INTERDISCIPLINARY THINKING IN AGRICULTURAL AND LIFE SCIENCES HIGHER EDUCATION

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SUMMARY

Interdisciplinary thinking as a skill appears to be of value to higher education students and those in employment. This idea is explored with reference to the agricultural and life sciences. The need for further understanding of the development of interdisciplinary thinking is acknowledged. This is closely related to the requirement for well-founded curriculum and course design. This publication presents a brief introduction to a systematic review of scientific research into teaching and learning in interdisciplinary higher education. While tentative, the understanding arising from the review findings is considered to be of potential value to educational practice. A selection of the review findings is presented by way of illustration. The selection is believed to be of relevance to the agricultural and life sciences. The review findings presented here take the form of interdisciplinary thinking subskills and enabling conditions.

Key words Interdisciplinary thinking, interdisciplinary higher education, agricultural and life sciences

INTRODUCTION

Interdisciplinary thinking can be defined as 'The capacity to integrate knowledge and modes of thinking in two or more disciplines or established areas of expertise to produce a cognitive advancement – such as explaining a phenomenon, solving a problem, or creating a product – in ways that would have been impossible or unlikely through single disciplinary means' (Boix Mansilla, Miller, & Gardner, 2000). Interdisciplinary thinking can be considered as a complex cognitive skill that constitutes a number of subskills (Van Merriënboer, 1997). Subskills are, for instance, the ability to change disciplinary perspectives and to create meaningful connections across disciplines. Two kinds of interdisciplinary thinking can be distinguished: narrow and broad (Newell, 2007). Narrow includes integration of knowledge of disciplines *within* a particular science. Broad includes integration *across* sciences, like natural and social sciences.

Traditionally, higher education has focused on domain-specific knowledge and general skills development. The ultimate goal of interdisciplinary higher education is to enable undergraduate and graduate students to become capable of integrating knowledge of different disciplines. Today, it is appropriate for students to experience interdisciplinary higher education and learn the subskills it has to offer such as the ability to tolerate ambiguity and those described above (Franks, et al., 2007; Newell, 2009). It is believed that these skills enable students to become capable of dealing with complex issues that arise in both scientific and professional environments (Jacobson & Wilensky, 2006). The integration of disciplinary knowledge is typical of interdisciplinarity; multidisciplinarity refers to the *addition* of disciplinary knowledge whereas interdisciplinarity refers to the *integration* or *synthesis* of disciplinary knowledge (Klein, 1990).

In view of workplace needs and the increasing interdisciplinarity of the research activity itself, it is advocated that interdisciplinarity be developed within the agricultural and life sciences (e.g., Ewel, 2001; Innes, 2005). Often named 'Bèta-Gamma integration', broad interdisciplinary thinking is frequently advocated in the agricultural and life sciences (e.g., Lund, Coleman, Gunnarsson, Calvert Appleby, & Karkinen, 2006; Luning & Marcelis, 2006). An illustration of the value of interdisciplinary thinking to food sciences is provided by the following student exercises. In a narrow interdisciplinary thinking exercise, students are required to integrate their knowledge of food microbiology and food processing to keep bacterial growth within food safety criteria. In a broad interdisciplinary thinking exercise, students are challenged to integrate their knowledge of sciences such as food processing and microbiology as well as social sciences, such as management and psychology, to realise safe food production that excludes contamination by employees (Luning & Marcelis, 2009b).

Numerous reports of interdisciplinary higher education in the agricultural and life sciences can be found in the literature (Jaykus & Ward, 1999; Parr & Van Horn, 2006; Vedeld &

Krogh, 2005; Warren, 2006; Zarin, Kainer, Putz, Schmink, & Jacobson, 2003). The reports tend to focus on organisational aspects or learning content. Less is said about the pedagogy required to achieve interdisciplinary thinking. Recent research in interdisciplinary higher education (Holley, 2009; Misra, et al., 2009) demonstrates the difficulties of providing a curriculum that enables students to master interdisciplinary thinking. Similarly, the need for greater understanding of curriculum and course design in interdisciplinary higher education is recognised (Stefani, 2009; Yang, 2009). After all, a pedagogically underpinned method does not yet exist. This implies that questions such as the following remain to be researched: (a) What is the evidential outcome of interdisciplinary thinking? (b) How can interdisciplinary thinking be achieved? and (c) What teaching and learning methods for developing interdisciplinary thinking are required? To provide a platform from which to move forward, Spelt et al., (2009) reviewed the scientific research into teaching and learning in interdisciplinary higher education.

METHOD

The objectives of the review were to systematically identify, critically analyse, and discuss scientific research on teaching and learning in interdisciplinary higher education. This was done by using the general teaching and learning theory of Biggs (2003) as a frame of reference. The theory approaches teaching and learning as an interacting system consisting of four components: *student*, *learning environment*, *learning process* and *learning outcomes*. The theory embodies the alignment principle, which means that teaching and learning methods are aligned with the desired learning outcomes. This supports an outcome-based approach to teaching and learning in higher education. An in-depth description about the review method can be found in Spelt et al., (2009).

RESULTS AND DISCUSSION

The systematic review of teaching and learning in interdisciplinary higher education yielded a tentative understanding of the development of interdisciplinary thinking (Spelt, et al., 2009). The tentative understanding relates to subskills and conditions. Subskills constituting the component interdisciplinary thinking were identified. In addition, for the components student, learning environment and learning process, enabling conditions for developing interdisciplinary thinking were identified.

The identified subskills (5) and conditions (26) should be considered as tentative. Nonetheless, the theoretical understanding gained seems to be of potential value to educational practice. The identified subskills and conditions may facilitate practitioners in agricultural and life sciences higher education in designing courses and curricula on interdisciplinary thinking. The total of 31 identified subskills and conditions provide rich material. Presented here in Figure 1, by way of illustration, are just eight of the identified subskills (2) and conditions (6). The selection reflects the first author's preliminary exploration in agricultural and life sciences higher education. The exploration centred on three curricula whose aim is to develop broad interdisciplinary thinking. Each curriculum is delivered at a different Dutch university. The exploration took the form of classroom observations and discussions with teachers and students.

For the component *interdisciplinary thinking* (Figure 1), the subskill of 'knowledge of disciplinary paradigms' indicates the importance of widening the focus on disciplinary knowledge to include the characteristics of the disciplines involved, such as their theoretical and methodological assumptions. This type of knowledge may support students to step beyond the disciplinary theories and methods on a meta-level (Boix Mansilla & Duraising, 2007). The meta-level may facilitate students to make connections between disciplines, to identify disciplinary contradictions, and to consider opportunities for integration. In addition, the subskill 'communication skills' indicates the need to pay attention to the language of discourse of different disciplines (Manathunga, Lant, & Mellick, 2006; Woods, 2007). This will facilitate students to negotiate meaning, resolve epistemological differences, develop shared understanding, and communicate cognitive advancements to a broad audience.

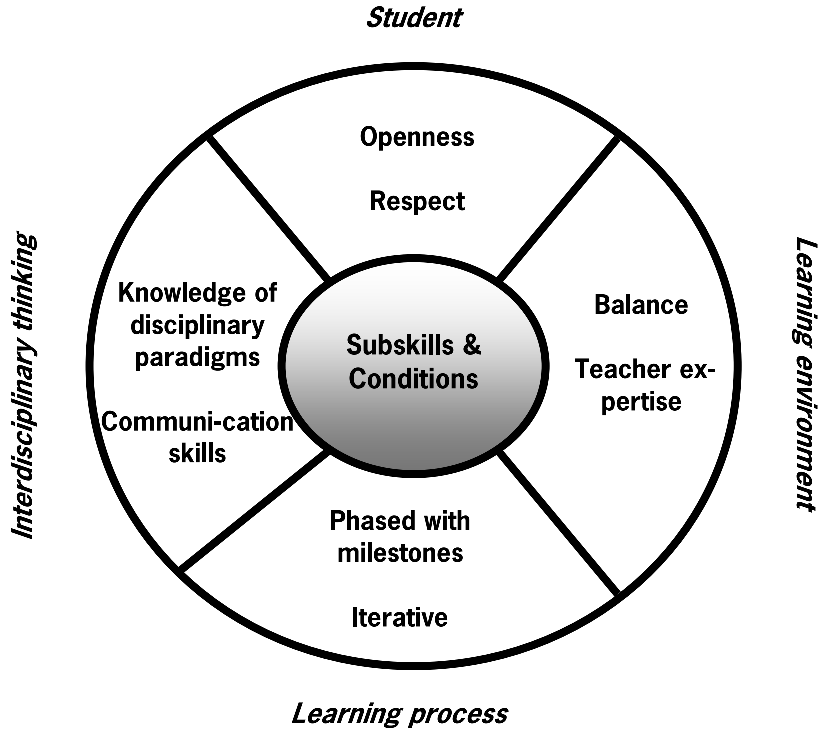

Figure 1: Examples of tentative subskills and conditions for interdisciplinary thinking development, based on Spelt et al., (2009).

In Figure 1 with respect to the component *student*, the tentative conditions 'openness' and 'respect' are presented. The conditions point to the necessity of developing the student's appreciation of other disciplines (Bruce, Lyall, Tait, & Williams, 2004). Student attitudes towards other disciplines appear to show wide variation (Woods, 2007).

For the component *learning environment* (Figure 1), the condition of 'balance' between disciplinarity and interdisciplinarity, which gives rise to an overarching framework, seems to be an essential focus (Newell, 1992). Such a framework links and sequences curricular and course content to provide context and a roadmap for learning interdisciplinary thinking. In addition, the condition of 'teacher expertise' points to the need for teachers' professional development to include interdisciplinarity (Gilkey & Earp, 2006; Graybill, et al., 2006; Newell, 1992). Such professional development would seem, for instance, to be beneficial to teacher teams; facilitating the necessary understanding and integration of one other's disciplines. Additionally, it enables teachers to realise a safe environment in which to mentor students on their journey towards interdisciplinarity.

In Figure 1 with regard to the component *learning process*, the tentative conditions 'phased with milestones' and 'iterative' are shown. The conditions refer to the need for a phased learning process with predetermined learning outcomes (Graybill, et al., 2006; Ivanitskaya, Clark, Montgomery, & Primeau, 2002; Manathunga, et al., 2006; Woods, 2007). The predetermined learning outcomes serve as milestones for each phase in which students are exposed repeatedly to interdisciplinary thinking.

CONCLUSION AND FURTHER RESEARCH

The need for greater understanding of the pedagogy underpinning the development of interdisciplinary thinking is recognised. The systematic review presented above identifies subskills of interdisciplinary thinking as well as enabling conditions. Some of these are presented by way of illustration. The example subskills described above are: knowledge of disciplinary paradigms and communications skills. The example conditions described are: openness, respect, balance, teacher expertise, phased with milestones and iterative. It may be fruitful to recognise these subskills and enabling conditions when organising the teaching and learning of interdisciplinary thinking.

Further research should examine whether empirical evidence can be found for the identified subskills and conditions (Spelt, et al., 2009). Empirical research is required to test the hypothesised value of the tentative understanding to educational practice in agricultural and life sciences higher education. Thereafter, it is proposed that the full range of subskills and conditions thus validated be used to analyse courses and curricula on interdisciplinary thinking. It would be beneficial to use such analysis as the starting point for techniques and guidelines for fostering the development of interdisciplinary thinking.

The tentative understanding of the development of interdisciplinary thinking gained from the review is already being tried out in practice. It is being applied in the analysis of interdisciplinary higher education in the agricultural and life sciences. The curriculum in question is the MSc Food Quality Management at Wageningen University in the Netherlands. The curriculum and the research involved (e.g., Luning & Marcelis, 2009a) exemplify the development of Bèta-Gamma integration among students and researchers in the field of food quality management.

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