Research Questions in Design-Based Research

Arthur Bakker

Freudenthal Institute

Utrecht University

a.bakker4@uu.nl

August 25, 2014

Design-based research (DBR) is a relatively new method in the learning sciences (Anderson & Shattuck, 2012; Brown, 1992; also see special issues in Educational Researcher, 2003; Educational Psychologist, 2004; Journal of the Learning Sciences, 2004). For older and more established methods such as randomized controlled trials (RCTs), the argumentative logic has already been worked out more clearly (Cobb et al., in press). Several predominantly qualitative approaches such as ethnography, case studies and action research have been around so long that they are discussed in most research methods books (Creswell, 2007; Denscombe, 2007), but DBR has not yet reached this stage. Despite its potential and importance for the improvement of education and educational research (Plomp & Nieveen, 2007; Van den Akker et al., 2006), there is thus still some way to go.

In this document I focus on the topic of research questions. Many design-based researchers struggle with formulating good research questions, and in many cases the debate on formulations continues until the end of a project. To some extent this inherent in qualitative research approaches, but in DBR the situation seems more poignant. I address the issue of what counts as a good research question, summarize some of the discussion points and propose an argumentative structure that seems to work for the type of DBR that our students in mathematics and science education do. I do not rehearse the main characteristics of DBR (see Bakker & van Eerde, 2014; Cobb et al., 2003).

Criteria for Research Questions

What counts as a good research question?

1. It addresses a **knowledge gap** (it makes no sense to ask a question if the answer is already known)
2. The question should be pragmatically and theoretically **relevant** (otherwise: why put so much effort and resources into the research?)
3. Its main concepts are **precise and anchored** in the literature.
4. It should be **manageable**: it is answerable by means of research within a reasonable time frame and available resources.
5. Its formulation should help the reader envision the **type** of research carried out (descriptive, evaluative, design-oriented, advisory etc.)
6. Taken together, answering research (sub)questions should lead to an answer of the main research question. In some situations, subquestions are not required. Avoid more than four subquestions because readers find it hard to digest too many questions.

Moreover, most researchers prefer one main question over two or more. They argue that one is always more general or important than the other. However, in some cases, it is artificial to formulate one question, for example if two questions can be answered by means of two subsequent studies. In that case, it may be possible to formulate one overall aim rather than a main research question.

These are general criteria. In the case of DBR it is important to decide whether you want a descriptive, evaluative, predictive or advisory answer. Technically speaking, asking about characteristics of a learning process or strategy is a descriptive question. Asking about how something can be accomplished is an advisory question.

In my view, the main question should not be a design-oriented question, but it is fine to have a subquestion that requires a design-oriented answer: Research aims to provide new knowledge, not just a product. But a new design can be required to provide this new knowledge. Hence, the answer to one of the subquestions could be the design of a unit, strategy, course or approach.

Discussion Points

Characteristics versus how questions

There seem to be two broad types of research questions in DBR. The first is to ask about characteristics of some kind of intervention. For example:

What are characteristics of valid and effective teaching and learning strategy to teach students about correlation and regression in such a way that they experience coherence between mathematics and the natural sciences? (Dierdorp, 2013)

What are the design characteristics for a practicable and effective learning, supervising and teaching strategy that enables VMBO students to recognize the functionality of biological knowledge of reproduction in work placement sites? (Mazereeuw, 2013)

One advantage of such a formulation is that it is through such characteristics that generalization can take place: if we know the key characteristics that make a strategy (unit, module, instructional sequence) work, then another researcher can try to make other strategies for other topics or domains with similar characteristics. It is assumed that similar results can then be expected.

The second type of research question in DBR is the *how* question, for example:

How can a learning-and-teaching strategy, aimed at the flexible use of biological concepts through recontextualising, be structured? (Wierdsma, 2012)

How can students be empowered in their opinion forming on personal and societal implications of genomics?

How can students be fostered in their connecting of gene as a molecular-level concept to phenomena at higher levels of biological organization? (reformulations of Van Mil's, 2013, main questions)

One advantage of such how questions is that they ask what most design-based researchers want to know: how particular learning goals can be achieved. In many cases, they are dissatisfied with how particular topics are typically taught or introduced in the curriculum. They have an innovative idea about how to teach them alternatively, or they even argue that new learning goals need to be achieved. Without satisfying examples in natural settings, they deliberately need to be designed and researched.

A possible point of critique on how questions is the rebuttal, But learning goals can be achieved in thousands of ways, why would you be happy with one way? How questions are so open and broad. Even if it is not possible to find the best way, don't you want to find at least an effective and efficient way? The design researcher could answer, OK, but in our case, there is nothing to compare with so we are happy with anything that works. Only then can we compare with other ways, but first we need a route to particular endpoints. Such design researchers are successful once they have provided a proof of principle or a proof of existence. It is possible. The next step is to improve effectiveness and efficiency, scale up, compare alternatives et cetera. But this phase should not be skipped. It is only in this later stage that evaluative or comparative research is sensible, and that true experiments such as RCTs are useful.

A possible point of critique on characteristics questions is the rebuttal: How do you know which characteristics ensure the success of your intervention? Can the results really be attributed to the characteristics you identified?

Moreover, design researchers typically try to enact particular characteristics they think are worth exploring or enacting. In that case it would be circular to ask about characteristics of a design that were intended. It may also sound odd to ask about characteristics of a unit that does not yet exist. Last, it has been shown that educational units designed to have similar characteristics can have very different effects. For example, Amettler, Leach, and Scott (2007) compared units with similar characteristics, but found that one of them did not work. Apparently, many different factors or characteristics are at stake that codetermine whether a unit is effective.

Personally I have a preference for how questions. In whatever formulation, we further need to ensure that we give an answer to the question. The characteristics variant is a descriptive question and requires a descriptive answer: a well-argued list of characteristics that matter. The how question requires a predictive or advisory answer: a well-argued strategy or hypothetical learning trajectory with empirical support.

A Possible Structure of DBR Research Questions

In this section, I propose a structure that seems to work for DBR projects as carried out by master and PhD students at our institute in classroom-based research[i]. Whether it works for professional development or larger scale projects needs to be thought through and tested empirically.

The main question of a DBR project often has this structure:

How can learning goal X be achieved for a particular group of learners (in particular conditions or under particular constraints)?

The question may also take shape of solving a particular problem: How can the problem Y be solved?

To answer this main question, a sensible list of research questions could be:

1. What is an appropriate learning goal….?
   Based on the literature and expert opinion what would be a suitable learning goal for a particular group of learnings?
2. How can this learning goal be achieved? What is a teaching-learning strategy that would help students to achieve this goal? (or help teachers to support students in achieving that goal)?
3. How well was this strategy/trajectory implemented?
4. What were the effects of this intervention?

The first question is only necessary if such a learning goal needs to be formulated. For example, Cobb (1999) did thorough reading to arrive at statistical distribution as suitable learning goal. Bakker (2004) concluded after several cycles of DBR that sampling should be added to this learning goal to prevent the one-sidedness in the Cobb et al. research.

Some design researchers may consider question 2 to be the heart of their work. Arriving at an answer is certainly a very time-consuming and creative process. The answer typically takes the form of a strategy description, an HLT or scenario. However, DBR is more than design—it is predominantly research, so it is still an empirical question how well the strategy worked. To this end we need to check whether the strategy or HLT was implemented as intended. If not, then it is impossible to attribute effects to the strategy. If yes, by and large, the effects found can be linked to the intentions.

Effects ideally include more than learning results on some tests (e.g, pre-posttests). Researchers may also have other aims such as raising interest, improving attitude, motivation, engagement or particular forms of interaction.

For Discussion

Let's consider some examples for further learning.

Here is a set of questions written by a student:

Main question: ***what learning and teaching activities can be designed that stimulate biology undergraduates in planning experiments and choosing appropriate tools that can gather the data needed to answer a research question in molecular biology?***

In order to answer this research question the following sub-questions are formulated:

1. What knowledge and skills should first year biology undergraduates have with respect to designing experiments in molecular biology?
2. What characteristics of a learning and teaching activity can be identified that can support students in an explicit and scaffolded manner in this aspect?
3. Does the developed learning and teaching activity indeed support students in learning to design experiments in molecular biology?

There is something odd with the main question due to its focus on "can be designed".

The student's first attempt to improve this was: ***What are adequate learning and teaching activities that support biology undergraduates in designing experiments in molecular biology****?*

Still, a problem of this main question is that the main focus of the answer to this question is the description of activities. The design seems more important than the research, whereas research should lead to new knowledge. In this formulation the effectiveness ("that stimulate…") seems of secondary importance. Moreover, the second question can only be answered once the main question has been answered. Identifying characteristics of the activity is only possible once the activities (or activity – set of questions is not consistent here) have been designed. The third question is a yes-no question, which is ideally avoided.

She also tried the form of a hypothesis:

The hypothesis underlying this study is: ***a problem-solving based educational approach can scaffold undergraduate biology students in designing experiments in molecular biology.*** In order to test this hypothesis, four sub questions are formulated, which are:

1. What are the features of a Hypothetical Learning Trajectory (HLT) and according learning activities that scaffold students in a problem solving approach for designing experiments in molecular biology?
2. How do students progress through the different learning activities of the designed lesson?
3. What are the effects of the learning activities on how students design experiments in molecular biology?
4. What are students' reflections on their learning process regarding the design of experiments in molecular biology?

To test the hypothesis it should be enough to design such an approach that works. Questions 1, 2 and 4 seem unnecessary for testing this hypothesis. Apparently, the student wanted to know more, for example how to improve her first design.

As a how question:

How can problem-solving based learning activities scaffold undergraduate biology students in learning to design experiments in molecular biology?

- Subquestion 1: what knowledge and skills do undergraduate biology students need with respect to designing experiments in molecular biology?
  Answer based on theory and intervews
- Subquestion 2: how can students learn these knowledge and skills?
  Answer: HLT
- Subquestion 3: What are the effects of the developed learning activities on students learning of designing experiments in molecular biology?
  Answer: pretest-teaching experiment-posttest results

Remarks: The main question works well as a DBR question. One problem with the second question is that it is now more general than the main question, whereas subquestions need to be more specific. This should not be too difficult to change though.

References

Ametller, J., Leach, J., & Scott, P. (2007). Using perspectives on subject learning to inform the design of subject teaching: an example from science education. *The Curriculum Journal, 18*(4), 479-492.

Anderson, T., & Shattuck, J. (2012). Design-based research: A decade of progress in education research? *Educational Researcher, 41,* 16-25.

Bakker, A., & van Eerde, H. A. A. (2014). An introduction to design-based research with an example from statistics education. In A. Bikner-Ahsbahs, C. Knipping, & N. Presmeg (Eds.). *Doing qualitative research: Methodology and methods in mathematics education.* Berlin: Springer.

Brown, A. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *Journal of the learning sciences, 2*, 141-178.

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble L. (2003). Design experiments in educational research. *Educational Researcher, 32*(1), 9–13.

Creswell, J. W. (2007). *Qualitative inquiry and research design. Choosing among five traditions* (2nd ed.). Thousand Oaks, CA: Sage.

Denscombe, M. (2007, 3rd ed). *The good research guide.* Maidenhead, UK: Open University Press.

Dierdorp, A. (2013). FIsme thesis.

Educational Researcher (2003). Special issue on design-based research collective.

Educational Psychologist (2004). Special issue design-based research methods for studying learning in context.

Mazereeuw, M. (2013). FIsme thesis

Journal of the Learning Sciences (2004). Special issue on design-based research, 13(1), guest-edited by S. Barab and K. Squire.

Plomp, T., & Nieveen, N. (Eds.) (2007*). An introduction to educational design research*. Enschede, the Netherlands: SLO.

Van den Akker, J., Gravemeijer, K., McKenney, S. & Nieveen, N. (Eds.) (2006). *Educational design research.* London: Routledge.

Van Mil, M. (2013). FIsme thesis.

Wierdsma, M. (2012). FIsme thesis.

[i] I thank Prof. Karel Stokking for interesting conversations on this topic. This structure has been inspired by his ideas. I also thank Christine Knippels and Paulien Postma for discussing and testing the structure.