Chapter 6

Design research on technology-based innovations

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The curriculum is, along with assessment, a key driver for education because curricula define goals, content and, in some cases, also the methods of teaching and learning. This chapter suggests that we regard curricula as a roadmap for education. In particular, the author looks at the benefits and limitations of curriculum design research and how its results have the potential to make an important contribution to curriculum policies and development. Rather than attempting to implement elaborate and complete interventions, a process whereby one comes to (successive) prototypes that increasingly meet the innovative aspirations and requirements is suggested. The process is often iterative, cyclic or spiral: analysis, design, evaluation and revision activities are iterated until a satisfying balance between ideals and realisation has been achieved. The author concludes with some specific research characteristics that would strengthen the growth of knowledge through design research.

Introduction

Over the last decades and building upon experiences worldwide, a lot of research-based knowledge has grown about the potential added value of Information and Communication Technology (ICT) for education (see Voogt and Knezek, 2008). Although it is not easy to come to general conclusions about the uptake and impact of ICT on educational practices, the overall picture is rather sobering. There are scattered promising pockets of success, but the potential of ICT is still rarely realised. Integration of ICT use in schools remains slow and transfer of exemplary classroom practices appears to be limited. ICT seems a typical illustration of the statement by Hargreaves and Fink (2006) that change in education is easy to propose, hard to implement, and extraordinarily difficult to sustain. Thus, notwithstanding great ambitions and many investments, there is still a long way to go.

How may educational research help in addressing these challenges? Those contributions vary over different research approaches. Plomp (2009) distinguishes various questions, aims and functions of research, such as: to describe, to compare, to evaluate, to explain, to predict, to design and to develop. One may also discern various primary orientations of research: theory, practice or policy. Much policy-oriented research on ICT occurs through surveys, monitoring and assessment, focusing on (descriptive) measures about actual practices and outcomes of ICT. However, the central orientation in this paper will be on research that aims for ICT-related *improvement and innovation* of education, under the label of *design research*. Design reserach in education is a relatively new approach, with its roots in the early nineties, and since then documented in a number of special issues of prominent journals (for example: *Educational Researcher*, Vol. 32, No. 1, 2003; *Educational Psychologist*, Vol. 39, No. 4, 2004; *Journal of the Learning Sciences*, Vol. 13, No. 1, 2004; *Educational Technology*, Vol. 45, No. 1, 2005) and a number of books (for example: van den Akker *et al.*, 2006; and Kelly, Lesh and Baek, 2008).

Moreover, this paper takes a broad *curricular* perspective as that appears very helpful for systematically addressing the challenge of strengthening ICT in education because it transcends the often too narrow and isolated approach of studying the use and effects of ICT in teaching and learning.

Curricular Design Research intentionally combines two fields: "curriculum design" and "design research". In particular, it focuses on how design research can increase the quality of curriculum design and development (also in relation to ICT potential). Moreover, it illustrates how the relevance of educational research – a widely debated issue – can benefit from a connection to curriculum policies and practices.

Given this aim it helps to have a number of basic concepts and analytical perspectives available that can structure curricular deliberations and reduce the complexity of curriculum tasks. The initial focus in this chapter (building on van den Akker, 2003; and Thijs and van den Akker, 2009) is on summarising a set of concepts and perspectives that help to increase the transparency and balance of curriculum analysis, development and discourse. Then, the focus will shift towards (curricular) design research (building on van den Akker, 1999, and van den Akker *et al.*, 2006).

Curriculum: What's in a name?

When there is a myriad of definitions of a concept in the literature (as with curriculum), it is often difficult to keep a clear focus on its essence. In those cases it often helps to search for the etymological origin of the concept. The Latin word "curriculum" (related to the verb *currere, i.e.* running) refers to a "course" or "track" to be followed. In the context of education, where learning is the central activity, the most obvious interpretation of the word "curriculum" is then to view it as a course, trajectory or "*plan for learnin*g" (*cf.* Taba, 1962). This very short definition (reflected in related terms in many languages) limits itself to the core of all other definitions, permitting all sorts of elaborations for specific educational levels, contexts, and representations. Obviously, contextual specification is always needed in curriculum conversations to clarify the perspective.

Given this simple definition, a differentiation between various levels of the curriculum has proven to be very useful when talking about curricular activities (policy making; design and development; evaluation and implementation). The following distinctions appear to be helpful:

- International/comparative (or *supra* level)
- System/society/nation/state (or *macro*) level (*e.g.* national syllabi or core objectives)
- School/institution (or *meso*) level (*e.g.* school-specific curriculum)
- Classroom (or *micro*) level (*e.g.* textbooks, instructional materials)
- Individual/personal (or *nano*) level

The supra level usually refers to international debates or agreements on aims and quality of education, sometimes fuelled by outcomes of internationally comparative studies. Curriculum development at the supra level is usually of a "generic" nature, while "site-specific" approaches are more applicable for the levels closer to school and classroom practice. Moreover, the process of curriculum development can be seen as narrow (developing a specific curricular product) or broad (a long-term, ongoing process of

curriculum improvement, often including many related aspects of educational change, *e.g.* teacher education, school development, and examinations). In order to understand problems of curriculum decision-making and enactment, a broader description of curriculum development is often most appropriate: usually a long and cyclic process with many stakeholders and participants; in which motives and needs for changing the curriculum are formulated; ideas are specified in programmes and materials; and efforts are made to realise the intended changes in practice.

Moreover, curricula can be represented in various forms. Clarification of those forms is especially useful when trying to understand the problematic efforts to change the curriculum. A common broad distinction is between the three levels of the "intended", "implemented" and "attained" curriculum. A more refined typology (van den Akker, 2003) is outlined in Table 6.1.

Table 6.1. **Typology of curriculum representations**

INTENDED	Ideal	Vision (rationale or basic philosophy underlying a curriculum)
	Formal/Written	Intentions as specified in curriculum documents and/or materials
IMPLEMENTED	Perceived	Curriculum as interpreted by its users (especially teachers)
	Operational	Actual process of teaching and learning (also: curriculum-in-action)
ATTAINED	Experiential	Learning experiences as perceived by learners
	Learned	Resulting learning outcomes of learners

Traditionally, the intended domain refers predominantly to the influence of curriculum policy makers and curriculum developers (in various roles), the implemented curriculum relates especially to the world of schools and teachers, and the attained curriculum has to do with the students.

Besides this differentiation in representations, curriculum problems can be approached from various analytical angles. For example, Goodlad (1994) distinguishes the following three different perspectives:

1. *Substantive*, focusing on the classical curriculum question about what knowledge is of most worth for inclusion in teaching and learning.
2. *Technical-professional*, referring to how to address tasks of curriculum development.
3. *Socio-political*, referring to curriculum decision-making processes, where values and interests of different individual and agencies are at stake.

Some might argue that this list is too limited as it refers especially to curriculum issues for "traditional" planning for learning in schools, and does not include the more "critical" perspectives that are amply present in curriculum theory literature (*e.g.* Pinar *et al*., 1995). However, from a primary interest in curriculum improvement, the three perspectives seem useful and appropriate.

Moreover, for the sake of technology-based innovations, it is important to notice that the various concepts, levels, perspectives and arguments in this section all have meaningful implications for a comprehensive approach.

The vulnerable curriculum spider web

One of the major challenges for curriculum improvement is creating balance and consistency between the various components of a curriculum (*i.e.* plan for learning). What are those components? The relatively simple curriculum definition by Walker (2003) includes three major planning elements: content, purpose and organisation of learning. However, curriculum design and implementation problems have taught us that it is wise to pay explicit attention to a more elaborated list of components. Elaborating on various typologies, we have come to adhere to a framework (see Table 6.2) of ten components that address ten specific questions about the planning of student learning.

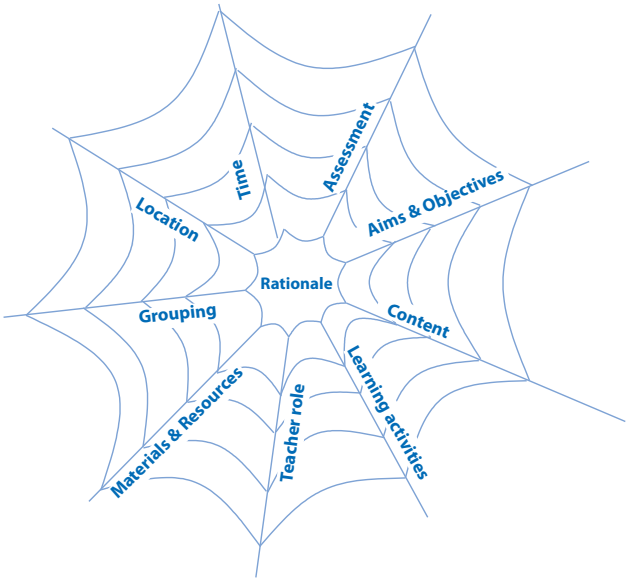
Table 6.2. **Curriculum components**

Rationale or Vision	Why are they learning?
Aims and Objectves	Toward which goals are they learning?
Content	What are they learning?
Learning Activities	How are they learning?
Teacher Role	How is the teacher facilitating learning?
Materials and Resources	With what are they learning?
Grouping	With whom are they learning?
Location	Where are they learning?
Time	When are they learning?
Assessment	How to measure how far learning has progressed?

The "rationale" (referring to overall principles or central mission of the plan) serves as major orientation point, and the nine other components are ideally linked to that rationale and preferably also consistent with each other. For each of the components many sub-questions are possible, not only on substantive issues (see the next section) but also, for example, on such "organisational" aspects as following:

- **Grouping**
  - How are students allocated to various learning trajectories?
  - Are students learning individually, in small groups or whole-class?
- **Location**
  - Are students learning in class, in the library, at home or elsewhere?
  - What are the social/physical characteristics of the learning environment?
- **Time**
  - How much time is available for various subject matter domains?
  - How much time can be spent on specific learning tasks?

Figure 6.1. **Curricular spider web**



Our preferential visualisation of the ten components is to arrange them as a spider web (Figure 6.1), not only illustrating its many interconnections but also underlining its vulnerability. Thus, although the emphasis of curriculum design on specific components may vary over time, eventually some kind of alignment has to occur to maintain coherence. A striking example is the trend toward integration of ICT in the curriculum with (usually) initial attention to changes in materials and resources. Many implementation studies have exemplified the need for a more comprehensive approach and systematic attention to the other components before one can expect robust changes.

The spider web also illustrates a familiar expression: every chain is as strong as its weakest link. That seems another very appropriate metaphor for a curriculum, pointing to the complexity of efforts to improve the curriculum in a balanced, consistent and sustainable manner.

Perspectives on substantive choices

A classic approach to the eternal question of what to include in the curriculum (or even more difficult as well as urgent: what to exclude from it) is to search for a balance between three major sources or orientations for selection and priority setting:

- Knowledge: what is the academic and cultural heritage that seems essential for learning and future development?
- Society: which problems and issues seem relevant for inclusion from the perspective of societal trends and needs?
- Learner: which elements seem of vital importance for learning from the personal and educational needs and interests of the learners themselves?

Answers to these questions usually constitute the rationale of a curriculum. Inevitably, choices have to be made, usually involving compromises between the various orientations (and their respective proponents and pressure groups). Oftentimes, efforts fail to arrive at generally acceptable, clear and practical solutions. The result of adding up all kinds of wishes is that curricula tend to get overloaded and fragmented. Implementation of such incoherent curricula eventually tends to lead to student frustrations, failure and dropout.

How to create a better curriculum balance? Easy answers are not available, but a few alternatives seem to have some promise. First, in view of the multitude of (academic) knowledge claims, it sometimes helps to reduce the big number of separate subject domains to a more limited number of broader learning areas, combined with sharper priorities in aims for learning (focusing on basic concepts and skills).

Second, referring to the avalanche of societal claims, more interaction between learning inside and outside the school may reduce the burden. However, the most effective response is probably to be more selective in reacting to all sorts of societal problems. As Cuban (1992) phrased it clearly: schools should not feel obliged to scratch the back of society every time society has an itch.

And third, about the learners' perspective: worldwide, many interesting efforts are ongoing to make learning more challenging and intrinsically motivating by moving from traditional, teacher and textbook-dominated instruction towards more meaningful and activity-based learning approaches.

Obviously, ICT creates new challenges but also offers new opportunities for addressing the substantive dilemmas described.

Development strategies

To sketch curriculum development as a problematic domain is actually an understatement. From a socio-political stance, it often seems more appropriate to describe it as a war zone, full of conflicts and battlefields between stakeholders with different values and interests. Problems manifest themselves in the (sometimes spectacular and persistent) gaps between the intended curriculum (as expressed in policy rhetoric), the implemented curriculum (real life in school and classroom practices), and the attained curriculum (as manifested in learner experiences and outcomes). A typical consequence of those tensions is that various frustrated groups of participants blame each other for the failure of reform or improvement activities. Although such blaming games often seem rather unproductive, there are some serious critical remarks to be made on many curriculum development approaches worldwide. First of all, many curriculum reform efforts can be characterised by overly big innovation ambitions (especially of politicians) within unrealistically short timelines and with very limited investment in people, especially teachers. Unfortunately, many ICT-related reforms have suffered from this problem. Second, oftentimes there is a lack of coherence between the intended curriculum changes with other system components (especially teacher education and assessment/examination programmes). And last but not least, timely and authentic involvement of all relevant stakeholders is often neglected.

From a strategic point of view, the literature has offered us many (technical-professional) models and strategies for curriculum development. Three prominent approaches are Tyler's rational-linear approach, Walker's deliberative approach, and Eisner's artistic approach. As it does not fit within the purpose of this chapter to explain those models in particular, the reader is referred to educative texts from Marsh and Willis (2003) or to the overview of prominent approaches in Thijs and van den Akker (2009).

Obviously, the context and nature of the curriculum development task at hand will determine to a large extent what kind of strategy is indicated. It is noteworthy that we are beginning to see more blended approaches that integrate various trends and characteristics of recent design and development approaches in the field of education and training (for an overview and a series of examples, see van den Akker *et al*., 1999; or van den Akker and Kuiper, 2009). Some key characteristics:

- Pragmatism: recognition that there is not a single perspective, overarching rationale or higher authority that can resolve all dilemmas for curriculum choices to be made. The practical context and its users are in the forefront of curriculum design and enactment.
- Prototyping: evolutionary prototyping of curricular products and their subsequent representations in practice is viewed as more productive than quasi-rational and linear development approaches. Gradual, iterative approximation of curricular dreams into realities may prevent paralysis and frustrations. Formative evaluation of tentative, subsequent curriculum versions is essential to such curriculum improvement approaches.
- Communication: a communicative-relational style is desirable in order to arrive at the inevitable compromises between stakeholders with various roles and interests and to create external consistency between all parties involved.
- Professional development: In order to improve chances on successful implementation, there is a trend towards more integration of curriculum change and professional learning and development of all individuals and organisations involved.

Design or development(al) research is a research approach that incorporates some of these characteristics, and it becomes even more promising by adding the element of knowledge growth to it. Such research can strengthen the knowledge base in the form of design principles that offer heuristic advice to curriculum development teams, when (more than in common development practices) deliberate attention is paid to theoretical embedding of design issues and empirical evidence is offered about the practicality and effectiveness of the curricular interventions in real user settings.

However, there are several persistent dilemmas for curriculum development that cannot easily be resolved, let alone through generic strategies. For example: how to combine aspirations for large-scale curriculum change and system accountability with the need for local variations and ownership? The tension between these conflicting wishes can be somewhat reduced when one avoids the all too common “one size fits all” approach. More adaptive and flexible strategies will avoid detailed elaboration and over-specification of central curriculum frameworks. Instead, they offer substantial options

and flexibility to schools, teachers, and learners. Although struggles about priorities in aims and content will remain inevitable, the principle of "less is more" should be pursued. However, what is incorporated in a core curriculum should be clearly reflected in examination and assessment approaches.

The "enactment" perspective (teachers and learners together create their own curriculum realities) is increasingly replacing the "fidelity" perspective on implementation (teachers faithfully follow curricular prescriptions from external sources). That trend puts even more emphasis on teachers as key people in curriculum change. Both individual as well as team learning is essential (Fullan, 2007). Teachers need to get out of their customary isolation. Collaborative design and piloting of curricular alternatives can be very productive, especially when experiences are exchanged and reflected upon in a structured curriculum discourse. Interaction with external facilitators can contribute to careful explorations of the "zone of proximal development" of teachers and their schools. Cross-fertilisation between curriculum, teacher, and school development is a *conditio sine qua non* for effective and sustainable curriculum improvement. The increasingly popular mission statements of schools to become attractive and inspiring environments for students and teachers can only be realised when such integrated scenarios are practised.

The potential of curriculum design research

Various motives for initiating and conducting curriculum design research can be mentioned. A basic motive stems from the experience that many research approaches (*e.g.* experiments, surveys, correlational analyses), with their focus on descriptive knowledge, hardly provide prescriptions with useful solutions for a variety of design and development problems in education. Probably the greatest challenge for professional designers is how to cope with the manifold uncertainties in their complex tasks in very dynamic contexts. If they do seek support from research to reduce those uncertainties, several frustrations often arise: answers are too narrow to be meaningful, too superficial to be instrumental, too artificial to be relevant, and, on top of that, they usually come too late to be of any use. Curriculum designers do appreciate more adequate information to create a solid ground for their choices and more timely feedback to improve their products. Moreover, the professional community of developers as a whole would be helped by a growing body of knowledge of theoretically underpinned and empirically tested design principles and methods.

Another reason for curricular design research stems from the highly ambitious and complex nature of many curriculum reform policies in education worldwide. These reform endeavours usually affect many system components, are often multi-layered, including both large-scale policies and small-scale realisation, and are very comprehensive in terms of factors

included and people involved. Those radical "revolutions", if promising at all, cannot be realised on the drawing table. The scope of diverse needs is often very wide, the problems to be addressed are usually ill-specified, the effectiveness of proposed interventions is mostly unknown beforehand, and the eventual success is highly dependent on implementation processes in a broad variety of contexts. Therefore, such curriculum reform efforts would profit from more evolutionary (interactive, cyclic, spiral) approaches, with integrated research activities to feed the process (both forward and backward). Such an approach would provide more opportunities for "successive approximation" of the ideals and for more strategic learning in general. In conclusion: curriculum design research seems a wise and productive approach for curriculum development. And innovative efforts to integrate ICT in education is an excellent example of such challenges.

Features of curriculum design research

Curriculum design research is often initiated for complex, innovative interventions for which only very few validated principles are available to structure and support the design and development activities. Since in those situations the image and impact of the intervention to be developed is often still unclear, the research focuses on realising limited but promising examples of those interventions. The aim is not to elaborate and implement complete interventions but to come to (successive) prototypes that increasingly meet the innovative aspirations and requirements. The process is often iterative, cyclic or spiral: analysis, design, evaluation and revision activities are iterated until a satisfying balance between ideals and realisation has been achieved.

To what extent do these design research activities differ from what is typical for design and development approaches in professional practices? What are the implications of the accountability of researchers to the "scientific forum"? At the risk of exaggerating the differences, let us outline some of them, based on what is known about routinised standard-patterns in curriculum development practices. Of course, a lot of activities are more or less common for both approaches, so the focus will be on those additional elements that are more prominent in design research than in common design and development practices.

Preliminary investigation

A more intensive and systematic preliminary investigation of curriculum tasks, problems and context is made, including searching for more accurate and explicit connections of that analysis with state-of-the-art knowledge from literature. Some typical activities include: literature review; consultation of experts; analysis of available promising examples for related purposes; case

studies of current practices to specify and better understand needs and problems in intended user contexts.

Theoretical embedding

More systematic efforts are made to apply state-of-the-art knowledge in articulating the theoretical rationale for curriculum design choices. Moreover, explicit feedback to assertions in the design rationale about essential characteristics of the intervention (substantive design principles) is made after empirical testing of its quality. This theoretical articulation can increase the "transparency" and "plausibility" of the rationale. Because of their specific focus, these theoretical notions are usually referred to as "mini" or "local" theories although sometimes connections can also be made to "middle-range" theories with a somewhat broader scope.

Empirical testing

Clear empirical evidence is delivered about the practicality and effectiveness of the curriculum for the intended target group in real user settings. In view of the wide variation of possible interventions and contexts, a broad range of (direct/indirect; intermediate/ultimate) indicators for "success" should be considered.

Documentation, analysis and reflection on process and outcomes

Much attention is paid to systematic documentation, analysis and reflection on the entire design, development, evaluation and implementation process and on its outcomes in order to contribute to the expansion and specification of the methodology of curriculum design and development.

Typical questions for design research are:

- What are essential features of successful interventions? (For complicated challenges or "wicked" problems, *cf.* Kelly, 2009.)
- How do those interventions operate in real life?
- How can they be developed and implemented?

In view of its aim, design research is never a "quick fix" operation, but it usually takes a long trajectory, where the research is intertwined with continuous development activities – from problem formulation up to and including implementation.

More than most other research approaches, design research aims at making both practical and scientific contributions. In the search for innovative

"solutions" for curriculum problems, interaction with practitioners (in various professional roles: teachers, policy makers, developers, and the like) is essential. The ultimate aim is not to test whether theory, when applied to practice, is a good predictor of events. The interrelation between theory and practice is more complex and dynamic: is it possible to create a practical and effective curriculum for an existing problem or intended change in the real world? The innovative challenge is usually quite substantial, otherwise the research would not be initiated at all. Interaction with practitioners is needed to gradually clarify both the problem at stake and the characteristics of its potential solution. An iterative process of "successive approximation" or "evolutionary prototyping" of the "ideal" intervention is desirable. Direct application of theory is not sufficient to solve those complicated problems. One might state that a more "constructivist" development approach is preferable: researchers and practitioners co-operatively construct workable interventions and articulate principles that underpin the effects of those interventions.

Another reason for co-operation is that without involvement of practitioners it is impossible to gain clear insight in potential curriculum implementation problems and to generate measures to reduce those problems. New interventions, however imaginative their design, require continuous anticipation at implementation issues. Not only for "social" reasons (to build commitment and ownership of users) but also for "technical" benefits: to improve their fitness for survival in real life contexts. Therefore, rigorous testing of practicality is a *conditio sine qua non* in design research.

Emphasis on formative evaluation

As has become clear in the previous sections, formative evaluation holds a prominent place in curricular design research. The main reason for this central role is that formative evaluation provides the information that feeds the optimisation of the intervention and the cyclic learning process of curriculum developers during the subsequent loops of a design and development trajectory. It is most useful when fully integrated in a cycle of analysis, design, evaluation, revision, etc., and when contributing to improvement of the curriculum.

Thus, the basic contribution of formative evaluation is to quality improvement of the curriculum under development. Quality, however, is an abstract concept that requires specification. During development processes, the emphasis in criteria for quality usually shifts from relevance to consistency, to practicality, to effectiveness.

Relevance refers to the extent that the intended curriculum is perceived to be a relevant improvement to practice, as seen from the varied perspectives of policy makers, practitioners and researchers. *Consistency* refers to the extent that the design of the curriculum is based on state-of-the-art knowledge and

that the various components of the intervention are consistently linked to each other (*cf.* the curricular spider web). *Practicality* refers to the extent that users (and other experts) consider the intervention as clear, usable and cost-effective in "normal" conditions. *Effectiveness* refers to the extent that the experiences and outcomes with the intervention are congruent with the intended aims. Also, issues of scalability and sustainability may be included in a broad interpretation of effectiveness.

The methods and techniques for evaluation will usually be attuned to that shift in criteria (*cf.* the various stages of alpha, beta and gamma testing in the IT sector). For example, adequate evaluation of validity can start with comments of critical friends on initial drafts and then move over to more systematic expert appraisal. Practicality is often tested *via* micro-evaluations and try-outs in real classroom practices. Evaluation of effectiveness usually requires (more large-scale) field tests. In later stages of formative evaluation, methods of data collection will usually be less intensive but with an increasing number of respondents (*e.g.* achievement test for many students at the end compared to in-depth interview with a few experts in the beginning). See Nieveen (2009) for more elaborate explanations and suggestions for these shifts in formative evaluation.

Formative evaluation within design research should not only concentrate on locating shortcomings of the intervention in its current (draft) version but especially generate suggestions on how to improve those weak points. Richness of information, notably salience and meaningfulness of suggestions on how to make an intervention stronger, is therefore more productive than standardisation of methods to collect and analyse data. Also, efficiency of procedures is crucial. The lower the costs in time and energy for data collection, processing, analysis and communication will be, the bigger the chances of actual use and impact on the development process. For example, samples of respondents and situations for data collection will usually be relatively small and purposive compared to sampling procedures for other research purposes. The added value of getting "productive" information from more sources tends to decrease because the opportunities for "rich" data collection methods (such as interviews and observations) are limited with big numbers. To avoid an overdose of uncertainty in data interpretation, often triangulation (of methods, instruments, sources and sites) is applied. These arguments especially hold true for early stages of formative evaluation when the intervention is still poorly crystallised.

Generalisation of curricular design research findings

In practical terms, the most relevant outcome of curricular design research is its contribution towards optimisation of the curricular product and its actual use, leading to better instructional processes and learning results. However, a

major contribution to knowledge to be gained from design research is in the form of "design principles" (both substantive and methodological) to support developers in their task. Those principles are usually incorporated within (a growing set of) heuristic statements, following a format such as:

- *If you want to design intervention X [for purpose/function Y in context Z]*
- *then you are best advised to give that intervention the characteristics* $C_1, C_2, \ldots, C_m$ *[substantive emphasis]*
- *and to do that via procedures* $P_1, P_2, \ldots, P_n$ *[procedural emphasis]*
- *because of theoretical arguments* $T_1, T_2, \ldots, T_p$
- *and empirical arguments* $E_1, E_2, \ldots, E_q$.

Obviously those principles cannot guarantee success, but they are intended to select and apply the most appropriate (substantive and procedural) knowledge for specific design and development tasks.

It is not uncommon in design research that such knowledge, especially the substantive knowledge about essential curriculum characteristics, can partly be extracted from a resulting prototype itself. That is one of the reasons that makes it so profitable to search for and carefully analyse already available curricula to generate ideas for new design tasks. However, the value of that knowledge will strongly increase when justified by theoretical arguments, well-articulated in providing directions, and convincingly backed-up with empirical evidence about the impact of those principles. Moreover, those heuristic principles will be additionally powerful if they have been validated in successful design of more interventions in more contexts. Chances for such knowledge growth will increase when design research is conducted in the framework of research programmes, because projects can then build upon one another.

Since data collection in design research is often limited to small (and purposive) samples, efforts to generalise findings cannot be based on statistical techniques, focusing on generalisations from sample to population. Instead one has to invest in "analytical" forms of generalisation (*cf.* Yin, 2003): readers/users need to be supported to make their own attempts to explore the potential transfer of the research findings to theoretical propositions in relation to their own context. Reports on design research can facilitate that task of analogy reasoning by a clear theoretical articulation of the design principles applied and by reflection on the results afterwards. Moreover, it is helpful to offer a careful description of both the evaluation procedures as well as the implementation context. Especially a "thick" description of the process-in context may increase the "ecological" validity of the findings, so that others can estimate in what respects and to what extent transfer from the reported situation to their own is possible. Another option that may stimulate exploration

of possibilities for (virtual) generalisation and transfer to various settings is to organise interactive (network) meetings with experts and practitioners from related contexts to discuss the plausibility of the research findings and recommendations for related tasks and contexts.

Last but not least, curricular design research may offer drafts of various relevant curriculum versions (with proven consistency and practicality) that can be compared in more quantitative, large-scale (quasi-)experimental studies.

Conclusions

In view of the (rapidly growing but still relatively) modest familiarity of educational design research to the wider audience, it is wise to invest a lot in the transparency, plausibility, "trustworthiness", and "reconstructiveness" of its arguments and findings. Also at stake is the "credibility" (expertise in depth and breadth; track record) of research team and partners.

For closure, we briefly mention some research characteristics that strengthen the growth of knowledge through design research:

- "Standing on shoulders": less isolated studies, but deliberate efforts to build on previous research and development work through a programmatic approach.
- Variation and adaptability in intervention and methodology.
- Deliberate triangulation in sites and sources of data gathering.
- Increasing insight in essence of successful interventions *versus* variations in other features.
- Preventing premature closure to seemingly effective but limited interventions.
- Knowledge sharing and distribution through systemic partnerships and networks.
- Involvement and joint professional development of many partners: teachers, school leaders, teacher educators, researchers, curriculum and textbook developers, assessment specialists, etc.

The more these characteristics receive attention, design research is also a very promising avenue for technology-based innovation.

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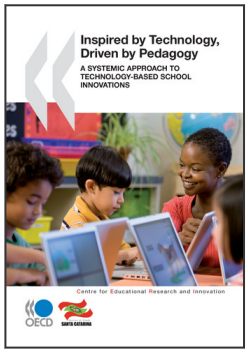

From:

Inspired by Technology, Driven by Pedagogy

A Systemic Approach to Technology-Based School Innovations

Access the complete publication at:
https://doi.org/10.1787/9789264094437-en

Please cite this chapter as:

van den Akker, Jan (2010), "Design research on technology-based innovations", in OECD, *Inspired by Technology, Driven by Pedagogy: A Systemic Approach to Technology-Based School Innovations*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/9789264094437-9-en

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