systems, 15 ECTS
PAE 303	Agroecology and Food Systems, intensive full-time eight week module with lectures, discussions, practical exercises, and major team project working with a community on designing its future food system using ecological principles, 15 ECTS
Spring semester 1 (spring first year)	Courses taken from regular course catalog at UMB (Norway), one of the other Nordic Universities, or elsewhere by special arrangement, with a co-advisor from the Agroecology Program at UMB, 30 ECTS
Summer research	Thesis research planning and initial implementation in Norway or another Nordic country, or elsewhere by arrangement.
Autumn semester 2 (fall second year)	Courses taken from regular course catalog at UMB (Norway), one of the other Nordic Universities, or elsewhere by special arrangement, with a co-advisor from the Agroecology Program at UMB, 30 ECTS
Spring semester 2 (spring second year)	MSc thesis research in Norway or elsewhere, under guidance of subject matter specialist and co-advisor from Agroecology Program at UMB, presentation of thesis and final exam, 30 ECTS A two-semester thesis option is available, 60 ECTS

The second eight-week module in the fall Norway semester is focused on study of food systems, using the same mix of activities described above. The group project has a goal of helping a local community catalog their sources of food and design a strategy to substitute local products for imports to the extent possible – creating a greater cycling of money in the local economy and promoting overall economic well-being. This consists of research on the food system in one fylke (county) in Norway, and involves interviews and focus groups with farmers, processors, marketers, government officials, and consumers. Students again present a written and oral team report, and have an individual learner document and oral exam as part of the learning and reflection process. One student group in 2002 was requested by the authorities in Hamar, Norway to design a strategy to convert the entire food supply to organic (ecological food, in Norwegian terminology), and the student report was well received and given thoughtful consideration. These courses have been described by Lieblein et al. (1999, 2000a, 2000b).

The second and third semesters of the MSc program include selected courses from the regular catalog at UMB in Norway. The choice of courses is based on individual student interests and future plans, and is done in consultation with an advisor in the area of specialization and a co-advisor from the Agroecology Program. Either or both of these semesters may be taken in other universities, and some students have done this in U.K., Canada, and Denmark. The MSc thesis project is often initiated during the summer after the first two semesters of courses, and is the full-time activity during the fourth semester of the study plan. The thesis may be done in Norway or elsewhere, and students are encouraged to "think outside the box" when choosing a location and topic. Research to date has been conducted in Norway, Colombia, Canada, and Brazil. The final presentation is made to faculty in UMB and the degree is from this Norwegian University.

Introductory and Capstone Systems Courses at UNL (Nebraska, U.S.A.)

The College of Agricultural Sciences and Natural Resources (CASNR) at University of Nebraska follows conventional tradition of majors and minors in specific disciplines and a minimal treatment of integrated farming systems. Recent innovations have helped students develop context and relevance for their 4-year degrees, and these are designed to broaden the appreciation of natural resource, agriculture, and food systems. There is a first-year required course, *Introduction to Agricultural and Natural Resource Systems* that is required of all students in CASNR. A second-year learning community in *Agroecology* provides opportunities for students to link with a mentor in agriculture, natural resource, university, or business professions, and a series of classes, seminars and field trips enriches the learning experience. A fourth-year capstone course in Agroecology is cross-listed in Agronomy, Horticulture, and Natural Resources for students majoring in any of those departments; the course is taught as the "ecology of food systems" (Francis et al., 2003). A summer travel course, *Agroecosystems Analysis,* is offered in collaboration with Iowa State University and University of Minnesota, and involves ten farm visits and student teams evaluating those farms based on production, economic, environmental, and social criteria (Rickerl and Francis, 2004; Wiedenhoeft, 2003). A new Agroecology option within the Agronomy major allows students to take more systems-oriented courses in a broader array of supporting departments compared to a traditional crop production or soils course of study.

Criticisms of the Alternative Approach

A frequent criticism of the Agroecology and systems approach is a potential danger that we will educate students who feel that they know everything, just because they have an overview in many subjects. If they never come into a situation where they really dig deeply into a subject, they can lack humility about the importance of deep knowledge, about research, and about the research process. The argument is that this could easily create a teaching approach that educates students with a broad but shallow knowledge of very much, but no respect and deep knowledge in any subject. Such an approach could then create candidates who never ask questions, but always think they have the answers, and graduates who are unable to delve into the detail needed to solve complex issues.

Such a scenario is based on a misunderstanding that deep knowledge is the same as the disciplinary theoretical subject knowledge, and we argue that deep knowledge is the meaningful engagement with the phenomenon. When we make real life situations the foundation for the education, we place reality in focus, with priority over textbook subjects. Such real situations will also further the integration of different disciplines. To solve real problems, it is necessary to have a multi-faceted approach to problems, recognizing that they cannot be solved by one discipline, but through interdisciplinary activity.

We argue that the concept of just in time education is related to both (1) WHEN the different things should happen and (2) HOW they should happen, compared to a conventional educational focus on WHAT happens. The WHEN suggests that context in time is important to understand biological phenomena, and that sequential events are critical to natural functions such as nutrient cycles, as well as when and for how long these cycles are important in the overall process. The HOW implies a shift from deductive learning, where theory comes first and then real life situations are used to exemplify the theory, to inductive learning, where the real life situation (the phenomenon) is the starting point for the learning process (experiential learning). Our personal experiences are that the more we learn across disciplines, the more humble we become in appreciating the depth of knowledge that is available. We can help our students strive to achieve the level of knowledge they need in each area, and guide them through the process of accessing information so they can apply this skill in the future.

Conclusions

From long experience in agricultural science education, we conclude that new approaches are needed that can personalize the curriculum for each student and provide topics and in-depth experiences at the phase in education when students are ready. Such *just in time education* will depend on individual student academic preparation and experiences, and will be grounded in practical field situations to provide the relevant context for problem solving. Standardized curricula that always begin with basic sciences and often are devoid of context fail to prepare students to face situations of uncertainty and complexity where information will be applied.

Providing opportunity for flexible schedules and varied courses at different times in students' study plans can better meet individual needs. An education with focus on agricultural and food systems prepares graduates to work in a systems context in a broad range of careers, while sacrificing to some extent the specialization that comes from a narrow, disciplinary focus. We believe that education to prepare students for a major contribution to future food systems will require general preparation, and that to be most valuable such education must be just in time, when students are ready and have a real world context for the concepts and information. As instructors and curriculum planners, we are responsible for providing our students with such an opportunity.

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