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The emergence of interdisciplinary knowledge in problem-focused research

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In this paper I explore the specific properties associated with the new knowledge produced by inter- or transdisciplinary research. Using my analysis of a land use planning study in the Meuse valley in The Netherlands, I argue that the process of knowledge integration requires the exercise of value judgement and that the outcomes are emergent. I also show that the selection of a boundary object as objective facilitates interdisciplinary research because it is shared amongst disciplines and because it necessitates judgement in its implementation.

Key words: *interdisciplinarity, boundary object, emergence, landscape quality, land use planning*

Introduction

The rationale for adopting an interdisciplinary approach has been discussed at length in scientific literature and policy documents. Taking a broad view across the different existing definitions, it can be summarised as the existence of multiple perspectives and the relevance of multiple disciplines, each of which have to be acknowledged if results are to be acceptable both academically and politically (I will elaborate on definitions below). While scholars have reported extensively on the specific properties of processes and methodologies of interdisciplinarity and its close cousin transdisciplinarity (e.g. Klein 1990 1996 2003; *Futures* 2004; Wickson *et al*. 2006), scant attention has so far been paid to the specific characteristics of the contents of inter- and transdisciplinary research. In this paper I want to explore what specific properties are associated with the new knowledge resulting from interdisciplinary research. This enables me tentatively to formulate some implications of the findings for interdisciplinary practices. A flood management study in the Meuse river valley in The Netherlands is my case study. This is an example of a regional land use planning project, where knowledge from different sources had to be somehow combined into an interdisciplinary result. As if this is not difficult enough already, this task had to be fulfilled in a societal context where there was no agreement on the merits of the present landscape or on overall future goals. While one case study can only produce tentative conclusions, the associations with earlier philosophical work suggests that they are likely also to apply to other instances of inter- or transdisciplinary knowledge production. Before describing the case study, in the next section I discuss my understanding of the particularities of interdisciplinarity. I will be using the terms 'interdisciplinarity', 'interdisciplinary research' and 'interdisciplinary knowledge production' interchangeably in this paper. The last version is most precise, most inclusive and therefore preferable, but for easier reading I often use the shorter versions in the understanding that I mean interdisciplinary knowledge production.

Interdisciplinary knowledge production

There are many different interpretations and definitions of interdisciplinarity and its close cousins, multi- and transdisciplinarity. Overviews are given

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Table 1 Interdisciplinary research classified

		Intellectual purposes addressed	
		University context (endogenous)	Social context (exogenous)
Definition of interdisciplinarity	New perspective	**1**	**2**
	New knowledge	**3**	**4**

Note: For an explanation of the numbers see text
Source: after Aram (2004)

amongst others by Klein (1990 1996), Paxton (1996), Weingart (2000) and Aram (2004). Although it is not the purpose of this paper to give a comprehensive overview of existing definitions and/or to discuss their merits, I need an elucidation of the attributes commonly associated with interdisciplinary research in order to clarify the issues related to the contents of interdisciplinary knowledge production, which is what I am interested in here. Aram (2004) proposes a useful systematisation of different concepts of interdisciplinarity using two attributes, which he deduced from existing literature and interviews with scholars responsible for interdisciplinary courses in academia. However, the two attributes also feature in the literature mentioned above and each of the definitions given there can be assigned to one of the four squares: the usefulness of this classification goes beyond the empirical material it was deduced from. I will discuss this further below. Aram (2004) distinguishes, first, the degree in which knowledge from different disciplines is integrated, and, second, the intended public of the research. Aram classifies the degree of integration into two groups: where new ways of producing knowledge are explored, and where, less radically, new perspectives are exchanged across disciplinary boundaries. This is the vertical axis in Table 1. The horizontal axis in Table 1 is the intended public: is it aimed at an academic audience or does it purport to solve a societal problem? Following Klein (1996), he labels these purposes endogenous and exogenous respectively.

Combining the two attributes yields four categories of interdisciplinary research (Table 1). In box 1, the aim of the research is to introduce new perspectives into each other's research in order to produce academic knowledge. In box 2, perspectives are exchanged in order to produce knowledge in a societal context. In box 3, the aim is to produce new knowledge in an academic context, and in box 4 the new knowledge serves a societal purpose.

Whether the four varieties of research should all be named 'interdisciplinary' is subject to debate, for not every scholar would call these four types of research interdisciplinary. The introduction of new perspectives (boxes 1 and 3) is often named multidisciplinary research, while striving to fulfil societal objectives (boxes 2 and 4) is often called transdisciplinarity to indicate that the research transcends academia to enter society (e.g. Weingart 2000; Balsiger 2004; Lawrence and Deprés 2004). Another interpretation of transdisciplinarity requires a transcendence of disciplinary boundaries within academia by employing new strategies for the construction of knowledge. Haberli *et al.* (2001) define transdisciplinarity as 'a new form of learning and problem-solving', and Klein describes transdisciplinary approaches as

> comprehensive frameworks that transcend the narrow scope of disciplinary worldviews through an overarching synthesis . . . a new mode of knowledge production that fosters a synthetic reconfiguration and re-contextualization of available knowledge. (2003, 4)

However, for other authors the transcendence of academic boundaries is the main characteristic of interdisciplinary knowledge production (Aram 2004). Obviously, there is disagreement amongst scholars on terminology. For the purpose of this paper it is not relevant which definition can or should be used. I am interested here in the construction of new knowledge by somehow integrating disciplinary knowledges (box 3 and 4), which is unrelated to the question whether this amounts to inter- or transdisciplinarity. I will use 'interdisciplinary' in this paper, although the case I describe can also be labelled 'transdisciplinary'.

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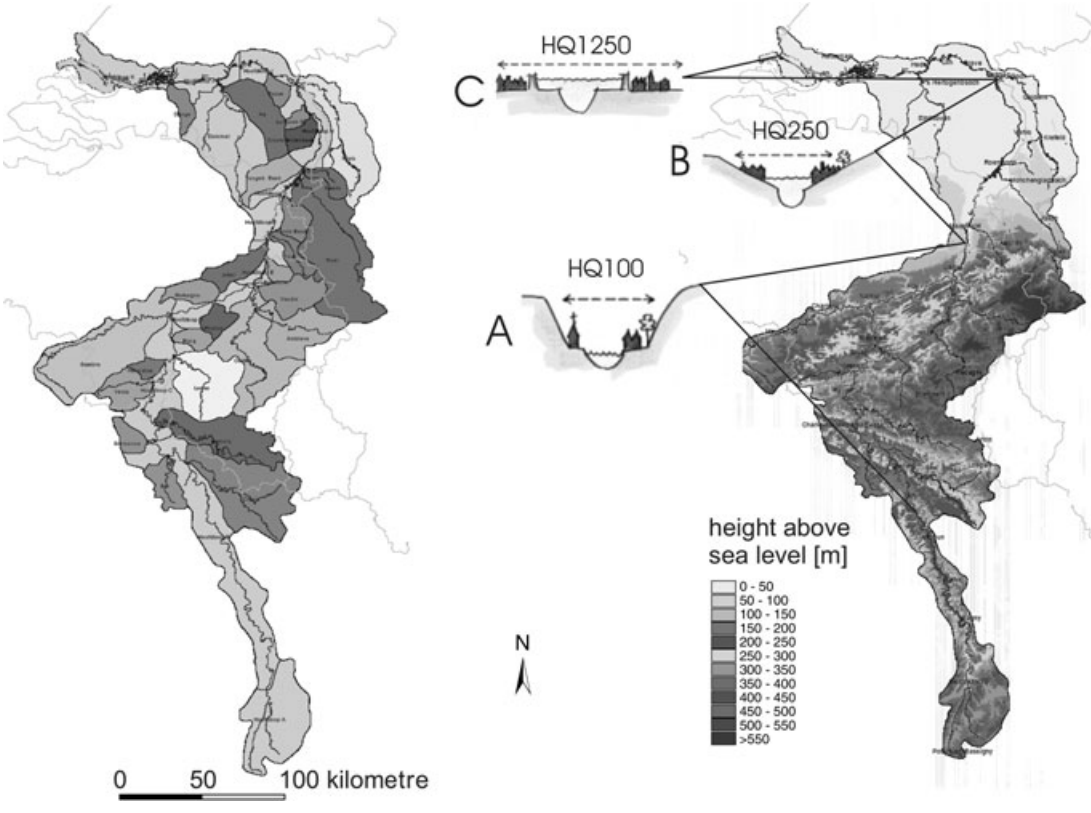


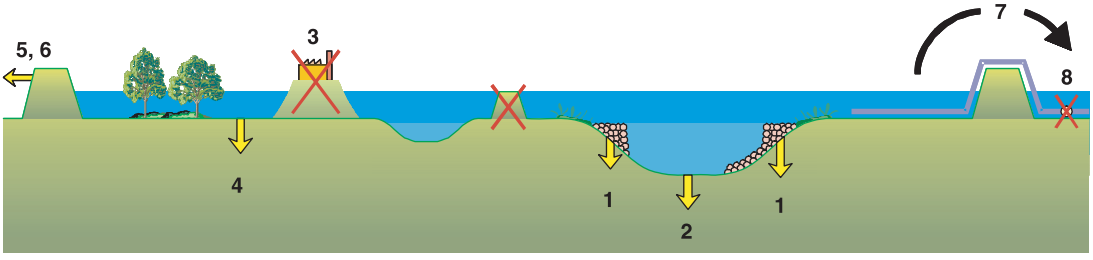
Figure 1 Catchment area of the River Meuse with tributaries, topography and typical cross sections. Return periods for flood defence design are indicated by 'HQ'
Source: Reuber *et al.* (2005)

The fact that these discussions are ongoing clearly means that scholars consider multi-, inter- or transdisciplinary research to be different from 'normal' disciplinary research. I do not want to pursue an inquiry into the nature of the disciplines here, nor do I want to elaborate on the character of disciplinary knowledge production (see e.g. Kuhn 1970; Klein 1990; Aram 2004; Turner 2000). I want to infer just the following: if inter- or transdisciplinary research is not 'normal' disciplinary research, then maybe the result is also not 'normal' knowledge. In this paper I want to tease out in what sense(s) the knowledge produced in inter- or transdisciplinary research is different from disciplinary knowledge. I shall do this through the case study of flood management in the Meuse river valley in The Netherlands described below.

The Meuse flood management study

The Netherlands is the most densely populated country in the European Community. The pressure on available space is correspondingly high and has been increasing with economic growth. Most of The Netherlands is protected from flooding by dikes along the major rivers – Rhine and Meuse – and by dunes along the North Sea coast. This system of flood protection has developed over the last millennium (e.g. Bijker 1993; TeBrake 2002) and there is little real prospect of changing it (Wesselink *et al.* 2007). An exception to this old system of protection is found in the southern part of the Meuse, where no dikes are present along the first 150 km (Figure 1).

In the second half of the 1990s, climate change predictions triggered the Ministry for Transport,



1 - lowering of groynes
2 - deepening low flow channel
3 - removing hydraulic obstacles
4 - lowering flood plains
5 - locally setting back dikes
6 - large-scale dike setback
7 - detention reservoir
8 - reduction lateral inflow

Figure 2 Room for the River measures: examples
Source: Ministerie van V&W (2003)

Public Works and Water Management to investigate how increased probabilities of flooding could be planned for. National policy aims to accommodate any increased discharge by spatial measures in the flood plain instead of dike enlargement, as the former is thought more robust. This principle was named 'Room for the River' (Bruijn and Klijn 2001; Reuss 2002). Suitable measures include retention reservoirs, parallel rivers, deepening or widening of the river bed and/or flood plain, removal of obstacles or relocation of dikes and levees (Figure 2). All of these require the reservation of land for flood protection measures, while a simple increase in dike heights hardly requires any extra space. Especially in the southern part of the Meuse valley, where inhabitants are accustomed to having no such restrictions on land use, this was proving difficult to swallow.

In this context of resistance, it was the task of the project 'Integrated Assessment of the river Meuse' (IVM) to propose a selection of politically acceptable flood management measures that would ensure the legal level of flood protection in future, when climate change would cause increased peak flows. The required space for the selected measures would have to be set aside and protected from future investments. This study followed a similar investigation for the Rhine and its branches (Kors 2004). Various ministries and administrative and political bodies were involved in the project. Through the discussions in the project group and the working groups, civil servants working for local and regional administrations were kept informed of, and to some extent contributed to, experts' investigations. The solutions that were investigated and the evaluation methods were mostly chosen by the experts involved in the project, but there was some degree of influence on substantive choices by local and regional public servants, and through them by the politicians. They were more closely involved in the detailed evaluation of measures.

At the start of the project in 2001 a total of 160 potential measures were identified on the 230 km stretch of the Dutch Meuse (Reuber *et al.* 2005). The hydraulic model showed that these measures together would more than compensate the expected water level rise and a selection would therefore have to be made. The two selection methods employed subsequently during the course of IVM illustrate multi- and interdisciplinary knowledge production respectively. In the first phase of the project factual studies into the effect of climate change on different land uses in the river valley were prepared (agriculture, housing, industry, recreation, ecology, river management). 'Wish lists' for future development were identified for each of the land uses. All individual measures were scored qualitatively for their effect on these functions. The project then set out to do a multi-criteria analysis using the information gathered. It would then have been possible to choose a set of measures that fulfilled the flood protection criterion and scored best on fulfilling individual ratings for land uses. If necessary, weights could be applied if one aspect was considered more important than another. However, the politicians felt that this approach did not do justice to the need to provide an integrated solution because they felt is was impossible to

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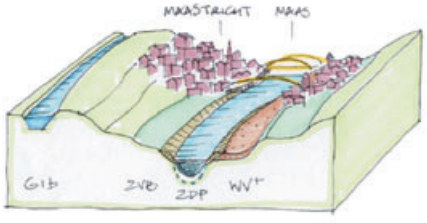
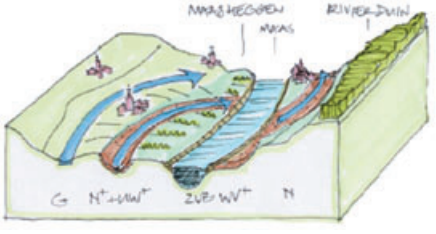
Upper Meuse



Vision: To develop a sustainable alliance between city and river. The need to interweave the increasing urbanisation and space for the river demands intelligent and creative solutions that provide the optimum of multiple land use and contribute to positioning Maastricht as a compact and complete city with a European cachet.

Meuse north of Venlo



Vision: The geomorphological underground indicates a slow sustainable development of the unspoilt countryside north of Venlo.

Figure 3 Characterisations of two of the eight river stretches using sketches and text
Source: Ministerie van V&W (2006)

compare the different entities in the multi-criteria analysis. Put differently, assembling information from different disciplines into a multi-criteria model did not yield an 'integrated assessment'.

The experts then proposed to look at landscape quality as a unifying concept that could be used to achieve integration. This became the second, interdisciplinary phase in the IVM project. While IVM was proceeding, the concept of landscape quality had become accepted in Dutch policy as an important objective for any spatial plan. The aim of IVM was therefore reformulated accordingly at the start of the second phase: 'to assess in which ways flood management objectives can be achieved . . . while maintaining or enhancing the quality of the landscape' (Ministerie van V&W 2006). This means there are now two objectives, flood management and landscape quality. However, these were not equally important since the primary objective is flood management. To assess the flood management objective a hydraulic model was used that showed whether the water level remained within the legal boundaries. The procedure to assess the landscape quality was not as clearly defined and experts set out to make this objective concrete. The starting point for the assessment was the information gathered in the first phase of IVM on land use functions and their preferences, which is of disciplinary character, but the result is an overall picture in which this information has been amalgamated into a vision for the future. To achieve this they applied the following method. They identified eight sections in the Meuse valley with distinctly different characteristics and produced pictures and a textual description of the spatial qualities of each of these sections. Two examples of the characterisations are shown in Figure 3. The text in Figure 3 is a summary of the comprehensive assessment for each river section. The full texts amount to several pages and provide a description of existing qualities and their potential for development, the socio-economical developments expected by 2050, challenges to be overcome, and criteria to be used for the assessment of potential changes. Together these descriptions and pictures constitute the landscape quality framework which would provide the boundaries and direction for future developments, including the flood management measures considered in IVM.

Parallel to the work on landscape quality, the technical and political feasibility of the proposed measures was examined in more detail before assessing their acceptability against the landscape quality framework. In the process many were rejected and many were reduced in size. It now appeared that all remaining measures were required to achieve the flood management target and no further selection was needed. For this reason the landscape quality framework was not used in the end to select measures. However, the fact that this was a politically as well as professionally acceptable evaluation framework presents important lessons for the way in which distinct knowledges can be integrated into a new whole. It also indicates how to provide results that are useful in a land use planning context where multiple interests are at stake and where people have different value systems. To explain why, I need to explore the character of landscape quality as interpreted in IVM.

The characteristics of interdisciplinary knowledge

The particular interpretation of landscape quality used in IVM was developed by Dutch landscape experts in interaction with water management professionals; both groups now consider it a useful concept for land use planning for water management (Musters *et al.* 2005). It is the result of nearly a decade of development and reflection, which swung between the extremes of an interpretation in which it was reduced to economic optimisation: 'landscape quality as an optimum allocation of land use functions' to a purely subjective enjoyment: 'landscape quality as a purely individual esthetical appreciation' (Musters *et al.* 2005). Guidelines for its implementation in a water management context have recently been published (Ministerie van V&W 2007). According to these guidelines, landscape quality includes, at least in the rhetoric, both reductionist and holistic elements. Landscape quality takes the multiple land use objectives as expressed by local, regional and national policies and politics into account. It also includes an assessment of the needs of primary functions of the river in the future, similar to the multicriteria table produced in the first phase of IVM. In addition to these reductionist elements, it appeals to a holistic esthetical imagination by asking users to sketch an ideal picture of the landscape, taking account of 'regional location specific characteristics, the assessment of which is partly subjective . . . to achieve quality in the whole' (Ministerie van V&W 2007, 58; my translation). Landscape quality is thereby both the objective and the result of land use planning for water management.

While this consensus on the application of landscape quality is a specifically Dutch development, it reflects the thinking about landscape as a combination of reductionist and holist elements more generally, expressed as a contrast between objective and subjective in this quote:

> The perspectives of more than half a century ago still affect the geographical treatment of landscape and endure in the ambiguity between objective and subjective attitudes towards landscape, while in late twentieth century geography, the subjective approaches are ascendant. (Muir 1998, 263)

This particular Dutch interpretation of landscape quality features two characteristics that allow different disciplinary knowledges to be synthesised into one result through subjective non-formalised choices: it acts as a boundary object and it is an emergent property.

Landscape quality as emergent property

While it was not their explicit intention to pursue interdisciplinary knowledge production, the experts in the Meuse case managed to produce a new kind of knowledge which integrated separate knowledges from different disciplines into a synthesising result. The experts started with disciplinary information about land use functions but used esthetical judgement of the landscape and political views on desirable future developments to arrive at one overall vision (a combination of pictures and text) labelled 'landscape quality'. The IVM landscape quality as described by the framework thereby presents an integration of different disciplinary inputs, but these are not recognisable any more. When combining the available information the experts integrated values into the mixture in order to produce 'a synthesis which is original, new, on a different level and enriching' (Hoppe 1983). This resulted in 'new knowledge' and the emergent property 'landscape quality'. This new knowledge is 'a synergy of the contributing parts [disciplinary knowledges] that are not visible any more' (Angyal 1939). It is therefore by definition an emergent property (Ablowitz 1939). The synthesis required the judgement of aesthetic values as well as the evaluation of relative importance of landscape functions.

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The Meuse case therefore suggests that interdisciplinary knowledge production implies the need for integration of facts and values into a new emergent property or synthesis. The emergence of new characteristics is a phenomenon associated with complex systems (Holland 1998). Both Klein (2000) and Harrison *et al.* (2006) argue that study of complex systems is inherently inter- or transdisciplinary because of the existence of multiple perspectives and the relevance of multiple disciplines, each with their own uncertainties. It appears then that the link between interdisciplinarity and emergence found in the Meuse case is not coincidental but related to the complexity of the situation under investigation. However, it is not my intention here to contribute to the debates about complexity; for a recent overview of different understandings see Harrison *et al.* (2006).

Integrating facts and values into new knowledge is a procedure not restricted to interdisciplinary knowledge production. Disciplinary knowledge is also a social construction in which views of 'reality' are susceptible to a variety of historical and cultural forces and 'truth' claims are interdependent with the nature and exercise of power (Knorr-Cetina and Mulkay 1983). Therefore, disciplinary knowledge production also involves the integration of values. In 'normal' disciplinary practice this process is subconsciously performed because it is part of a disciplinary training (or 'disciplining') to assimilate the prevailing values, then to forget this was done and to assume the knowledge produced is value-free (Knorr-Cetina and Mulkay 1983; Robinson 2008). However, there is no such prevalent set of values in interdisciplinary knowledge production, so a more deliberate additional round of value integration is necessary to produce interdisciplinary new knowledge. Interdisciplinary research can transcend disciplinary values and propose a context within which to manage them by choosing a boundary object as goal, as I will discuss next.

Landscape quality as negotiable boundary object

The second characteristic of landscape quality relevant to interdisciplinarity is its boundary object character. A boundary object is

> an analytic concept of those scientific objects which both inhabit several intersecting social worlds . . . and satisfy the informational requirements of each of them. . . . They are weakly structured in common use, and become strongly structured in individual-site use. . . . They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation. (Star and Griesemer 1989, 393)

This definition is not limited to physical objects, for '[t]hese objects may be abstract or concrete' (Star and Griesemer 1989, 393). A boundary object can be the starting point for interdisciplinary collaboration, when it is a still weakly structured objective of the research. As the researchers advance towards a concrete result, they are engaged in the process of making the boundary object strongly structured, as they specify its parameters for the concrete case they are working on.

The objective of IVM was unknowingly interpreted as a boundary object by the experts involved, still weakly structured when the project started but then all experts worked together to give it a more concrete meaning. Interestingly, in this particular case the description of landscape quality they produced (the landscape quality framework) is still not fully structured, albeit further defined than the original two-word objective. It is still 'sketchy', both as picture and as text, and needs to be further interpreted when applied to a particular space and time, for example if it is used to select flood measures. It will still be acting as a boundary object because it is not concrete enough yet for implementation on the ground. In this case the process of structuring the boundary object 'landscape quality' has two steps because the IVM project set out to produce a general assessment, not a plan for action.

Landscape quality speaks to the different social worlds of the various experts concerned with land use functions but also to politicians and public servants involved in the decisionmaking process. While the need for negotiation is apparent in a societal setting such as the Meuse case or land use planning in general, a boundary object also facilitates academic interdisciplinary knowledge production. If new knowledge is the purpose of endogenous interdisciplinary research, this is also likely to involve judgement of one kind or another. Where several people work together on one question, they will have to give priorities and value certain aspects higher than others. To be able to work together towards one purpose, the common objective will have to be sitting on the boundary between the disciplines, be shared by all contributors but specifically interpretable in each discipline. This is exactly the purpose of a boundary object as first described by Star and Griesemer (1989). This makes

boundary objects suitable objectives for interdisciplinary research in general, whether they are aimed at societal problem-solving or at academic knowledge production.

Boundary objects and emergence in policy contexts

Setting landscape quality as an objective for land use planning clearly presents a number of advantages. Most importantly, it leaves room for interpretation and adaptation to local circumstances. Much negotiation will be needed to arrive at a solution acceptable to stakeholders, experts and project initiators. Negotiation between actors is the way in which the translation between different social worlds and the structuring in individual-site use mentioned in the definition of boundary objects take place in the setting of projects such as IVM. It is also sufficiently appealing as a policy or project objective to motivate stakeholders to participate in its elaboration in the region where they live. In fact, the Dutch guidelines affirm that

> the plan should be a collective plan of landscape designers, politicians and inhabitants in the region. . . . It is important that the project initiators and the region should reach agreement about the appreciation of present and future qualities of the area as well as the desired design of a measure. (Ministerie van V&W 2007, 58)

Boundary objects are common in natural resource management. Policy objectives such as sustainability, safety, social justice, robustness or resilience can all act as boundary objects, provided they are not interpreted in a reductionist way. Molle shows that integrated water resource management can also be conceived as a boundary object because it is

> a concept that all parties will appropriate and use and also remodel by their own discourse and practice. As such it can be seen as a collective construct offering common ground to stakeholders willing to engage with other parties. (2008, 136)

Conversely, Turnhout *et al.* (2007) have shown that even a seemingly non-integrated concept like an ecological indicator often plays a role as boundary object in practical settings where the implementation of ecological goals has to be negotiated with stakeholders.

Both Collins and Ison (2007) and Robinson (2008) recently described 'integrated water management' as an emergent property of the local and context-specific outcome of integrated water management projects. I maintain that it is no coincidence that these policy objectives with boundary object character lead to emergent properties in implementation processes: their evaluation is not wholly objective and depends on particular circumstances, such as the meaning of boundary objects can only be made specific in relation to a particular site. Again, in some way or another, a value judgement has to be made to assess whether the objective has been achieved. It is this integration of values which is essential for the emergence of new properties and for making boundary objects concrete.

Boundary objects as objective in interdisciplinary research

The choice of a boundary object as shared objective can help considerably to fulfil interdisciplinarity's

> considerable potential to provide knowledge production that is problem-oriented, responsive and open to external knowledge producers, contextualized and systems-based, adaptable, consultative and socially robust. (Russell *et al.* 2008)

It should be clear from the previous discussion that exactly what objective can act as boundary objective depends on the context: seemingly well-defined objectives (ecological indicators) can still be made flexible, while a predetermined interpretation of sustainability could prevent its boundary object potential. A greater awareness of the fluidity of apparently well-defined concepts as well as the usefulness of not defining every concept at the start of interdisciplinary research projects should help to advance the potential of interdisciplinary research. However, it is not possible to give clear guidelines and rules as each of these interdisciplinary projects is unique and requires new creative solutions. This is exactly why awareness of general principles, such as boundary objects, is so important: this enables researchers to be more reflexive about their work.

The choice of a boundary object as shared objective does not guarantee success however, because this depends also on the researchers' ability to communicate across borders (Bracken and Oughton 2006; Jones and Macdonald 2007). After all, interdisciplinarity 'is a practice, not an institution, and the more flexible, adaptable and open it remains, the greater will be its contribution' (Russell *et al.* 2008). Explicit attention to value choices and their effect on

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uptake of results by the policy area is an essential ingredient in this reflexive exercise.

Even though the conclusion that interdisciplinary research is inherently normative sits uncomfortably with the dominant view of science as a value-free exercise, it is important to recognise this if interdisciplinary research is to fulfil its promise of helping to solve 'societal' problems. The risk of not doing so is to be rejected as a useful way of knowing, while it is in fact exactly this opportunity to include values that makes interdisciplinary research so suitable for solving 'societal' problems. This opportunity is greatly increased if the objective of research and policy is a boundary object, as this is a concept that sits on the boundary between different social worlds, each with their own values and interests. Choosing such a boundary object also increases the possibilities for achieving value-integration in results and emergent properties. The association of interdisciplinarity with boundary objects is a powerful one and should be exploited.

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Note

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