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# Design-based research – issues in connecting theory, research and practice

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**Abstract**: *During the last 20 years, design-based research (DBR) has become a popular methodology for connecting educational theory, research and practice. The missing link between educational theory, research and educational practice is an ongoing issue and DBR is seen as an integrated methodology to bridge the gap. But is this as easy as it sounds? The purpose of the article is to identify and discuss issues involved in applying DBR. The article is based on methodology chapters and essays from three PhD studies applying the DBR framework to implement problem and project based learning (PBL). The findings indicate several key issues at both the scientific and personal level. Scientifically, the main issues are contribution to theory and the role of the researcher. At the personal level, it is an investment beyond normal research procedures to involve yourself as a researcher in curriculum change.*

## Introduction

> *In short, at present, both students and teachers of education are excessively concerned with trying to evolve a body of definite, usable, educational directions out of the new body of science. The attempt is only too natural. But it is pathetic. The endeavor to forestall experiment and its failures and achievements, the attempt to tell in advance how successfully to do a new kind of things ends, at most, in rectification of old ways and results, plus a complacent assurance that the best methods of modern science are employed and sanction what is done. This sense of being scientifically up-to-date does endless harm. It retards the creation of a new type of education, because it obscures the one thing deeply needful: a new personal attitude in which a teacher shall be an inventive pioneer in use of what is known, and shall learn in the process of experience to formulate and deal with those problems which a premature 'science' of education now tries to state and solve in advance of experience. (Dewey, 2009, s. 4).*

So said Dewey in 1922 (Dewey, 2009) in his essay 'Education as Engineering', which contrasts educational science and educational practice. Dewey emphasized that educational change does not derive from educational science as it very often looks backward, but change might occur after a substantial number of individuals have experimented, which takes a lot of courage and creativity. Dewey argued that theory, research and scientific knowledge are not sufficient for educational change; on the contrary, educational change can happen without research (Biesta, 2009).

The same 'provocation for the academic word' is made by Felder and Hadgraft (2013). They debate the relationship between research and theory on one side and, on the other side, educational practice as a core element in the discussion of engineering education research (EER), arguing that EER has moved away from practice – even though there is a need for more solid reflection and knowledge of how to change educational practice (Felder & Hadgraft, 2013; National academy of Engineering, udateret; Royal Academy of Engineering, 2007). They formulate four alternative hypotheses indicating that successful educational change can take place without a strong link to theory and rigorous research; however, they invite validation of their four anti-hypotheses.

From the development side, there is no doubt that there is a growing concern for change in engineering education. In the western world, governmental bodies such as the EU, and

accreditation institutions, have formulated requirements for outcome-based education (OBE) and specified needs for innovative and entrepreneurial competences (e.g., Leuven communiqué). Several reports on new engineering competences state that universities have to pay much greater attention to real-life problems and to societal needs, in order to address the employability agenda, including collaboration with businesses (National Academy of Engineering, n.d.; Royal Academy of Engineering, 2007).

During the last five years, the same demand for change and new types of innovative competences, have been formulated in Asian countries. In India, several studies indicate the lack of employable engineers (Shinde, 2014). In Thailand and Malaysia there is a process of implementing outcome-based education at all levels in the educational system to emphasize the development of competences (Borhan, 2014; Coffin, 2014). The same trend is seen in South America and elsewhere, where there also is a growing awareness of the need to educate new types of engineers and academics to be are able to participate in global, collaborative, and sustainable innovation processes. OBE implies a broader educational scope from purely focusing on knowledge to a focus on knowledge, skills and competences, and involves reorganization of teaching and learning from a teacher centred to a student centred approach. The need for change of practice is obvious, however, it is not obvious how theory and research actually contribute to the educational change.

At the Aalborg UNESCO Centre, several international PhD students are enrolled for the purpose of establishing research-based educational change in home institutions. Three PhD students from Asian countries were enrolled in 2010, with the explicit aim of being able to change education to problem and project based learning (PBL) on return from their PhD studies. After a longer period, with methodological discussions, we ended up by applying Design-Based Research (DBR). The conditions, when we made that methodological choice, were that the PhD students were expected to train and lead a group of academic staff to implement a student centred learning curriculum – more specifically, a problem and project based curriculum. However, reality took over for several of the PhD students as conditions changed along the way. In all the studies, the PhD students managed to establish a change in a course or a curriculum and, therefore, the relationship to practice was actually quite close. Without doubt, it has been a personal investment in all three cases, struggling with resistance in their institutions and especially among their colleagues. So, it is a story of courage and creativity as Dewey highlighted.

This article address the research question: what are the implications of using DBR? Is it possible to both meet that academic requirements and change the real world practice? This article will describe experiences concerning the issues involved in connecting research, theory and practice from both a research point of view and a practical/personal point of view.

## Design-Based Research – what do we know?

During the last 20 years, a growing number of researchers have applied DBR as a framework for combining research and practice. Basically, DBR has been developed as a reaction to the educational psychological experiment which takes place in laboratories and treats participants as subjects. DBR aims to understand the complexity of practice by partnering with practitioners and enhancing learning by iterative analyses, designs, developments, and implementations (Barab & Squire, 2004). Collins et al. (2004) systematically compared laboratory studies with design experiments and pointed to the following differences (see Table 1):

**Table 1: Comparison of two scientific approaches**

| Laboratory studies | Design experiment |
|---|---|
| • Laboratory settings | • Messy situations |

| • Single depend variables | • Multiple dependent variables |
|---|---|
| • Controlling variables | • Characterizing the situation |
| • Fixed procedures | • Flexible designs |
| • Social isolation | • Social interaction |
| • Testing hypothesis | • Developing a profile |
| • Experimenter | • Co-participant design and analysis |

<div align="center">(Adapted from Collins, Joseph, & Bielaczyc, 2004)</div>

As table 1 indicates, DBR researchers argue with a positivistic research paradigm more than a constructivist paradigm. Compared to a more positivistic research paradigm (Creswell, 2013), DBR belongs much more under a heading of pragmatism oriented to the real world, where the problem/research question determines the methodology. Pragmatism is an emerging research paradigm in EER, however it is mostly related to a mixed methods approach (Borrego, Douglas, & Amelink, 2009) and not interpreted as a philosophy or a research methodology encompassing the research questions, the approach to theory and practice (Biesta, 2009).

Collins defines four principles for DBR: 1) to address learning theories, 2) study learning in context, 3) develop new measures of learning, and 4) contribute to new research findings (Collins, 1992). Collins' understanding of theory is best teaching practice based on theories of learning, so the understanding of theory is closely related to pragmatism, i.e. what works in practice – however, Collins distinguishes between theory and research, which might be quite important in the understanding of the scientific impact of DBR (Collins, 1992). Wang and Hannafin describe DBR as: 1) pragmatic, especially in the value of theory to inform and improve practice; 2) grounded, by emphasizing both theory and practice; 3) interactive, iterative and flexible by interacting with participants; 4) integrative, by applying mixed methods and still purposeful with rigour; and 5) contextual, in the sense that the research results are connected to the particular practice with possible guidance for more general results (Wang & Hannafin, 2005). This approach to DBR is much more methodological, which certainly is needed in DBR.

Most of the DBR literature concerns the understanding and development of DBR and argues for DBR as a rigorous scientific approach. Few articles report on some of the issues. Dede (2004) raises some important issues: 1) DBR involves an enormous amount of data, as it can be hard to set a limit on the situation; 2) the DBR design seems to be under-conceptualized and over-methodologized, in the sense that one cannot see the alley in the darkness; 3) the concept of design is not well defined. In particular, the under-conceptualization is interesting as it links to the theoretical understanding and the contribution to theory. Although it is a high requirement to develop new theoretical concepts, it can be understood as understanding and analyzing the new practice by conceptual and theoretical lenses. Reimann does not agree on the point made by Dede (2004) as he sees a need for further developments of design methodologies, describing in detail the process of design. Many of the results are new educational designs, but how these were developed is not transparent (Reimann, 2011). Anderson and Shattuck (2012) agree that there should be stronger links to theory and research in the creation of the design, but also in the expectation that DBR will contribute to theory and research. They also claim that the partnership between researchers and teachers indicates strongly that DBR distinguishes between different roles and that these often are too intertwined (Anderson & Shattuck, 2012). However, it is exactly this closer relationship that has in-built dilemmas, e.g. in research questions, research findings require specific questions, while collaborative design will need flexibility (Joseph, 2004).

Summing up the characteristics for the DBR framework:

- DBR is a pragmatic research approach.
- Originating from research and learning theories, with the aim to contribute to theories/research.
- The design should be based on literature studies, research and theories as a basis for the design of experiments that can be implemented in a new educational and cultural context.
- The design should also be based on real world problems as the starting point for the research process.
- Collaborative partnership between researcher and practitioner.
- Multiple iterations in the implementation phase and further development of the educational practice. These iterations are based on reflection and immediate adjustments as well as results from analyses of data collections. Integrate formative evaluation.
- Focus on the effect of designs by collection of data during the process by using mixed methods approach.
- Multiple iterations in the development of the research design.
- Contribution to the development of instruments for data collection and models for changes in practice.
- Development of new design principles.
- Contribution to theoretical development and new research findings.

DBR shares a lot of similarities with action research. A comparison between DBR and action research on a more specific level is complicated as there are many different 'schools' within action research ranging from action research in general to participatory action research, critical action research and action learning. One could claim that in higher education practitioners have 'hijacked' action research in some communities and it is used particularly as a strategy for academic staff to experiment and improve their practice. Andreissen combines action research and DBR by using action research methods for the implementation phase, containing the iterations and reflections and the data collection and findings, whereas DBR adds a theoretical component in design development (Andriessen, 2007).

## Methods

In this article, the point of departure is the DBR work and experiences of three Asian PhD students. They have all been enrolled in the PhD programme at Aalborg UNESCO Centre and have all defended their PhD thesis with success. The DBR processes are quite complex to handle for experienced researchers and even more so for young researchers. In that sense, the complications and issues that occur during the process might be interpreted differently. On the one hand, PhD students in a learning process could have the tendency to swipe away the scientific dilemmas and issues they meet during the process. On the other hand, they might have difficulties in handling more complex designs and research processes and therefore identify more issues. But regardless of whether they do or not, the issues do exist.

Two other considerations that might impact results are the cross cultural aspect and the fact that the author has been co-supervising the PhD students. The cross cultural aspect is beyond the scope  of this article as it involves so many different issues, such as organizational hierarchy and support for educational changes, and cultural issues in learning. The supervision part has given insight into the process in a totally different way, as I have been the one pushing, supporting, criticizing and, not least, assessing.

The data have been collected in several ways:

- by reading their PhD theses and drawing attention to the methodology section,

- by asking them to write an essay on issues in applying DBR methodology, including scientific and personal issues.

In general, the methodology chapters in the PhD theses described the DBR methodology and each student developed their own framework of the DBR phases according to the diversity in the three practices. However, a more critical reflection on DBR was non-existent in the methodology chapters and only appeared in the essays.

## Findings

On the outcome side, it is important to stress that a result from the three DBR studies is a change of courses/curriculum. In the Indian and the Malaysian case, problem and project based learning was implemented successfully in single courses in science and engineering. In the Thai case elements of the entire curriculum changed together with single courses in both engineering and humanities field. Research results across the three studies clearly indicate that the students reported they learned more, students got higher grades and student were much more motivated (Borhan, 2014; Coffin, 2014; Shinde, 2014).

For all three PhD studies, there is no doubt that there has been a clear outcome on the practice side as well – not only has the changed courses and curricula had an impact on students' learning, it is also reported scientifically. However the DBR process was not without difficulties, and the essays containing a reflection on the process reveal the following issues:

Formulation of *research questions* is one of the core issues in all the studies. In the three PhD studies, the research questions balance between a broad 'how to' question for practice and specific questions on relationships between various variables. For a PhD study, this might always be the case, however what is more general is the dilemma between a research question and a practice relevant question. This is a general dilemma that might be very hard to solve. A research question normally takes the departure in either pre-defined variables or a desire to identify core variables and create understanding. But the practice question belongs to the "how" questions pointing in direction of practical answers. Even if a how question in DBR can be answered by more theoretical design answers, practicalities will occur during implementation process.

*Flexibility in the design* is an issue and it has been hard for the PhD students to have an overview of possible solutions to the issues in both practice and research. In one of the PhD theses' methodology chapters, it was concluded that the design of practice and design of the research has to be formulated in broad terms in order to be flexible (Borhan, 2014). Management of flexibility in both the design and implementation of practice and subsequently in the research design requires overview of possible solutions to emergent problems. Depending what type of DBR that is utilized, the planning of the collaboration with practitioners is un-predictable. Especially in a PhD study, this is a critical component, however it is also in general very critical. The collaboration between practitioners and researchers is not well described in the DBR literature.

The *amount of data* is reported both in literature and in this small study. The students collected everything to be sure of having the required documentation. The selecting the data and analysis of the data afterwards has taken time. In a PhD study, this might be overwhelming, however this also counts for a "normal" DBR project.

As a new aspect that is not reported in the literature, all three PhD students point at the *various roles* they have had. Some have had to become the practitioner as well as the researcher when conditions at their local university changed and there was a lack of support from top management. That was actually the case for two out of three of the PhD students. The management that sent them changed and there was a lack of commitment from the department levels and problems in convincing any colleagues to try out PBL. The PhD students also report on personal investment of time and energy that have felt enormous.

One was acting as DBR researchers but also had to act as change agents to get academic staff involved and to train them. It could seem that the purpose of changing practice overshadowed the objectives of theoretical and scientific contributions – and often the PhD students felt that they were put in dilemmas in between a management top and their own colleagues. However, not only training of colleagues but also continuous negotiations on how what kind of curriculum practice and the daily practice in the classroom was a component that took a lot of time and sometimes potentially created conflicts in the organisation.

The dominance of practicalities will create a risk that DBR will be difficult to use as a methodology for combining theory and practice, as it will always be under suspicion as being a non-rigorous approach. The methodology chapters in the PhD theses and the conclusions reveal that the research findings are related to the existing literature study and there are contributions to the designs, empirical findings and design methodology. In general, the DBR researchers in this case have drowned in data and flexibility in the designs and have not had the time and/or resources for conceptual development. However, there is a conceptual development in the methodology by new phase definitions that can reflect an intercultural dimension.

## Discussion and perspectives

The interaction between theory, research, design and practice is hard to describe. There are multiple interactions, but first and foremost there are ongoing negotiations between the DBR researchers and the practitioners. How many times researchers and practitioners meet and negotiate will depend on the context and the partners involved. Trying to sum up the results and the contributions to the DBR literature, figure 1 has been developed.
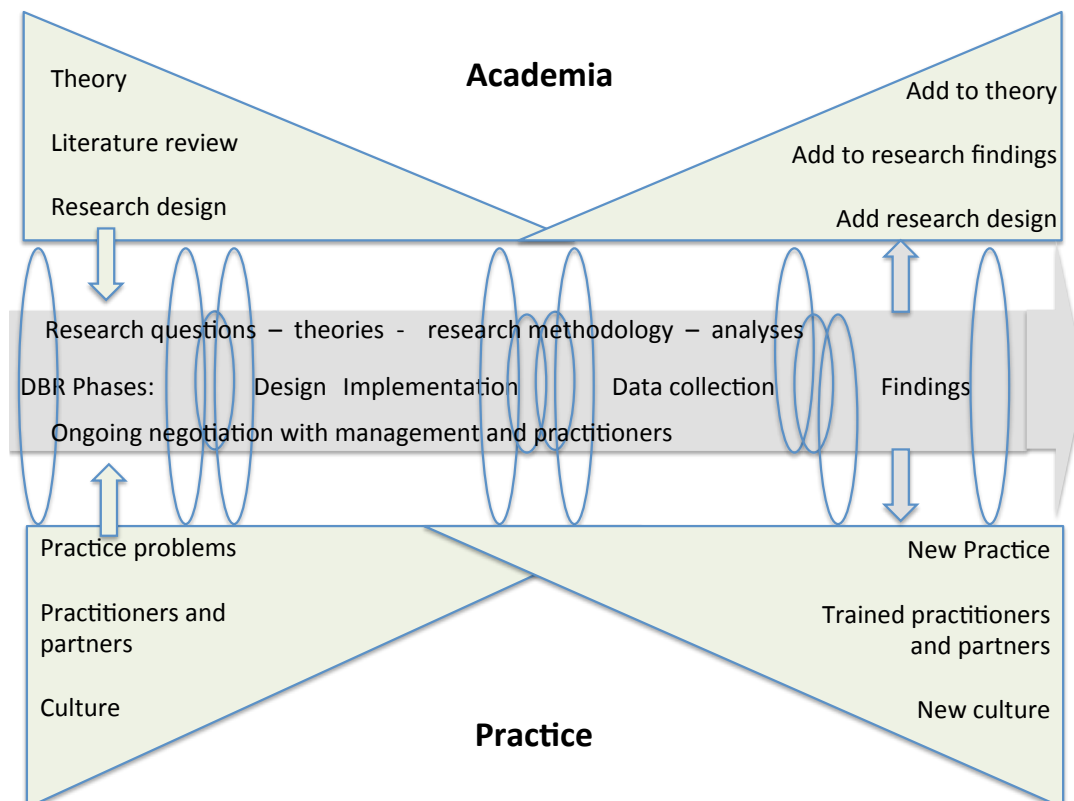


**Figure 1: Complex interaction between academia and practice**

The complexity in DBR is high –just the fact that the design has to be based on both theory, research and practice problems, adds to what is already a really complicated start to a

research project (Kolmos, 2015). In figure 1, the full picture is captured. On one side there is academia with demands of theory, solid literature review and a research design. On the other side there are the practitioners who have a totally different language compared to the actors from academia and who look at practical problems. The dilemma between the two cultures can be analyzed in the way they formulate problems/research questions. Very often in academia, a research question expresses a wish to identify variables in a given context, whereas the practitioner problem is much more a question of how to do certain things. The DBR researcher

Much more reflection, methodology and theories are needed in this area, such as different models of DBR research connecting theory, research and practice. DBR combines a series of theories and methods applicable to given contexts and, of course, this will lead to variation. Bell has started by identifying different modes of connecting theory and practice within four different educational psychology research paradigms: developmental psychology, cognitive science, cultural psychology, and cognitive anthropology – all contributing to DBR but from their own very different angles concerning the theory-practice perspective (Bell, 2004).

DBR is a methodology covering a series of designs. One important design is, of course, to build up the design of the practice in negotiation with practitioners, but another important design element is the research design of the data collection. In the DBR literature, this is rarely drawn attention to, however, it is an essential part of the scientific approach. Normally, a research design will have to address the research questions, theoretical backbone, methods and the analytical framework. In a DBR context, the research design has to be flexible in following the iterations of the practice designs. If practice changes, the collection of data might change also, e.g. there might be a change of active learning strategies which might be better researched by observation than interviews. Even if the researcher has planned to make observations, the degree of observations might increase.

No doubt that DBR can connect theory and practice – and can change practice. As such it would be great to see more DBR studies within engineering education, however, the use of DBR requires resources as and abilities to handle both academia and practice.

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