Chapter 34

Design Research Focusing on the roles of Multiple Stakeholders in the Development of a Professional Development Programme for Early Childhood Teachers

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Contents

34. Design research focusing on the roles of multiple stakeholders in the development of a professional development programme for early childhood teachers

Abstract 713

1. Introduction to the problem 713

2. Analysis phase 717

3. Prototyping phase 722

4. Assessment phase and yield of the project 725

Key sources 728

References 728

Credits

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Abstract

In this case study the processes and outcomes of an educational design research project focusing on the creation of a professional development programme for early childhood teachers to foster inquiry-based science education are discussed. Within this project a research model based on the methodology of educational design research was developed and refined. This model is used to discuss the different phases of the research process, the involvement of stakeholders during the whole research project, the role of the project team, and the 'unpredictability' of the project's outcomes. With the assistance of experts in methodology, the project team developed insights into combining diverse forms of formative evaluation and data processing. This chapter also shows how the project team gained expertise in the active and intensive cooperation with a diverse group of stakeholders.

One of the key and crucial aspects contributing to the success of the research has been the open and appreciative relationship between stakeholders and members of the project team.

1. Introduction to the problem

The problem in context

In Flanders, early childhood education is free for children from the age of 2,5 up to the ages of 6. Within this context both literature (e.g. Entiteit Curriculum, 2007) and observations from practice indicate that Flemish early childhood and primary school teachers are too often directing the actions and thinking of their classroom children. As a consequence, young children are not fully encouraged to find creative solutions to problems they experience, or, put differently, to learn to learn in an environment that stimulates inquiry. In this context, young children's skills in solving problems and exploring their environment may be insufficiently encouraged or developed. Inquiry-based learning opportunities and early explorations are important for the general and scientific development of children, as stressed by Johnston (2005) in her book 'Early explorations in science'. Indeed, Laevers (2002) clearly highlights the importance of such experiences at a young age, stating that '*It is not by seeding mathematics that one will harvest better engineers, but by putting them in a firm background of experience on which they can inoculate abstract ideas*'.

In this context, it is interesting to see that researchers are focusing on young children's early explorations and experiences (Siry & Kremer, 2011; Eshach & Fried, 2005; Akerson, Buck, Donelly, Nargund-Joshi, & Weiland, 2011). For instance, the project group 'Talentenkracht' (Power of talent) in the Netherlands explores the link between the encouragement of inquiry learning and beta-thinking of young children, and how this influences their future choice for beta-sciences (science, maths and technology) (Raijmakers, 2008). The consequence of learning through inquiry is that teachers may have less control over the progress of the activities

and thus need to be creative and innovative. It is particularly important within science subjects that children can learn from their own experiences, although misconceptions must be avoided. It is clear from literature (Kallery & Psillos, 2001; Rohaan, Tacaonis, & Jochems, 2008) that science (and technology) can indeed be taught in a proper manner if teachers possess enough, correct and relevant knowledge to respond to events within a child's environment, to translate complex scientific questions of children into researchable questions, and support children in their development.
In other words, there is a clear need to support teachers in becoming more skilled at fostering an inquisitive attitude, i.e., an attitude that fosters inquiry in their classroom children.
This highlights the need for an effective professional development programme. However, it is necessary to tailor such a programme to the needs of early childhood teachers, and, as such, early childhood teachers should be closely involved in the development of such professional development programmes.
For this context, the 'educational design research' methodology (Plomp & Nieveen, 2009; Van den Akker, Gravemeijer, McKenney, & Nieveen, 2006) was the most appropriate method to conduct the study on the development of a professional development programme for early childhood teachers to foster inquiry-based education, dominantly because of the opportunity of involving teachers as co-researchers and different other stakeholders.

Research question
The educational design-based research project presented in this case study is structured around the following research question: "*What are the characteristics of a professional development programme for early childhood teachers to foster and support inquiry-based science education in their classrooms?"*
This research question is further translated into the following sub-questions identified by the project team:
RQ 1: What are the characteristics of learning environments for young children that foster inquiry and exploration?
RQ 2: What are the basic principles of inquiry-based science teaching in early childhood education?
RQ 3: What are the main characteristics of professional development programmes for early childhood teachers?
RQ 4: What are the needs of early childhood teachers to foster inquiry in their classrooms and beyond?

These research questions were answered using a range of data collection methods during the analysis phase as well as in the prototyping phase. In this chapter reference is made to each research question by using its corresponding number (rq 1, rq 2, rq 3 and rq 4). To expound the line of reasoning a brief overview of the research actions and their effects on the outcomes is given below.

A review of the literature provided the general aspects of inquiry-based science teaching and learning environments that foster inquiry and exploration (rq 1 and 2). These general characteristics were discussed and fine-tuned in collaboration with practitioners and experts in the field. Observations of teachers with their children inside and outside the schools during the analysing and prototyping phases were necessary to enrich the findings from both the literature and the discussions.
To ascertain the needs of the different participating practitioners (rq 4), the team observed the practitioners during the different try-out sessions in the project, such as the intake session and

other prototype sessions of the professional development programme. After every session the project members used critical reflection to analyse the needs and teaching style of the different teachers in order to adjust the programme. Conversations and digital communication with the practitioners were also analysed in order to gain insight into their reasoning and knowledge. The main characteristics of a professional development programme (rq 3) were ascertained by reviewing the literature and consulting stakeholders during the analysing phase.

Based on these data, sessions of the professional development programme were developed and refined over several micro-cycles of design. The amount of data and the participation of a diverse group of stakeholders resulted in additional outcomes, including a vision, a handbook, educational didactics, an observation guide, an initial teacher education course, a professional development programme, and an educational design model.

Applied research approach

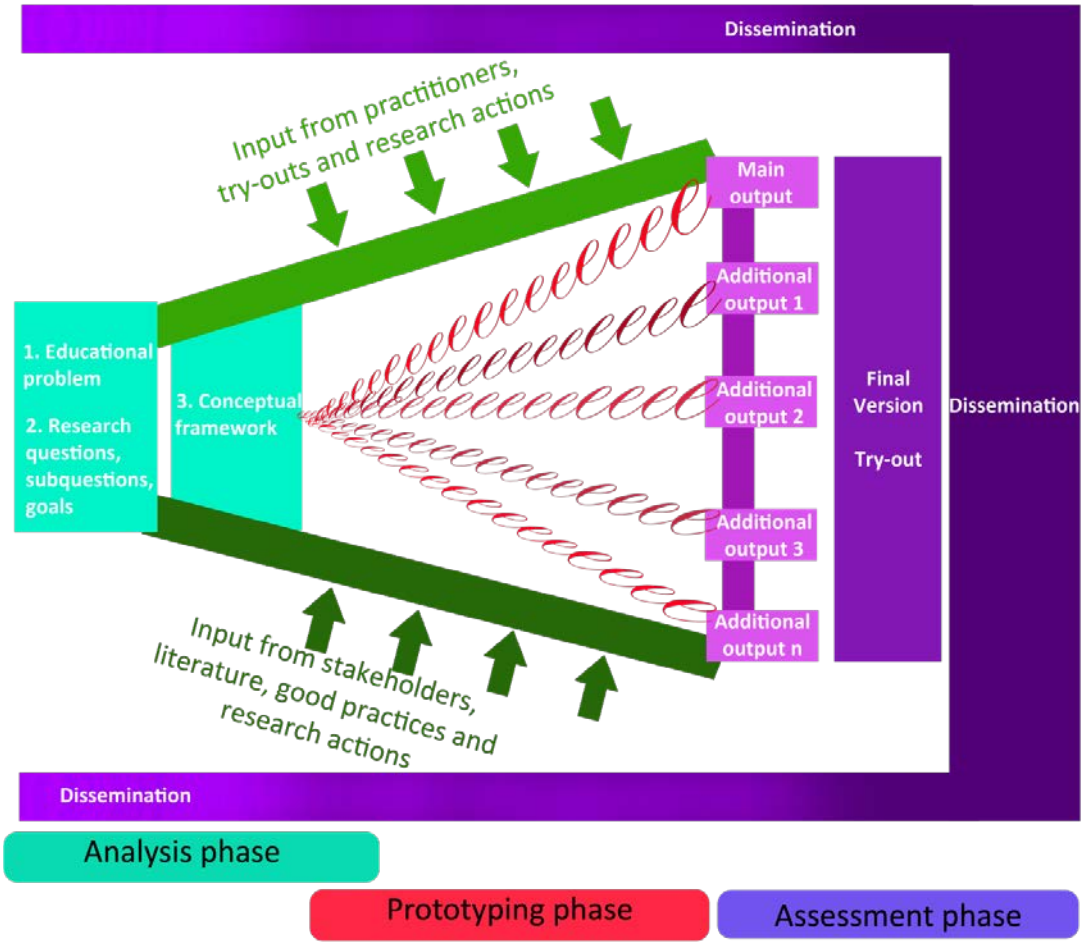
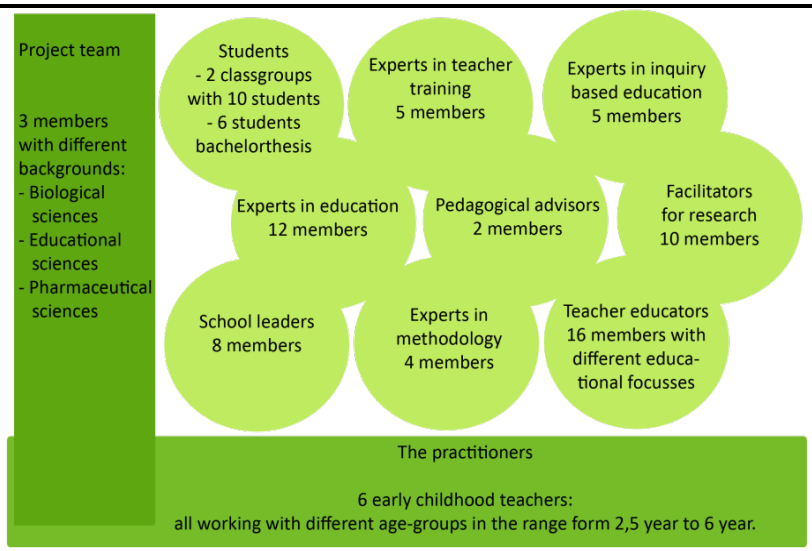


Figure 1: Educational design based model

The main structure of the model presented in Figure 1 is based on literature in educational design research (Plomp & Nieveen, 2009), and was further adapted based on the project teams' experiences in former educational design research projects (Van Houte, Martens, Devlieger, & Ollieuz, 2009; Devlieger, Ollienz, Martens, Schaffler, Mertens, Remerie, & Van Houte, 2010).

The project was divided into three phases: Figure 1 illustrates the three phases of the research projects' educational design research model: (1) a preliminary phase or analysis phase, (2) a development phase or prototyping phase, and (3) an assessment phase. The model shows that the main and additional outputs were all designed using iterative processes during the prototyping phase. During the processes there was input from practitioners and other stakeholders; literature and good practices were selected and try-outs were carried out. As the input and active participation of practitioners was considerably higher, they were placed separately into Figure 1. In this specific project the outputs were: a vision, a handbook, educational didactics, an observation guide, an initial teacher education course, a professional development programme, and an educational design model. The different phases of the model will be further presented and explained in this case study chapter.

During each phase of this educational design research project, several stakeholder groups were highly involved. Figure 2 presents the different stakeholders engaged in the project: practitioners – early childhood teachers (Pr), school leaders (SL), experts in research methodology (EM), teacher educators (TE), experts in education (EE) including educative coordinators in musea or coordinators of educational projects from the government, pedagogical advisors (PA), facilitators for research (FR) including research coaches from the university college, experts in inquiry-based science education (EI), experts in teacher training (ET), and students in teacher training (St). Because of their high involvement in the project, the practitioners - the early childhood teachers - were considered as co-researchers (see Figure 2). This means that practitioners acted as co-designers in the development of the prototypes based on the design principles. At the same time they also had to test, evaluate and refine the prototypes in collaboration with the project team. Since formative research data, regarding aspects such as teachers' style and beliefs, had to be discussed with other stakeholders as well as school leaders, the privacy of the teachers was respected from the start of the project. Figure 2 further illustrates the central position of the core participants - the members of the project team (PT) and the practitioners (Pr) - in the axes. These axes represent the researchers of the project surrounded by the different stakeholders. As illustrated by the connected circles, these groups of stakeholders interacted during several research actions in the analysis and prototyping phase (see below). All participating stakeholders were directly involved in the research, and aware of their active role in the research. The social interactions (face-to-face interactions; exchange of ideas, experiences, and opinions) between these different stakeholders, in or between members of the same of different groups, were substantial and enriched the research. In Table 2 (see below) an overview is presented of the formative research actions and in which the different stakeholders were involved.



code	Stakeholdergroups
Pr	*Practitioners*
SL	*School leaders*
EM	*Experts in methodology*
TE	*Teacher educators*
EE	*Experts in education*
PA	*Pedagogical advisors*
FR	*Facilitators for research*
EI	*Experts in inquiry-based education*
ET	*Experts in teacher training*
St	*Students*
PT	*Project team*

Figure 2: Stakeholders

2. Analysis phase

The main goal of the analysis phase was the development of the first version of criteria for the professional development programme. For this purpose a conceptual framework was constructed based on a literature review, an analysis of the practical context of the early childhood teachers, and different consultation rounds with the stakeholders (see Figure 2). The intensive involvement of the same stakeholders in both the analysis and the prototyping phase led to an interaction or overlap between these phases, as illustrated in Figure 1. For example, the analysis of the practical context provided suggestions for the design of the prototypes, and these suggestions were tested by the practitioners (Pr) (illustrated by the line above the conceptual framework in Figure 1).

Review of relevant literature

Consistent with the research goals, the literature review focused on research on learning environments for young children that foster exploring and inquiry as well as research on characteristics of a professional development programme.

Learning environments for young children that foster inquiry-based science education - rq 1 and rq 2

Inquiry and inquiry-based education are not easy to define (European Commission, 2007). The use of the concept ‘inquiry’ in an educational context seems to be characterized by a lack of clarity in terminology (Eurydice, 2011). In a more concrete context of science education, the inquiry-concept refers to at least three distinct categories of activities (Minner, Levy, & Century, 2010). It first refers to what scientists do (e.g., conducting investigations using scientific methods), second, to how students learn (e.g., actively inquiring through thinking and doing in relation to a phenomenon or problem, often mirroring the processes used by scientists), and finally, to a pedagogical approach that teachers may employ (e.g., designing or using curricula that allow for extended investigations). However, these activities are more strongly linked with secondary education than with early childhood education. Furthermore, no suggestions were found concerning the establishment of learning environments for young children.
Exploration and inquiry are also key elements in approaches such as ‘Reggio Emilia’, experiential education and High Scope (Brouwers, 2010). These approaches are characterized

by an “open framework” approach or a “child-centered approach”. This means that the child has the freedom to think, experience, explore, question and search for answers. The role of the adult is characterized by active listening and observation. In these approaches communication, interaction and a rich environment are essential. In this respect, young children have the opportunity to develop a strong basis for later abstract learning. Children get time to develop an intuitive understanding of the properties of the material world around them, of spatial relations and of quantities (Laevers, 2005).
Broderick and Hong (2005) support these approaches by stating that an inquiry curriculum is often negotiated in the sense that both children and teachers have input into how the curriculum is designed. They speak about ‘inquiry teachers’ who must be open to children’s strengths, challenges, questions, theories, interests and perspectives (Worth & Grollman, 2003).
For this research project, determining a vision on inquiry-based science education in early childhood education, based on the principles of the open framework approaches (active listening, observation, initiative of the child), was identified as one of the key development principles.

Characteristics of professional development programmes – rq 3

In order to further construct the design principles of a professional development programme, a literature review was conducted to clearly identify the main characteristics of professional development programmes.
Literature on change in education teaches us that professional development should be *long term*, with several short-term, realistic, and manageable goals in mind (Dawson & Suurtamm, 2003). This is confirmed by Selmi (2009), who argues that professional development must be a permanent process that rebuilds the knowledge of the teacher, and fosters curiosity, inquiry and exchange. Teachers must have time and ample opportunities to reflect and discuss their ideas with others (e.g. teachers and experts). Such opportunities are provided in ‘professional learning communities’ as these initiatives encourage sharing, discussion, exchange, and collaboration among its members. Indeed, research on professional development (e.g. Borko, 2004) provides evidence that strong professional learning communities are important contributors to instructional improvement and school reform. According to Borko (2004), the role of the leader or facilitator in these communities is crucial to the success of the professional development programme. Facilitators must be able to establish a community of learners in which inquiry and critical dialogue is valued, and they must structure the learning experiences for that community. Continuous professional development facilitators need to be experts on the content as well as experts in adult and professional learning (Cordingley, Bell, Rundell, & Evans, 2007).
Furthermore, professional development is strongly shaped by the context in which the teacher works (Timperley, 2008; Borko, 2004). This implies that when designing professional learning opportunities, it is important to consider teachers’ prior knowledge of curriculum and assessment and how they view existing practices. The link between teacher learning and pupil learning appears to be another element in designing professional development programmes (Schollaert, 2011). Timperley (2008) argues that professional development cannot be called effective unless it leads to improved pupil outcomes. Davies (2010) also stresses the necessity of full commitment and trust. The author found that learning activities designed to raise engagement and develop teachers’ skills, knowledge, and enthusiasm were: classroom workshops, consultancy, and educational visits.
To conclude, the following characteristics were identified as key elements that need to be considered when designing a professional development programme: a long term and community-based programme, taking into account the prior knowledge and beliefs of teachers,

fostering inquiry and critical dialogue among teachers, considering the teacher educators as facilitators and experts, improved pupil outcomes, and full commitment and trust of all participants.

Analysis of the practical context

The analysis of the practical context consisted of two different elements. Teachers and school leaders were screened during an intake session. The teachers' inquiry practices, teaching style and the classroom environment were observed during classroom visits using observation lists and video recall. As mentioned above, the analysis of the practical context provided insight into the needs of the teachers and enriched the findings from the literature.

Intake sessions – rq 4

During an intake session teachers and school leaders were screened together in their own school to give the research team the opportunity to closely screen the diversity of the practitioners and the school leaders. Diversity is related to their teaching practices, their learning styles, their motivation to facilitate the research and to act as co-researchers.
The project team selected nine schools for intake screening, based on earlier participation in projects or on the recommendation of teacher educators. The screening process included a) an informative talk about the goal of the research, the role of the teachers and school leaders, the conditions of the cooperation, and the possible benefits; and b) an interview with the teachers concerning their classroom practices and with the school leaders concerning the schools' pedagogical project. These interviews provided part of the information about the starting situation and the diversity of the different participants. Only when the teacher agreed to fully engage in the project and the school leader agreed to facilitate the cooperation, could they join in with the practitioner group or the school leader group (see Figure 2). Finally seven schools agreed to participate. The six teachers involved were early childhood teachers from classes with children aged 2,5 to 6 years old.

Analysis of the practical context using video recall and observation lists – rq 1, 2 and 4

In order to get acquainted with the teachers' teaching styles, their ideas about inquiry education and teaching, and their perceptions of their teaching practice, all participating teachers and their classroom children were observed during inquiry activities within a predefined subject theme (water, sand or light).
Prior to these observations, in a preliminary group session teachers received instruction about the inquiry activities, background information on the subject themes (water, sand and light), and a box with day-to-day materials relevant for the subject theme. No pedagogical or didactical information was provided in order to not influence the teachers in their preparations and practice.
Each teacher was observed in their own classroom by two researchers: one researcher videotaped the activities, the other one observed the activity using a fixed coding list. Afterwards, the videos were watched and discussed together with the teachers using the coding list. The results were analysed by the researchers and discussed with the participating teachers during a second group session using the videos of the different inquiry activities. Special attention was also given to the needs of each teacher (e.g. information about didactics, information about content, discussions about visions, and reflection on the actions of children). Based on the analysis of the inquiry activities and the teachers' styles, the role of the researchers changed, and they increasingly became coaches, consultants and experts.

Consultation of stakeholders

Stakeholders from every group (see Figure 2) were consulted regarding their expertise on or experiences with inquiry-based education and professional development programmes.

Inquiry-based education – rq 1 and 2

The advice of experts was invoked by using focus groups in order to translate 'inquiry-based learning and education' into education that fosters an inquisitive attitude, and to formulate the research teams' vision on inquiry-based learning and education. Two focus groups were organized: one group with teacher educators (TE), and another group consisting of pedagogical advisors (PA), research facilitators (FR), experts in teacher training (ET), inquiry-based education (EI), and methodology (EM). The focus group meetings were recorded and important issues concerning inquiry and inquiry-based education, and the role of teachers and learning environments, were extracted and further analysed by the project team. Additional interviews with individual experts were conducted to test and elaborate on these issues. Based on the results of both the discussion groups and the interviews, it became clear that the terms 'inquiry-based learning', 'inquiry-based teaching' and 'inquiry-based education' were very confusing, and different stakeholders had different opinions. However, they all agreed that education has to foster creativity, inquiry, curiosity, exploration, engagement, and conversation. Active learning and more natural learning was found to be important, and education was to be considered more from a holistic point of view.

The findings of the brainstorm group discussions confirmed the necessity of developing a common vision about inquiry learning, inquiry teaching and fostering/developing an inquisitive attitude. In order to be relevant for a broader field of practitioners, teacher educators, and educational advisors, this vision needed to be constructed in collaboration with the participating stakeholders.

Professional development programme fostering inquiry-learning – rq 3

On the basis of the project team's experiences in earlier teacher training programmes, interviews with experts specialized in training programmes (e.g. pedagogical advisors (PA)), focused interviews with school leaders, and brainstorm sessions with practitioners (Pr) during the first session, a list of criteria concerning the professional development programme was created. This list was combined with other data to extract the design principles of the professional development programme (see Table 1).

One of the major criteria is that the focus has to be on the development of a curious, inquisitive, reflective and critical attitude. The same philosophy was found in the objectives of a professional training programme about science and technology in the Netherlands (Walma van der Molen & Kuijpers, 2010). This programme assumes that the development of an inquisitive attitude is more important than training in subject knowledge. Furthermore, the six aspects of a 'scientific' inquisitive attitude (Van der Rijst, 2007), i.e., wanting to know, understand, criticize, share, achieve and innovate, were also taken into account.

Design principles and implications of the analysis phase

In this analysis phase the necessary requirement of *a complete and strong vision* concerning fostering and developing an inquisitive attitude in young children emerged. The issues extracted from the focused interviews with experts and practitioners in combination with the results of the literature review were used to design important key aspects, from which a first-draft vision text concerning inquiry in early childhood education was created. The vision text was further developed during the prototyping phase (see below). Key aspects of the analysis phase were:

- Young children are natural born inquirers, explorers and researchers.
- Teachers have to start from the child itself by, for example, listening to the children, observing the children, taking the perspective of the child, seeing talents in children.
- Teachers have to become inquirers/researchers themselves.
- It is important to see opportunities in daily (school)life.
- During learning activities:
  - teachers have to encourage creative problem solving*:* more than one solution is possible for every problem;
  - teachers have to encourage self-regulation;
  - teachers have to provide materials and rich contexts;
  - teachers have to encourage the recording, expression and exchange of aspects such as ideas, results and observations (oral, visual, digital, practical);
  - teachers have to provide time to execute the learning activity.

Based on these key aspects (vision) and on other results from the literature review, the analysis of the practical context, and the consultation of stakeholders, the *design principles of the professional development programme* were developed using the spider web model of van den Akker (2009). The key aspects were seen as the rationale of the programme and the criteria for development were structured following the eight components of van den Akker's model (see Table 1: prototypical design principles).

Table 1: Prototypical design principles

Time	• The programme has to be longer than one year and professional development does not end after a training programme. • Teachers need time to learn in a natural way and to become inquirers, facilitators and reflective practitioners.
Location	• The programme can be conducted both in and outside the school environment (e.g. outdoor, museum), in a real-classroom context and in each place where inquiry is possible.
Teacher educator role	• The teacher educator should act as a coach, facilitator, expert and consultant. She/he can be consulted during and outside the sessions. • The teacher educator must encourage the teachers to become inquirers themselves; to learn through discussion with other teachers. • The teacher educator should encourage the self-belief of the practitioners. • The teacher educator should enhance the teachers' information skills and familiarity with science so the teacher is able to react to unanticipated events in the child's environment. • The teacher educator should take the teaching style, the beliefs and the teaching practices of the participants into account.
Learning activities	• Theory should be applied as concretely and actively as possible. Teachers must experience the same things children experience so that they can better assess the learning process of children and the time these children need to learn. Teachers have to see and experience the phenomena themselves. Teachers have to experiment, handle and play with the materials the children will be using. • It must be possible for teachers to acquire new ideas and innovative practices.

Table 1: Prototypical design principles (continued)	
	• It must be possible for teachers to learn from each other (watch inspiring practices) by conducting classroom visits. • Teachers should learn to listen to and observe children, learn to interact with them and to act as a coach. • Teachers should learn to use children's questions to start and encourage further investigation. • During the programme the development of a learning community as described by Schollaert (2011) should be empowered.
Content	• In the programme there is no need for a specific scientific content, everything in the world around the children and in the environment of school and classroom can be used.
Assessment	• The programme should use observation lists and video recall during individual sessions with teachers. • The programme should use stories of the teachers, drawings made by the children and stories of the children (written down by parents) during group and individual sessions.
Grouping	• In the programme group sessions should alternate with individual sessions. • The groups in the programme should be limited to a maximum of 10 teachers. • In the programme individual sessions in real-classroom contexts with video feedback are needed to reflect on current practices and to combine them with new approaches. • The programme should organize separate sessions with school leaders.
Materials and resources	• The programme should use materials of everyday life (no special equipment for science lessons). • The programme should use multimedia and resources such as web-based resources, articles from educational journals, books, and databases. • The programme should give access to materials and resources fostering inquiry-based learning and exploration.

3. Prototyping phase

As mentioned above, and illustrated in Figure 1, the analysis phase emerged in the prototyping phase. This is due to the fact that all participating stakeholders were already intensively involved in the analysis phase. They also had a strong impact on the research process and the dissemination activities which resulted in several additional outputs (see Figure 1), such as a publication of the common vision on inquiry education (rq 1 and 2), educational didactics combining fantasy, science and inquiry (rq 1 and 2), an observation guide (rq 4), an initial teacher training, and the design-based research model (this chapter). As mentioned above, during the prototyping phase the main and additional outputs were all designed using an iterative process. This iterative process is illustrated in Figure 1 by the micro-cycles of design.

In this project all research steps and formative evaluation actions focused on the main goal *"to foster the inquiry learning of young children and their teachers".* The different prototypes were developed, enriched, evaluated and/or refined through formative research based on the following criteria: Prototypes need to be relevant, consistent, practical and effective (Nieveen, 2009). The criteria for developing the different prototypes were evaluated and adjusted through formative evaluation. Additionally, all prototypes should have the potential to foster the inquiry-

based learning of young children. Thus, the main goal of the different formative research methods was to collect relevant information in order to adjust and refine the prototypes on the criteria above. The micro-cycles illustrate the enrichment of these prototypes. Due to these criteria some of the formative research methods appeared to be useful as a tool for teachers, for instance:

- An observation tool was developed by the project team to observe the teachers and their classroom settings. This observation tool was not only used for research purposes; teachers also used the observation tool as a guide to look at their own practices.
- In order to gather feedback on the teachers' practices, teachers asked the parents to write down what children said at home about their classroom activities or class visits. This evaluation method was also used in the different educational didactics to get an idea on what children found the most fascinating.

Table 2: Overview stakeholders, main and additional outputs and research methods

Formative research methods	*Reflection*	*Screening*	*Brain-storm group*	*Experts appraisal*	*Walk-through*	*Try-out*	*Critical friends*
Stakeholders	PT	PT, Pr	Pr, SL, EM, TE, PA, FR, EI, ET, ST, PT, EE	SL, EM, TE, PA, FR, EI, ET, PT, EE	SL, EM, TE, PA, FR, EI, ET, PT, Pr, EE	Pr, St	EM, TE, PA, EI, FR, ET, Pr, EE
Main and additional outputs							
Vision	PT		Pr, SL, EM, TE, PA, FR, EI, ET, ST, PT, EE	EM, TE, PA, FR, EI, ET, PT, EE		PR	PA, EI, ET
Handbook	PT		Pr,PT		Pr, EM, TE, PA, FR, EI, ET, PT, EE	Pr	FR, Pr, TE
Educational didactics	PT	Pr, PT	Pr,PT			Pr	Pr, ET
Observation guide	PT	PT	PT			Pr	Pr
Initial teacher education course	PT	PT	TE,PT		TE, PT	St	TE
Professional development programme	PT	PT	Pr,PT	SL, EM, TE, PA, FR, EI, ET, PT, EE	Pr,SL, EM, TE, PA, FR, EI, ET, PT, EE	Pr	PA
The educational design model	PT	PT	PT	SL, EM, TE, PA, FR, EI, ET, PT, EE		Pr	EM

*PT= The project team is only mentioned when the formative research method is done by the project team without other stakeholders.
Note: See Figure 2 for the meaning of the acronyms

An overview of the main and additional outputs, the formative research methods, and the different stakeholders involved is presented in Table 2. Sometimes prototypes of different outputs were evaluated together and/or affected each other. For instance, components of the programme were first evaluated by the group of practitioners, and afterwards were integrated into the initial teacher education course and evaluated again together with the student teachers. In the table the code of the stakeholder group was only added to a cell corresponding with an output and a formative research method if they participated in that specific method, for that specific output. When more than one stakeholder group is mentioned in the cell, it doesn't automatically mean they participated in the formative research method together. It also doesn't mean they take in the same role within the formative research method, so it's possible the act in a different manner according to their own expertise.
In addition, the presence of a code in a cell doesn't give any indication of the number of times the formative research method was done. For example, while the project team reflected several times about the vision, i.e., after each formative research action mentioned in the table, the code of the project team is mentioned only once in the cell vision/reflection. As mentioned above, sometimes prototypes of different outputs were evaluated together; however, it could be that they were in a different micro-cycle of design. Because of this complexity there is no chronological overview of the different formative research methods leading to the final outputs in Table 2. Note also that, the length of time needed for these different research actions depended on the necessity for the research action and the specific research context at the give time.
In the section below the formative research methods used in this study and presented in Table 2 are explained with examples.

- **Reflection:** discussions about drafts, prototypes, vision and research actions within the project team to select important elements that should be integrated into the outputs or into the research actions.
- **Screening**: checking the prototypes or part of the prototypes by stakeholders based on specific criteria.
  For example: The practitioners (Pr) were given a 5-point checklist to screen their practice in order to generate more insight into the role of the teacher in a learning environment that fosters the inquisitive attitude of young children. Afterwards the checklist was discussed together with the project team, and adjusted and incorporated into the outputs (e.g. the handbook and the initial teacher education course).
- **Brainstorm groups:** sessions with brainstorm activities on subjects linked with the research or on new literature findings (for example, new practices).
  Examples: a session with teacher educators (TE) brainstorming about curriculum adaptation using statements concerning professionalisation of student teachers.
  There were several brainstorm sessions with the practitioners (Pr) to create new practices based on literature or on ideas of the project team.
- **Expert appraisal**: groups of experts from the same or different expert areas gave feedback on prototypes or parts of prototypes.
  For example: organized sessions with experts from different stakeholder groups (experts in methodology (EM), pedagogical advisors (PA), facilitators for research (FR), experts in inquiry-based education (EI), experts in teacher training (ET)) in order to give feedback on one of the prototypes of the educational design model (Pr).
- **Walkthrough:** going through a prototype with one or several of the stakeholder groups.
  For example: The prototypical professional development plan was presented step by step to the group of school leaders (SL) in order to receive feedback.
- **Try-out:** testing materials and components of the prototypes into the real classroom settings.

For example: During the research project there were several try-outs. The content and type of the try-out depends on the different outputs of the project. For instance, the use of a research book for young children (part of the educational didactics) was tried out by the practitioners (Pr) in their classrooms.
A second example: a real scientific inquiry based session (part of the professional programme and the initial teacher training course) was tried out with the practitioners (Pr) and the student teachers separately.

- **Critical friends:** Experts who gave feedback on specific matters during a consultation in order to improve the process and outputs.
  For example: Members of the teacher educators group (TE) were asked to proofread written prototypes of the handbook.

4. Assessment phase and yield of the project

Outputs of the project

This project led to a main output, a professional development programme, and additional outputs: a vision, a handbook, educational didactics, an observation guide, an initial teacher education course, and an educational design model (see Figure 1). Unfortunately, not all outputs could be assessed. For instance, the field test of the complete professional development programme within a larger group of teachers wasn't possible because of the real-life context. This means that a large field test was not possible due to financial and time constraints. However, parts of the professional development programme were assessed in professional development workshops, and the programme as a whole was reviewed critically by the expert groups, the teacher educator group, the practitioner group and the school leader group.

Some of the outputs could, however, be evaluated on a larger scale. The initial teacher education course was field tested twice and is now integrated into the curriculum of a bachelor in education: early childhood education. During the forthcoming years the course will be refined based on feedback of future student teachers.

The vision is implemented in documents of several organizations, such as schools, pedagogical centres, and initial teacher education institutions, proving the value, the usability and the relevance of the vision.

The handbook - based on the vision and the programme - 'Young children, great inquirers. And the teacher?' (Van Houte, Devlieger, & Schaffler, 2012) has been published and gave rise to several other activities (on demand), such as new project proposals, articles, panel debates and workshops. Due to the strong vision and the publication of the handbook, the members of the project team are also seen as experts in the field of inquiry-based education by other university colleges and educational centres.

The effectiveness and value of the project outcomes could be explained by the intensive involvement of all the important stakeholders of the educational field. Their feedback, ideas, and suggestions gave rise to additional outputs and were integrated into the prototypes. From the start of the project an emphasis was also put on dissemination, as illustrated in Figure 1. The participating stakeholders were well positioned to provide the project team with advice concerning the dissemination strategies. The handbook that was developed is, for instance, based on advice of educational advisors and experts in inquiry-based education. This additional output made it possible to create a more effective dissemination strategy, as the stakeholders suggested including the structure and build up of the professional development programme. One of the chapters in the handbook highlights the development and the final version of this professional development programme. This chapter presents concrete advice to trainers and

teacher educators who want to develop a professional development programme on inquiry-based education.
In addition, the stakeholders themselves act as disseminators. Some student teachers involved in the project developed their own workshops, based on sessions in the initial teacher education course. Several of these student teachers integrated the practices into their field experiences and influenced their mentors.
The practitioners involved participate in workshops for teachers and student teachers. Because of their intensive involvement and the objective of the project (i.e., to encourage the inquisitive attitude of the teachers) the practitioners became critical researchers and inquirers. This group has become invaluable to the team for future projects. Thus, practitioners and the project team decided to create a research community in which all parties are involved. This research community provides critical input and advice to several other projects and since its inception, in 2011, meets three times per year. These practitioners have also gained more self-confidence and they have become real inquirers in their own classrooms. This is illustrated by one practitioner:

“The research project has given my self-confidence a boost, and it has taught me several things: discover, just try out, encourage young children, let them be the initiators of the activities … it can’t go wrong. Experiences of success give you the taste to do more, that’s for sure." (Participating teacher)

Reflection: lessons learned
The intensive involvement and open-minded participation of the different stakeholders and the project team formed a dynamic research process which resulted in the creation of important new developments. In this section, emphasis is placed on the professional development programme, the project team, the practitioners as co-researchers, and the unpredictability of the project outcomes.

General design principles of a professional development programme fostering an inquisitive attitude
This project shows that a real inquiry-based session with teachers is a crucial component in a professional development programme that seeks to develop and encourage the inquisitive attitude of teachers. In addition, video recall was proven to be very effective in developing the curious, reflective and critical attitude.
During each session of a professional development programme the coach has to take the perspective of the teacher and has to focus on the learner-centred approach. Therefore the coach should be a facilitator, inquirer and important role model for the teachers.
As shown in this project, professional development can only be effective if school leaders are involved and have a substantial role in the programme.
Designers of professional development programmes also have to take in account some practical issues, such as rush periods during the school year and making teachers class-free.

Participation of co-researchers
“*I would participate again, simply because I find it interesting to work with other like-minded teachers, on a vision…I think the coaching was approached very professionally, so that I always got new ideas to get started in the classroom. I found the exchange of ideas in practice with other people (whom I otherwise wouldn’t meet) very pleasant, informative and feasible. " (Participating teacher)*

This project clearly shows that in educational design research the practitioners, as co-researchers, see their active participation as professional development. This is an interesting conclusion for teacher programme designers.
They also felt the need to continue the process in a similar way. Hence, a community was created with the teachers and school leaders, as mentioned above. The active participation of the teachers in the community is facilitated by the project team. Student teachers replace teachers in their classrooms during community sessions. The latter could be an interesting solution for other educational design researchers.

The role of the project team

This study highlights some dilemmas of educational design research for researchers. Since the participating practitioners saw this educational design research project as professional development, the members of the project team inevitably had a double role. They were educational design researchers as well as teacher educators. This double role is characterized by finding a difficult balance between expert in design research and expert as facilitator within different school areas. As described by Schollaert (2011), the project members had to link the new developments in the project with current practice, make use of experiential learning, promote reflection, support practitioner research, use a diversity of learning approaches, take into account the participants' emotions, take into account group dynamics, model desirable behaviour, and focus on content and process alike. This was a very intense and demanding process.
On the other hand, the project team had their own goals, extracting criteria for the development of the professional development programme for early childhood teachers to foster inquiry-based science education. This meant they had to collect data and therefore encourage the practitioners in their co-research role.
To realize this balance, practitioners and researchers have to be equal partners, discussing their specific needs and goals, starting from a mutual respect for each other's goals. Thus, educational design research is also about respecting each other and appreciating the expertise and personality of each participant. This project shows that finding a balance is also facilitated by a multidisciplinary and multi-talented project team. Educational design research makes it possible to use these different disciplines and talents, but on the other hand it also requires them to accelerate the research process, deepen the reflective process, foster creativity, and create a positive flow.
The project generated a lot of data and forced the project team to give priority to realistic processing. Therefore the criteria mentioned in the prototyping phase were used as guidelines to adjust and take important decisions concerning these data. This required profound reflection by the project team after each formative research action.

The unpredictability of outcomes of the project

In this particular project, educational design research was experienced as exciting and unpredictable. The project team noticed changes in the project goals and outcomes, and therefore could conclude that carrying out educational design research is a step into the unknown over and over again. They had to be open for solutions and suggestions they couldn't predict at the start of the project, due to the involvement of several stakeholders with different ideas and expertise.

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