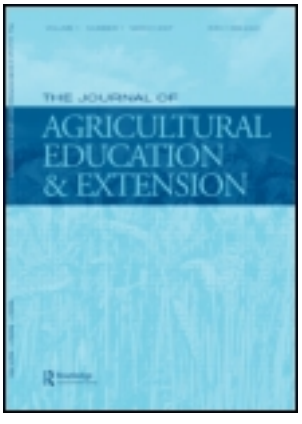

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Interdisciplinarity and education: towards principles of pedagogical practice

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Disciplines play a major role in agricultural education and extension. Biology, chemistry and physics are all essential to understand nature and to improve the quality of agricultural production. During the past centuries, disciplines have evolved, and a multitude of specialisations emerged, like cell biology, colloid chemistry and geophysics. The development of specialisations went so far that we can speak of overspecialisation in areas, the problem of which is that there is too little communication and cooperation between subspecialisations.

Students at various levels are being introduced to disciplines in education. Primary school pupils learn reading, writing and arithmetic to name a group of core elementary education fields which are disciplinary of nature. In secondary education students learn the essentials of languages, mathematics, physics, chemistry, biology, geography, history, economy and social science. And in higher education students are being introduced to a discipline or profession, and in later stages in their programmes to specialisations. At PhD level many students work on a highly specialised topic of research.

However, reality is not divided in disciplines and super-specialisations. If we want to understand dairy-farm performance, for instance, we need notions of economics, sociology, communication science, marketing theory and competence science. If farmers need to decide about entering the global market, they need knowledge about international food markets, chains and networks, foreign trade regulations, quality requirements and intercultural negotiation processes. If extension workers want to give advice about a certain production method, they need knowledge about their target group and their level of professional development, the business model in use, property rights, production technology, and learning methods. Reality presents itself as interdisciplinary in nature, and being able to solve problems or to realise intentions always calls for an interdisciplinary approach.

Even disciplines are not all purely disciplinary. Physics includes a fair portion of mathematics. The borders between chemistry, biology and physics are also quite blurry in certain fields. This is even stronger in social, behavioural and applied sciences like psychology, sociology and education sciences. To understand human behaviour, it is necessary to understand also the basic laws of economics, although it is evident that economics does not fully rule human decision making. When trying to explain social processes in society, it is also essential to understand the historical

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side of these processes. And when planning of educational change is at stake, knowledge is needed about educational philosophy, management studies, public administration, curriculum studies, teacher professional development, learning and instruction, implementation studies and educational testing. The definition itself is already a bit awkward. Webster's dictionary gives the following definition of discipline: '1. Punishment; 2. Instruction; 3. A field of study; 4. Training that corrects, molds, or perfects the mental faculties of moral character; 5a. A control gained by enforcing obedience or order; 5b. Orderly or prescribed conduct or pattern of behaviour; 5c. Self-control; 6. A rule or system of rules governing conduct or activity.' Examples given are, amongst others:

> The teacher has a hard time maintaining discipline in the classroom. The troops were praised for their dedication and discipline. Some parents feel that the school's principal has been too harsh in meting out discipline. Keeping a journal is a good discipline for a writer. Sir Robert Peel is credited with creating the first modern police force, the bobbies, in London, in 1829, but the transformation of law enforcement, and especially forensic science, into a professional discipline was a haphazard affair.

Discipline as will be clear is strongly associated with power and control. Where does this leave personal autonomy, creativity, innovation, independent thinking and transformation? Scientific breakthroughs in the field of cancer treatment, medical imaging, electro-active polymer actuation and neurosciences would never happen in strictly disciplinary doctrines. So, instead of speaking of interdisciplinarity, we should in fact speak about trans-disciplinarity, as if we would move beyond the repressing and controlling functions of disciplines and interdisciplines.

For agricultural education and extension or, more generally speaking, for life and social sciences to be relevant for innovation and transformation, interdisciplinary education is absolutely essential. Agricultural education and extension are interdisciplinary by nature. Both have a strongly applied character and, as said, practical problems, challenges and goals exist regardless of disciplines or interdisciplines. Disciplines are the scientific lenses through which phenomena are being studied.

However logical this all may sound, it is surprising that the pedagogy of interdisciplinary education is underdeveloped. For practically all disciplines a field of pedagogical content knowledge exists. Germans call this field *Fachdidaktik*, which neatly expresses what it is: the knowledge about the way in which teaching and learning can be realised in given subject-matter fields, such as physics, mathematics or chemistry. There is a host of journals in pedagogical content knowledge fields, such as the *Journal of Chemical Education*, the *Journal of Research in Science Teaching*, *Physical Review: Physics Education Research*, *Physics Education*, *Physics Teacher* and *Research in Science Education*. In Germany, where *Fachdidaktik* (or Pedagogical Content Knowledge, PCK) fields are quite strong, there are even chairs, like in the PCK of Agriculture and Horticulture sciences. For a university as Wageningen University this would imply that there would be chairs in Food Science PCK, Health Science PCK, Horticulture Science PCK, Animal Science PCK, Environmental PCK, and Social Science PCK.

The existence of (more or less strong) fields of PCK is related to the existence of teacher-education programmes. Teacher education is related to the subjects in education, which are derived from the related academic disciplines. There are transversal themes in teacher education such as youth psychology, motivation theory, class management, and general learning and instruction methods, etc., but the introduction of future teachers to the teaching of their subjects is more meaningful for them if educational theory is illustrated based on examples in these subjects. For instance, a mathematics student will understand and appreciate teaching and learning principles better if these are explained within the context of mathematics teaching. Unless sufficient attention is being paid to the interdisciplinary nature of reality, and the value of interdisciplinary education, teaching education along the traditional lines of PCK leads to compartmentalisation and tunnel views, hampering subject-transcending thinking.

Given the importance of interdisciplinary education, it is absolutely necessary to develop an interdisciplinary field of PCK. This can best be taught to future teachers by introducing them to different fields that are included in solving practical problems, or trying to attain certain goals.

Within Wageningen University, interdisciplinary education is practised in various ways. The most prominent course in which this is practised is a course named Academic Consultancy Training. This course consists of 12 European Credits (1 credit equals 28 hours of student workload), which includes 3 credits of Modular Skills Training. In the course, students from different disciplines work together in groups on a project, which is (in most cases) commissioned by an external organisation (a company, institution, or NGO, for instance). The groups need to solve a problem from different scientific perspectives by using the expertise from their own study programmes or from other disciplines. Examples of recent projects are: 'Finding and reaching the market for an innovative sub-surface land surveying technique'; 'Making greenhouse tomato production in Georgia feasible and environmentally friendly'; 'Ecologically sound weed management for Petro chemical facilities'; 'Exploiting marine plastic litter'; and 'A business model based on water, solar energy and algae'. Students choose two Modular Skills Courses (of 1.5 European Credits each) from the following list: Skills Assessment, Information Literacy, Speaking with Confidence, Negotiation Skills, Intercultural Communication Skills, Argumentation Skills, Scientific Writing Skills, Advanced Presentation Skills, Intuitive Intelligence, Career Development and Planning, Train the Trainer, Entrepreneurial Skills, Consultancy Skills, Management Skills, and Integral Leadership for Sustainability.

But also in the different Bachelor and Master programmes there are interesting examples of interdisciplinary education. In fact, many MSc programmes are interdisciplinary as such, like 'Agricultural and Bioresources Engineering', 'Aquaculture and Marine Resource Management', 'Bioinformatics and Biotechnology', 'Food Quality Management', 'Leisure, Tourism and Environment', and 'Urban Environmental Management', to name a few. But also programmes without explicit interdisciplinary names such as the BSc-programmes 'Animal Sciences' and 'Plant Sciences', are interdisciplinary. They include courses from varying disciplines. For instance, the BSc-programme 'Animal Sciences' includes courses in chemistry, physics, mathematics, environmental sciences, ecology, geo-information science, hydrology, etc. The BSc-programme 'Plant Sciences' includes courses like chemistry, cell biology,

genetics and molecular biology, agroecology, mathematics, and business economics, management and marketing. However, integrating these courses in one body of knowledge is largely the responsibility of the student.

Interesting examples of interdisciplinary courses within certain study programmes are 'Food Quality Management', 'Food Law' and 'Food Ethics' in the MSc programme 'Food Quality Management', and the courses 'Food Safety Economics' and 'Food Safety Management' in the MSc programme 'Food Safety'.

The dynamics at the curriculum and course levels are quite different. At the curriculum level the dynamics are created by the forces of the work field (which articulate the societal demands for graduate attributes), the advancement of sciences (which provides new insights that need to be integrated in the curriculum), the developments in politics and administration (which leads to new rules in education), and the power of departments (which want at least to maintain their position or rather enlarge their share in the curriculum). At the course level teachers are struggling to combine the different perspectives of the science fields that are being combined to illuminate problems, processes and challenges. These struggles involve defining the right intended learning outcomes, selecting the adequate learning material, developing the most effective learning tasks in which students preferably cooperate, constructing appropriate final assignments including papers and tests, and arranging valid and reliable grading practices. There are many intrinsic issues at stake here, such as teachers from different fields who concentrate on their specific contributions to the course (leaving the integration of all perspectives to the integrity of the students), who withdraw from professional conversations if their specific specialisation is not involved, and who employ skewed standards of assessment of student work between their specialisations (stricter standards) and other disciplines (looser standards).

In a situation in which there are no or hardly any guidelines for implementing interdisciplinary education beyond the generic recommendations of educational research (on teacher professional development, curriculum consistency and alignment, instructional design and development, and the measurement of educational achievement), how can we make progress with the creation of a PCK for interdisciplinary education?

The first thing is to define interdisciplinary thinking. For, if we cannot define that, recommendations and measures for the implementation of interdisciplinary education can never be made. Attempts to explore and elaborate on pedagogical measures for the advancement of interdisciplinary education without an operational definition of what these measures try to evoke, are doomed to fail.

As a first attempt, the following operationalisation of interdisciplinary thinking is proposed:

(1) Knowing that knowledge from other disciplines is necessary in one's problem context;
(2) Understanding and appreciating the content of relevant units of other disciplines;
(3) Being interested in applying insights, knowledge and skills from other disciplines, and being able to do so;
(4) Integrating interdisciplinary approaches of thinking and acting in one's own professional acting repertoire;

(5) Being able and motivated to manage processes of interdisciplinary design, consulting and problem solving;
(6) Being able to show leadership in developing, innovating or transforming interdisciplinary thinking and acting.

These six characteristics of interdisciplinary thinking can serve as a foundation of a taxonomy of educational objects in the field of interdisciplinary education. Level 1 is the most basic level, level 6 the most advanced.

Regarding the implementation of interdisciplinary education, the following principles can be used.

- Convey the interdisciplinary education philosophy at all levels (institution, curriculum, course, learning assignments) were appropriate in a clear, coherent and transparent way. It is important that learners understand the reasons as to why an institution, a programme or a course embraces interdisciplinarity. Therefore:
- Provide clear examples in science and society of the necessity and added value of interdisciplinary thinking and acting.
- Assess the tendency of students to orient themselves towards other science fields. Some are passionate about their own field of science, whereas others are more interested in making creative combinations with other science fields.
- Introduce ways of knowing and fundamental concepts of foreign fields. This helps students to understand the (potential) contributions of other science fields.
- Take care of the right timing of introducing specific knowledge during courses. It is ineffective if knowledge from other science fields is introduced when learners are not able to understand the added value of that knowledge. Also, if that knowledge comes too late, it is ineffective.
- Arrange assessment procedures and set grading rules that accommodate the scientific backgrounds of different teachers. For instance, when an expert in chemical technology has to assess student work in social science which includes elements of the field of chemistry, this teacher may judge the way in which the chemical part in the student work is treated much more severely than a teacher from social science. This interdisciplinary standardization of judgement norms is something that deserves a great deal of attention.

There are also some recommendations at education management level.

- When programmes are made interdisciplinary, they have to overcome the perennial antagonism between specialisations. It is often the case that the closer the specialisations are, the greater the tension is between them. Maintaining this culture is detrimental to implementing sound interdisciplinary education, as it would betray students by saying that interdisciplinary cooperation is needed and by acting in a way that shows that actually centrifugal forces are in place.
- The development and implementation of interdisciplinary education takes time and energy. Additional facilities for course development, teacher interaction and grading of student work are needed to make it happen.

- The easy way out of the implementation of interdisciplinary education is the dispersion of teaching tasks according to the specialisations of the lecturers involved, without arranging interaction with lecturers from the different disciplines. This dispersive teaching model needs to be replaced by a concentrated teaching model, which should be based on interdisciplinary research collaboration.
- Interdisciplinary education, just like interdisciplinary research and publishing, requires more effort of the professionals involved. Institutions often preach interdisciplinarity, but the reality is that many evaluation and reward systems favour monodisciplinary approaches. Institutions that are serious about moving ahead with interdisciplinary education have to implement accompanying reward schemes for departmental, group and individual contributions.

As said, the quality of interdisciplinary education depends to a large extent on the use of general theories and principles of educational design and implementation. There are many of these theories, methods and activities recommended to improve the quality of education. However, the principles and recommendations given above are specifically aimed at the introduction and support of interdisciplinarity in education. It is an educational innovation that—like others—requires ample attention, specific dedication, an experienced need and sufficient resources, without which it will never happen.