Development of a Pedagogical Design Matrix for ICT-based Boundary Crossing in Dual VET

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Abstract

Research on networked learning is concerned with finding new and productive ways of connecting people and their practice across boundaries in different contexts. Particularly in *dual* Vocational Education and Training (VET), there is a need to focus continuously on learning in and between boundaries of domains, practices and the school-workplace contexts. Information and Communications Technologies (ICTs) have been proposed as artefacts that enable mediation and bridge the gap between different boundaries.

In this paper, we present findings from a research project aimed at understanding Danish VET teachers' use of ICT as boundary objects in relation to boundary crossing activities. In the first phase of the research project, interviewed VET teachers pointed to the need for new materials directed at the planning stage in their work with design for boundary crossing. As part of the research project a pedagogical design framework, including design principles and a design matrix that focuses on boundary crossing mediated by ICT-based boundary objects, was developed and tested. While the research project has been designed as a multiple case study, the development and testing of the design matrix has been inspired by Educational Design Research (McKenny & Reeves, 2013). Theoretically, the research project is founded on a sociocultural perspective with research on boundary work, boundary crossing and boundary objects (Akkerman & Bakker, 2012, 2011a, 2011b) and research on mediating artifacts (Henningsen & Mogensen, 2013) as the backdrop. By way of combining four dialogical boundary crossing activities (identification, coordination, reflection and transformation) with four main affordances (documentation, simulation, construction and interaction) of the ICT-based boundary objects, the pedagogical design matrix was developed and tested in three iterations.

Selected findings show that the participating Danish VET teachers do not fully realize the potentials of using ICT-based boundary objects in their boundary work. Our data show that the VET teachers designed ICT-mediated activities aimed at boundary crossing through identification, coordination and reflection, whereas data point to no activities directed towards transformation. In terms of ICT-based boundary objects, the VET teachers were mainly focused on ICTs that afford documentation with sparse focus on construction and interaction, and no explicit focus on simulation as boundary activity. In the final discussion we point to possible explanations as to why the VET teachers' use of ICT in boundary work is relatively limited and we suggest further research.

Keywords

VET, boundary crossing, boundary objects, ICT, Educational Design Research

Introduction

According to Dohn (2014) *networked learning* is:

> (…) learning in which information and communications technology (ICT) is used to promote connections: between one learner and other learners; between learners and tutors; between a learning community and its learning resources; between the diverse contexts in which the learners participate (ibid, p. 30).

This makes networked learning relevant in the Danish Vocational Education and Training (VET) system, given that it is based on a *dual* principle, which means that students alternate between school and workplace periods throughout their education. Making sense and use of learning in and from different contexts and experiencing continuity between school and work has long been considered a major pedagogical challenge in Danish VET research resulting in a continuous focus on the transfer phenomenon. Nonetheless, transfer is a contested concept both in research (Engle, 2012; Hager & Hodkinson, 2009; Lobato, 2006) and among practitioners. In this paper, the concepts of boundaries, boundary crossing and boundary objects are adopted as a way of challenging the traditional notion of transfer understood mainly as a one-time and one-directional transition between a context of acquisition and that of application. Boundaries in education and learning processes are intuitively apprehended as something that needs to be avoided or diminished, but according to research on boundaries and boundary crossing (Bakker & Akkerman, 2017; Tuomi-Gröhn, Engeström & Young, 2003; Wenger, 1998), this may not be the best approach. In fact, Wenger-Trayner & Wenger-Trayner claim that:

> Rather than hindering boundaries under an illusion of seamless applicability across contexts, it is better to focus on boundaries as learning assets (Wenger-Trayner & Wenger-Trayner, 2015, p. 18).

As stated by several authors (Motta, Cattaneo & Gurtner, 2014; Nortvig & Eriksen, 2013; Wals, Lans, & Kupper, 2012), ICT can be used to bring about some of the learning potentials in and between domains, practices, and contexts in dual education. However, in Danish VET research knowledge of pedagogical use of ICT is highly limited (Ørngreen, Henningsen & Louw, 2016). To remedy this lack of knowledge, a research project investigating Danish VET teachers' understanding and use of ICT-based boundary objects in boundary crossing activities was conducted between 2015-2018.

In this paper, we present selected findings from the research project. In the first phase of the research project, interviewed VET teachers pointed to the need for new materials directed at the planning stage in their work with design for boundary crossing (Riis et. al., 2016). As part of the project a design framework, including design principles and a design matrix that focuses on boundary crossing mediated by ICT-based boundary objects, was developed and tested. Here, we focus on the development of the pedagogical design matrix, convey main findings regarding the development and usefulness of the matrix, and point to further research.

Research design, methods and main questions

The research project has been designed as a multiple case study (Yin, 2009) with the involvement of nine VET schools and two workplaces. In different phases of the project, we conducted 20 interviews (35 VET teachers, students, trainers) and 30 hours of classroom observations as primary methods to generate and collect data. Furthermore, the study was inspired by Educational Design Research (McKenny & Reeves, 2013) in so far as the design framework and the design matrix was developed, tested and refined in three iterative cycles. However, even though the goal of the study was focused on the development of theory and a design framework, the research project did not provide the opportunity to conduct experiments in the participating VET schools or workplaces. Instead the design matrix was tested in workshops and in teaching sessions, predominantly involving in-service VET teachers, and we are still in the process of finalizing the design principles and additional materials. While students, trainers, pedagogical leaders and consultants have participated in different phases of the project, the VET teachers are the main target group of the project. Table 1 below shows the connection between the two main research questions, methods and the expected outcome.

Research question	Methods	Expected outcome
RQ1: In what ways and why do VET teachers use ICT-based artefacts as boundary objects to design for boundary crossing and	Interviews and classroom observations	New knowledge of how VET teachers understand and use ICT in relation to boundary work and design for boundary crossing.

continuity in and across different contexts?		
RQ2: What pedagogical recommendations and materials can support VET teachers' future work with establishing enhanced school-workplace interaction through the use of ICT?	Design iterations tested among in-service VET teachers in workshops and teaching sessions.	A design framework consisting of design principles, a design model/matrix and additional scaffolding materials.

Table 1. Connection between research questions, methods and expected outcome.

Boundary crossing and boundary objects as theoretical backdrop

The research project is based on a sociocultural understanding of knowledge, skills and practice requiring a sensitivity towards participation in boundary contexts. Based on a review of 187 educational studies, Akkerman & Bakker (2011a) contend:

> All learning involves boundaries. Whether we speak of learning as the change from novice to expert in a particular domain or as the development from legitimate peripheral participation to being a full member of a particular community (Lave & Wenger, 1991), the boundary of the domain or community is constitutive of what counts as expertise or as central participation (ibid, p. 132).

Akkerman & Bakker define a boundary as 'a sociocultural difference leading to discontinuity in action or interaction' (ibid., p. 133) with discontinuity indicating actions or interactions that do not result in the intended or desired progress or when they require substantial effort. One typical boundary in dual VET, is the difference in epistemic cultures, and thus practices and possibilities for participation, in and between the school and the workplace. Although Akkerman & Bakker (2012) assert that boundaries can function as learning resources, the authors also emphasize that intersecting sociocultural practices do not per se lead to boundary crossing but rather necessitates deliberate pedagogical design in order to reach the full potentials of dual education.

Inspired by Star & Griesemer (1989), Akkerman & Bakker suggest the use of boundary objects as a means to facilitate boundary crossing. Boundary objects are 'artefacts doing the crossing by fulfilling a bridging function' (Akkerman & Bakker, 2011a, p.133). While Akkerman & Bakker are not particularly focused on the use of ICTs as boundary objects, Heilesen, Mogensen and Gleerup (2012) found that ICT can extend formal learning into the workplace during apprenticeship periods. According to the authors, this will lead to empowerment of apprentices and give the learners a more active and responsible role in their learning. Correspondingly, Nortvig & Eriksen (2013) state that new and easily accessible technologies provide opportunities for construction of a third, intermediary space of learning and integration of theory and practice, thus pointing to a boundary crossing potential.

Akkerman & Bakker (2011b) have identified four learning mechanisms or processes that potentially occur in and between the boundaries of sociocultural systems, namely:

1. **Identification**: Boundary crossing can lead to the identification of the intersecting practices, whereby the nature of practices is (re)defined in light of one another.
2. **Coordination**: Boundary crossing can also lead to processes of coordination of both practices in the sense that minimal routinized exchanges between practices are established, to make transitions smoother.
3. **Reflection**: Reflection is a more profound effect of boundary crossing. It is about learning to look differently at one practice by taking on the perspective of the other practice.

4. **Transformation**: In the case of transformation boundary crossing leads to changes in practices or even the creation of a new in-between practice, for example a boundary practice. (Akkerman & Bakker, 2011b, s. 3)

Central to these learning processes is a dialogical demand, which necessitates scaffolding from either the VET teacher in the school periods or the VET trainer in the workplace periods, preferably both in collaboration. Given that research shows that Danish VET students more often than not are expected to cross the boundaries in and between school and work on their own, potentially leading to confusion, lack of meaning and coherence and general dissatisfaction, this dialogical and collaborative demand is important.

Akkerman & Bakker primarily focus on the processes of boundary crossing. With regard to boundary objects we have been inspired by Henningsen & Mogensen (2013) who, based on research in dual education, propose the use of different types of mediating artifacts in boundary work. Such mediating artifacts have the capability of mediating the development and transformation of knowledge and skills, and Henningsen & Mortensen identify four main types of artifacts aimed at interaction, reflection, construction and simulation (ibid. p. 109). We understand these four action possibilities as inherent properties/affordances of different artifacts, e.g. ICTs.

Selected findings related to the design process

As previously mentioned, in the initial phase of the research project, VET teachers pointed to the need for new materials to guide them in the *planning* of their pedagogical designs for boundary crossing. In line with foundations in sociocultural theories, such as boundary crossing theory, the VET teachers called for a focus directed at *activities* undertaken by the learners. By way of combining ideas from Akkerman & Bakker and Henningsen & Mogensen, we created a model focusing on boundary crossing mediated by ICT-based boundary objects, which has been refined through three iterations so far. In all three iterations, the model has been tested by different practitioners (mainly VET teachers). It is beyond the scope of this paper to present the full design process, but the following account provides the reader with an impression of the type of reflections the iterations resulted in and how we tried to accommodate suggestions from the practitioners who were involved in the process.

From the conception, the design model was intended as a pedagogical tool for the VET teachers *to use in their planning and subsequently evaluation* of designs for boundary crossing. The first iteration of the model (figure 1), depicted the four boundary crossing processes combined with four main affordances related to the boundary objects. Based on initial research and testing of ideas in teaching sessions, we decided to revise and reduce Henningsen & Mogensen's (2013) original suggestions and ended up with highlighting the following dominant affordances of the ICT-based boundary objects:

- **Documentation** – incl. potential processes of collecting, classification and archiving
- **Simulation** – incl. potential processes of imitating, testing and experimenting
- **Construction** – incl. potential processes of imagining, generating and creating
- **Interaction** – incl. potential processes of mutual affecting, dialogue and co-creating

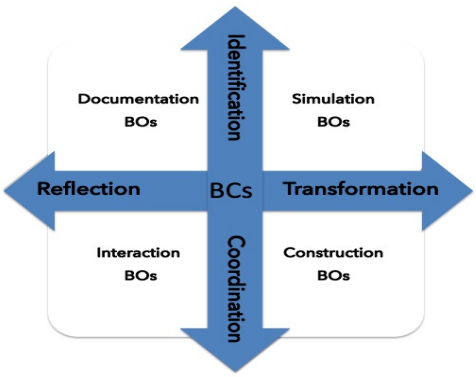

Figure 1. The first iteration of the design model.

This iteration of the model was tested in two workshops; 1) a workshop with 16 in-service VET teachers enrolled in a further education program, where two of the authors were teaching, and 2) a workshop with approx. 40 participants from the VET sector (mainly pedagogical leaders and pedagogical consultants from VET schools). During the workshops, the participants were, among other things, asked to discuss and decide where in the model different ICTs (of their own choosing) could be placed and why, and this resulted in the suggestions shown in figure 2 below.

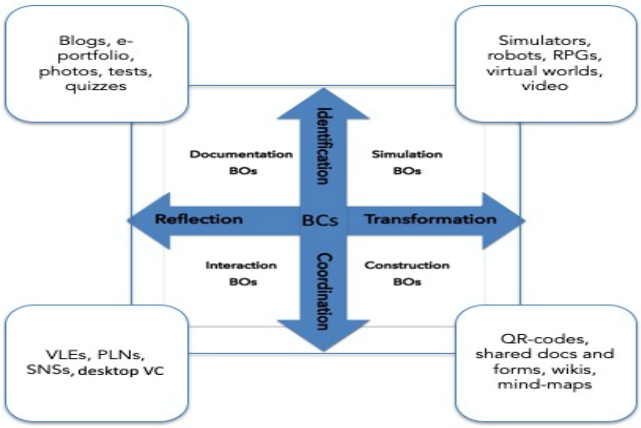

Figure 2. The first iteration of the design model with examples of ICTs.

As seen in figure 2, the workshop participants pointed to many different types of ICTs. Nonetheless, even though the participants found the model useful as a 'planning tool', which could trigger reflections on different ICTs and their relation to boundary crossing processes, the model was conceived as misleading. This first iteration seemed to indicate that the ICT-based boundary objects only were related to two of the four processes. Further, many of the mentioned ICTs are complex technologies with more than one affordance, and while the participants decided the position of the ICTs based on perceived *main* affordance, this was unsatisfactory. As the participants stated, often they would choose a specific ICT precisely because of its *various* affordances. Thus, the participants called for a different type of model, which could encompass such considerations.

Based on these experiences, we developed a second iteration of the model, which as it turned out still did not meet the expectations or needs of the VET teachers. The testing of the second iteration pointed to a fundamental challenge in using the model, which led us to conclude that a narrow focus on boundary processes and affordances was insufficient in the teachers' planning processes. Testing in this phase, showed that the VET teachers often neglected to consider other crucial elements in design for boundary crossing such as the purpose of the activity, the learners' (and teachers') prerequisites, the curricular content etc. In other words, there was a need to complement the model with additional pedagogical design questions for the VET teachers to consider,

when using the model. In the third iteration, the model was changed to a matrix, which illustrates the many ways it is possible to combine the boundary crossing processes with different affordances of the boundary objects.

In the final data collection phase of the project we decided to interview 14 VET teachers focusing on their use of ICT, and in our analyses, *we* used the pedagogical design matrix to map our findings. In figure 3 the pedagogical design matrix is depicted with examples of the different ICTs as they were discussed in the interviews. With regard to the elements in the design matrix, our data show that the VET teachers designed ICT-mediated activities aimed at boundary crossing through identification, coordination and reflection, whereas data point to no activities directed towards transformation. In terms of ICT-based boundary objects, the VET teachers were mainly focused on ICTs that afford documentation with only little focus on construction and interaction. Among the interviewed VET teachers, the rare mentions of simulation were in connection to the use of physical simulation dolls and the use of a flight simulator, which was used as a training object, and not as an intentional boundary object.

	ICT-based Boundary Objects *- Based on dominant affordances*			
ICT-based Boundary Crossings *- Based on dialogical learning mechanisms*	**Documentation** (collecting, classification, archiving)	**Simulation** (imitating, testing, experimenting)	**Construction** (imagining, generating, creating)	**Interaction** (mutual affecting, dialogue, co-creating)
Identification - Othering - Legitimating coexistence	Video OneNote		Video Thinglink	Facebook Google+
Coordination - Communicative connection - Efforts of translation - Routinization	Facebook Google+ Elevplan ItsLearning OneNote		Video Thinglink OneNote	Facebook Google+ OneNote
Reflection - Perspective making - Perspective taking	Facebook Google+ Elevplan ItsLearning OneNote		Video Thinglink OneNote	Facebook Google+ OneNote
Transformation - Hybridization - Crystallization - Continous joint boundary work				

Figure 3. Third iteration: the pedagogical design matrix.

Overall our data show that the interviewed VET teachers did not recognize the full potentials of ICT in relation to boundary crossing activities. In general, our study shows that VET teachers employ different pedagogical strategies for integrating ICT in their teaching practices, e.g. enhancing student activity or accommodating students' prerequisites through multimodal approaches, but that the use of ICT in relation to boundary crossing activities is limited.

Discussion

For us as researchers, the pedagogical design matrix was useful in terms of mapping existing use of ICT-based boundary objects related to specific boundary crossing processes. However, in order to better understand *why and how* VET teachers use ICT in boundary work, the matrix was insufficient pointing to a need for a more elaborate framework, if such questions were to be uncovered solely through design analyses.

For the VET teachers, the use of the matrix as pedagogical design tool also pointed to the need for at more elaborate framework and thus further iterations. Looking back at the many different types of ICTs, and combinations with boundary crossing processes, the participants pointed to in the two initial workshops, the findings in the final interviews seemed relatively sparse with regards to diversity and use of ICTs in practice. The data show that the VET teachers used a variety of ICTs, often these were, however, not used as *intentional* boundary objects.

For all the interviewed VET teachers, the theory of boundary crossing and boundary objects was new, and even if they were thinking in lines of designing for connections and transformation of knowledge and skills, they were

accustomed to think about traditional transfer, mainly focusing on creating similarities and reducing differences. Considering boundaries as 'learning assets' (cf. Wenger-Trayner & Wenger-Trayner, 2015), was quite new to most of the teachers. Among the four boundary crossing processes, reflection was the most recognized and used.

In relation to the boundary objects, perhaps the VET teachers did not acknowledge the affordances of the ICTs and thus found it difficult to envision the use of the ICTs in relation to the four boundary crossing processes. Some affordances are complex and need to be learned, in particular when combined with the boundary crossing processes. Throughout the project, most of the VET teachers expressed the need to know more about ICT and more precisely how different types of ICT can afford different types of action possibilities and how they can be combined with the four boundary crossing processes. This points to a general need of enhancing in-service VET teachers' *pedagogical imagination,* which would require additional research.

Finally, in this project focus has been on what we would term 'pedagogical' ICT. Our data also reveal that VET teachers use a variety of subject matter related ICT and not least ICT directly related to the vocations of the different VET educations. In summary, a fair account of VET teachers' understanding and use of ICT-based boundary objects in boundary processes, should also include such types of ICT, which also would demand further research.

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