Unravelling design principles for open-ended problem solving through boundary crossing in higher professional education (0147)

Marieke Veltman, Hanno van Keulen, Joke Voogt
Windesheim University of applied sciences, The Netherlands

In contemporary society professionals are challenged by complex tasks and problems and a high degree of dynamics and boundary-crossing activities. They are expected to take the lead in solving open-ended problems in a context that has become complex in the past several decades (Koppenjan & Klijn, 2004).

Higher professional education (HPE) is called upon to be responsive to the needs of society and to place more emphasis on the knowledge, experience and skills suitable to working in open-ended and collaborative situations (Alford & O'Flynn, 2012; Head & Alford, 2015; Williams, 2012). However, according to the Dutch Advisory Council for Science and Technology Policy (AWTI), rapid changes in the required knowledge and skills make it difficult to accurately predict what qualities higher educated professionals need to possess in the future. AWTI stresses the need for a skills action plan*;* more emphasis on societal challenges; greater understanding and awareness of the role of skills in the field and to make skills an explicit part of HPE curricula (AWTI, 2013). A successful preparation of students to participate in the collaborative process of open-ended problem solving requires not only a better understanding of the nature of these problems, but also of the required skills and of the way the acquirement of these skills can be enhanced (Head & Alford, 2015). This implies that more knowledge about the design of learning interventions in HPE in the context of open-ended problem solving is needed.

Purpose of this study was to reveal design principles for collaborative open-ended problem solving in educational practices in higher professional education. In this study we examined curricula in HPE with examples of open-ended problem solving, drawn from engineering, agriculture, social work and business.

Awareness of the increasing complexity and open-endedness of societal problems began to take shape in the 1960s and the 1970s. Rittel & Webber introduced the term wicked problems (Rittel & Webber, 1973). Wicked problems are multidimensional and have the following characteristics (Roberts, 2000):

- There is no definitive statement of the problem and no agreement on what the problem is.
- The search for solutions is open-ended and generates conflict among stakeholders. They compete with one another to frame the problem in a way that directly connects their respective preferred solution and their preferred problem definition.
- The problem solving process is complex because of constantly changing constraints, such as resources.
- Changes in constraints are also generated by the fact that stakeholders “come and go, change their minds, fail to communicate, or otherwise change the rules by which the problem must be solved” (Conklin & Weil).

In our study we refer to these wicked problems as open-ended problems. They can be mapped in terms of (1) uncertainty in relation to risks, consequences of action and changing patterns, (2) complexity of elements, sub-systems and interdependencies and (3) divergence and fragmentation in viewpoints, values and strategic intentions (Head, 2008; Head & Alford, 2015). Open-endedness is the combination of these three dimensions:

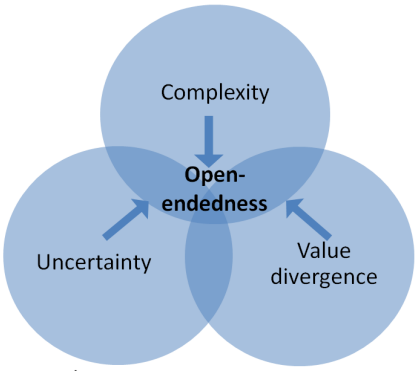

Figure 1 Dimensions of open-endedness

Despite this open-endedness it is possible to frame "partial, provisional courses of action" against open-ended problems (Head & Alford, 2015). In this context we think it is useful to explore the concept of boundary crossing (Engeström, 2014; Engeström, Engeström, & Kärkkäinen, 1995). Boundary crossing theory provides a positive perspective on boundaries by focussing on the possibilities for making connections between different practices of which the boundaries are perceived as problematic. A boundary can be seen as a socio-cultural difference leading to discontinuity in action or interaction (Akkerman & Bakker, 2011). To avoid fragmentation, professionals search for ways to connect and mobilize themselves across practices (Hermans & Hermans-Konopka, 2010). Boundary crossing refers to a person's transitions and interactions across different sites and to efforts to accomplish or restore continuity in action or interaction between practices (Akkerman & Bakker, 2011; Suchman, 1993).

All boundaries carry potential for learning. Akkerman & Bakker (2011) conducted a literature review in which they analysed the learning processes that can take place at boundaries. They identified four dialogical learning mechanisms: identification, coordination, reflection, and transformation. They show various ways in which socio-cultural differences and resulting discontinuities in action and interaction can become resources for development of intersecting identities and practices (Akkerman & Bakker, 2011, 2012).

We formulated the following research question to drive our research: which design principles lead to curricula that prepare students to successfully collaborate in open-ended problem solving through boundary crossing?

We studied curricula in higher professional education. The criteria for selecting curricula reflected the following aspects: the practice has (1) a clear focus on open-ended problem solving, (2) involves boundary crossing, (3) constitutes a substantial component of the curriculum of a degree programme or honours programme, (4) was developed between 2010 and 2015, and (5) still takes place. In order to guarantee sufficient breadth in sampling, we assured that the practices were diverse, with regard to the boundaries involved, the place in the curriculum, and the disciplines involved. Data were derived from literature and document study. For the data analysis we used a coding scheme based on the dimension of open-endedness of problems and the dimension of boundary crossing efforts.

The study provides an analytical framework and a conceptual lens for studying curricula aiming at open-ended problem solving. The study revealed and detailed several crucial principles for the design of practices that result in open-ended problem solving skills. The first set of principles imposes conditions on the nature of the problems. We conjecture that these problems should be complex, uncertain and value-divergent. The second set of principles concerns the enhancement of learning efforts for boundary crossing and imposes conditions such as students' involvement in multiple stakeholder collaborations.

The revealed design principles can support the design of HPE curricula aiming at open-ended problem solving skills. Future research should study the curriculum design process and examine the way in which these design principles are used by curriculum design teams and implemented in practice.

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