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Boundary Crossing in R&D Projects in Schools: Learning Through Cross-Professional Collaboration

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Background/Context: *School leaders, teachers, and researchers are increasingly involved in collaborative research and development (R&D) projects in schools, which encourage crossing boundaries between the fields of school and research. It is not clear, however, what and how professionals in these projects learn through cross-professional collaboration.*

Purpose: *The purpose of our study is to create a better understanding of the learning of boundary crossers who are involved in cross-professional collaboration in R&D projects.*

Research Design: *In this multicase study, we analyzed data from interviews with school leaders, teachers, and researchers involved in 19 R&D projects in Dutch secondary schools. We interpreted boundary crossers' learning in terms of learning mechanisms (identification, reflection, coordination, and transformation) and related these learning mechanisms to different types of cross-professional collaboration.*

Findings: *Three combinations of learning mechanisms were prevalent: identification and coordination, reflection and transformation, and transformation for school leaders, teachers, and researchers. Different types of collaboration appeared to evoke different learning mechanisms.*

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Conclusions: *Boundary crossers on R&D projects learn from the other professionals' tools and objectives and, in the case of transformation, integrate these in their own professional methods of working and aims. When transformation occurs school leaders and teachers develop a research attitude towards teaching and researchers incorporate contributing to educational improvement as an objective in their research. This is mainly the case in school- and researcher-directed types of cross-professional collaboration.*

INTRODUCTION

School practitioners and researchers, advisers, and supervisors are increasingly involved in research and development (R&D) projects in education in the United States, the United Kingdom, and elsewhere in Europe, such as the Netherlands (Coburn & Stein, 2010; NTRP, 2012; Onderwijsraad, 2011; Rust, 2009). R&D projects encourage professionals to engage in practice-based research that seeks to contribute to school development, i.e., activities undertaken with the intention of improving practice and generating new knowledge. R&D projects facilitate cross-professional collaboration, which is described in this study as a process in which diverse professionals meet with various reasons for achieving project goals. These professionals attempt to reach project goals by guiding, directing and performing research and development activities and by mutual communication (Penuel, Fishman, Cheng, & Sabelli, 2011; van de Ven, 2007; Wagner, 1997). As the school practitioners and external educational experts collaborate on the project, these professionals have the opportunity to learn from one another's backgrounds and perspectives on the fields of school and academic research. However, little is known regarding what and how school practitioners and external educational experts learn as they collaborate on an R&D project. Furthermore, whether and how learning results in changes in the practices of both parties is also unknown (Max, 2010; Vanderlinde & Van Braak, 2010).

In R&D projects school practitioners and researchers, advisers, and supervisors interact whereas generally they operate in different fields that have their own rules and communities and are even perceived as being separated by a gap (Broekkamp & van Hout-Wolters, 2007; Engeström, 2001). A promising concept with which to investigate the learning of professionals in R&D projects is boundary crossing (Hora & Miller, 2011; Taylor, 2008; Tsui & Law, 2007). Practitioners can cross boundaries to the field of researchers by being engaged in a study. This is notable, for example, in the collaborative action research of teacher researchers. As these professionals conduct research activities in schools, they

may use terminology and tools that are derived from the academic field (Leeman & Wardekker, 2014; Lytle & Cochran-Smith, 1990; Rust, 2009). Researchers are crossing boundaries when they engage in a study that requires them to focus on questions raised in school practices. As researchers become involved in educational activities, they may use the terminology and tools of school practitioners (Coburn & Stein, 2010; Geijsel, Krüger, & Sleegers, 2010; Grundy, 1998).

In studies on collaboration between school practitioners, researchers, advisers, and supervisors, the issue of the learning of those who collaborate has remained largely unexamined. Instead, the research and development activities themselves and the results of these activities are generally the focus of such studies. The goal of our study is to create a better understanding of the learning of boundary crossers who are involved in cross-professional collaboration in such R&D projects. Awareness of the complexities and opportunities that such learning entails may contribute to better collaboration between practitioners, researchers, advisers, and supervisors in the future.

BOUNDARY CROSSING IN R&D PROJECTS

To understand boundary crossing by school practitioners, researchers, advisers, and supervisors on R&D projects, it is helpful to characterize the different worlds of these professionals as activity systems. Consistent with cultural historical activity theory (CHAT), we identify schools and research institutes as activity systems that can be characterized as collective, tool-mediated and objective-oriented. Actions of individual educational practitioners and researchers must be understood against the background of these activity systems. They work with the tools that have been developed within these activity systems in order to achieve the purposes of that activity system. According to CHAT, members ("subjects") of the same activity system thus share certain motives or objectives (Engeström, 2001; Wenger, 1998). Teachers' objectives are to provide good education, and their primary motive is to support students to develop as full members of society. Teachers' tools consist of curricula, pedagogical approaches, teaching methods, tests, etc. School leaders' objectives are generally to ensure good education. As members of the same activity system their motives are similar to teachers´ motives, although the tools they us are different, since their task is to provide the right conditions in which teachers and students may learn. The motive of educational researchers is knowledge development, although their objectives may be oriented more toward contributing to educational practice or to academic knowledge development. Researchers' tools are,

for example, questionnaires, statistical methods and disciplinary concepts. Educational advisers and supervisors are generally perceived as intermediaries between the school field and the academic research field; their purpose is to translate research knowledge to school practices, and these advisers and supervisors are critical friends to school practitioners. Contributing to educational change is perceived as the primary motive of advisers and supervisors (Akkerman, Bronkhorst, & Zitter, 2013; Cornelissen, van Swet, Beijaard, & Bergen, 2011). Advisers and supervisors function between the activity systems of school and research. In this sense, advisers and supervisors have their own activity system with their own tools, objectives and motives adjacent to the activity systems of schools and research (Engeström, 2001; Swaffield, 2004; Vanderlinde & van Braak, 2010). Traditionally, researchers, advisers, supervisors, and school practitioners do not often encounter one another. Researchers, advisers, and supervisors work at universities or other research or advisory institutes whereas practitioners work at schools. Thus, their primary work occurs at a physical distance. Teachers often perceive academic researchers as out of touch whereas researchers may say teachers are not interested in research results (Broekkamp & van Hout-Wolters, 2007; Gore & Gitlin, 2004).

Boundaries exist between activity systems. Boundaries can be perceived as social constructs of barriers that exclude others from an activity system; simultaneously, boundaries motivate insiders to remain members of the activity system (Edwards, Lunt, & Stamou, 2010; Wenger, 1998). In situations in which boundaries between activity systems are crossed, these professionals are perceived as "cultural brokers who can walk between worlds and translate the cultural models of one group for another" (Hora & Miller, 2011, pp. 92–93). Walking between worlds, or crossing boundaries between activity systems, makes professionals aware of new tools and objectives and offers all professionals the opportunity to use these tools and pursue these objectives. We define the boundary crossing of professionals on R&D projects as a process during which these professionals become aware of (new) tools and objectives that are common in other activity systems; consequently, boundary crossers have the opportunity to expand their professional methods of working (Hora & Miller, 2011; McLaughlin & Black-Hawkins, 2007; Roth & Lee, 2007; Taylor, 2008).

Earlier studies on boundary crossing concentrated on persons who cross boundaries from one activity system to another over time, for example, from a training situation to work (Akkerman & Bakker, 2011; Engeström, Engeström, & Kärkkäinen, 1995; Max, 2010). The perspective of boundary crossing has not previously been used to study R&D

projects in education, which are characterized by cross-professional collaboration among researchers, advisers, supervisors, and school practitioners. Studies on such cross-professional collaboration are generally anecdotal and based on reflections on experiences with R&D projects (Coburn & Stein, 2010; Penuel et al., 2011). We seek to study boundary crossing in the context of R&D projects in a more large-scale and systematic manner, focusing on learning by boundary crossers.

LEARNING MECHANISMS

Based on a review of 181 studies on boundary crossing, Akkerman and Bakker (2011) distinguished four learning mechanisms that characterize the learning processes of professionals who cross boundaries between activity systems. We will provide a short description of these learning mechanisms as these mechanisms apply to professionals working in education:

- *Identification*: This learning mechanism entails at first the identification of the different perspectives of the school and research fields. In fact, the boundaries between the different worlds become more prominent, and professionals create a better understanding of their own positions as those positions relate to the boundaries of their own activity systems (Edwards et al., 2010; Roth & Lee, 2007; Tsui & Law, 2007). Ultimately, identification results in legitimizing coexistence.
- *Coordination*: In this situation, professionals overcome the boundaries of two or more activity systems, which leads to effortless movement between different practices although the characteristics of the activity systems remain unchanged. Coordination can be associated with role transition (Ashforth, Kreiner, & Fugate, 2000), by which boundary crossers relegate their original roles to the background, at least temporarily. As experience with this new role grows, the role transition becomes less difficult in future situations; this is called routinization (Akkerman & Bakker, 2011).
- *Reflection*: Professionals can also reflect on their own roles and the roles of others. By "making and taking perspective," they are able to develop a new understanding of their own and others' activity systems. Reflection also leads to an expanded set of perspectives originally belonging to others that are used by these professionals in newly encountered situations (Bronkhorst et al., 2013).
- *Transformation*: This learning mechanism entails confronting the boundaries of existing activity systems, for example, because problems cannot be solved with the professionals' original tools.

> Participants will apply the new tools and objectives of the other activity system(s), which leads to transformative changes in the professional activities of the professionals themselves as well as changes in their own activity systems. This process can also potentially lead to a new in-between practice in which tools and motives are collectively shared among the professionals (Star, 2010, p. 602), which is also known as a boundary practice in which elements from both activity systems are present and in which boundary crossers display efforts to proceed with joint work (Akkerman & Bakker, 2011; Tsui & Law, 2007).

These learning mechanisms may be a useful framework with which to characterize the learning of school practitioners, researchers, advisers, and supervisors on R&D projects. Each learning mechanism may provide specific opportunities to at least become more aware of others' professional methods of working as professionals come in close contact with the tools and objectives of other activity systems. Thus, each learning mechanism can involve individual changes of the school practitioners, researchers, advisers, and supervisors in the manner in which they perceive and enact their original roles. Individual learning may also resonate in the manner in which the professionals in an R&D project collaborate.

Cross-professional collaboration among school leaders, teachers, researchers, advisers and supervisors on R&D projects has been examined in an earlier study (Schenke, van Driel, Geijsel, Sligte, & Volman, 2016). In this study, the characteristics of cross-professional collaboration on R&D projects were analyzed by focusing on three dimensions. The first dimension is reasons for collaboration, with *congruent reasons* indicating similar goals and motives of practitioners, researchers, advisers, and supervisors for the project and *additional reasons* indicating that researchers, advisers, and supervisors also have their own research-related goals that are not necessarily relevant to the school. The second dimension is division of roles and tasks, which includes the following questions: Who directs and guides the research? Are teacher researchers involved in the project? The third dimension is communication structure, which asks how communication is organized and how much time is invested in meetings. Based on differences in the three dimensions, we distinguished between four types of cross-professional collaboration (Schenke et al., 2016).

- School-directed collaboration: In this type of collaboration, teachers and school leaders are responsible for performing practice-based research in their schools, during which researchers and supervisors are perceived as critical friends.

- School- and researcher-directed collaboration: Teachers and school leaders are responsible for performing practice-based research in their schools, during which researchers, advisers, and supervisors are perceived as sparring partners who provide support for decisions to be made regarding the research and school matters.
- School- and adviser-directed collaboration: Researchers and advisers control this type of collaboration. The researchers and advisers concentrate on achieving the project goals as established by the school board. Often there is a steering committee in which school leaders participate.
- Researcher-directed collaboration: Researchers have interests in addition to the questions a school has raised. School practitioners have a minor role in the practice-based research.

A primary difference among the four types of collaboration is the extent to which the school or an external party directs and guides the project (Schenke et al., 2016). In addition to the learning of individual professionals in R&D projects, we are interested in relations between learning mechanisms that occur during these projects and the type of cross-professional collaboration that is characteristic of the project.

RESEARCH QUESTIONS

The purpose of our study is to create a better understanding of the learning of boundary crossers who are involved in cross-professional collaboration on R&D projects in secondary education. For this purpose, we will use the four learning mechanisms that were proposed by Akkerman and Bakker (2011) to characterize the learning processes of educational practitioners and researchers in such collaborations: *identification*, *coordination*, *reflection* and *transformation*. The research questions we address are as follows: (1) Which learning mechanisms are characteristic of boundary crossers in collaborative R&D projects? and (2) How are types of cross-professional collaboration and the learning mechanisms of boundary crossers related?

METHOD

THE CASE STUDIES

This study is organized according to a multi-case study design (Yin, 2009). The cases were 19 R&D projects in secondary schools in the Netherlands. Five cases were studied in more depth. The projects received funding from the Dutch Council for Secondary Education for research purposes for 1, 2, or 3 years after the funding application was accepted. This study covers the first 2 years of the projects. The funding plan was intended for conducting practice-based research that examines questions and problems experienced in schools. For example, the use of digital material designed by teachers was evaluated, an instrument for measuring literacy skills was developed, teachers honed their pedagogical skills and changes in the classroom were observed. Only schools could apply for funding; however, schools were supposed to (partially) transfer the research budget to an external party with research expertise: researchers, advisers, and supervisors from universities, universities of applied sciences, teacher education institutes, and research and advice bureaus.

PARTICIPANTS IN THE STUDY

In the collaborative R&D projects in schools, school practitioners, researchers, advisers, and supervisors were involved. Participants in our study were school leaders, teachers, and researchers. We decided not to include professionals who identify their primary role as adviser and supervisor. The primary reason is that their boundary crossing is different from boundary crossing by school leaders, teachers, and researchers. In fact, it is inherent in their role as adviser and supervisor: Cross-professional collaboration is in the core of their professional identity. Their learning is differential and therefore lies beyond the scope of our study. In the discussion, this will be elaborated on further.

In three rounds of interviews, we interviewed a total of 28 school leaders and teachers who functioned as project managers in their schools and 23 researchers from educational institutes. In most schools, project managers and researchers remained the same from round to round although in one school, we interviewed a different project manager in Rounds 2 and 3. In three projects, other researchers became involved during the process; thus, more than 19 researchers were interviewed. Additional information on the role of teacher researchers in the projects was acquired by interviewing nine teacher researchers who collected and analyzed data in their schools.

DATA COLLECTION

Data were collected in three rounds of interviews; at the beginning (Round 1) and end of the first year (Round 2) of the R&D projects and at the end of the second year of the projects (Round 3). The participants in each project were interviewed individually to ensure in-depth conversations with all individuals regarding their perceptions of boundary crossing in the project in which they participated. All interviews with the school leaders, teachers and researchers on the projects were based on prestructured interview guidelines (see Appendix A). These interview guidelines contained questions regarding project activities and output; reasons for collaboration in project; changes in project team; division of roles and tasks in project; boundary crossing; communication structure in project; involvement of researcher; vision on research; advancing and restricting factors. Additional documentation was also collected, i.e., project applications, progress reports by project managers, and reports of meetings in which experiences were shared among professionals of different projects. The purpose of collecting these documents was to use them to prepare for the interviews and in the analysis of the interviews as background information.

DATA ANALYSIS

The first phase in the data analysis involved the construction of a coding scheme (see Appendix B). An important component of the coding scheme were the codes that identified school leaders, teachers, or researchers as boundary crossers. The first indicators we used for recognizing boundary crossers were concentrated on how these subjects perceived their role and tasks. Secondly, we extracted indicators from the definition of boundary crossing as mentioned earlier. In this definition, tools and objectives of the specific activity systems were essential elements. School leaders and teachers were characterized as boundary crossers when they mentioned to aim at contributing to knowledge creation (originally an objective of researchers) and used questionnaires or concepts such as validity or reliability (originally tools of researchers). Researchers were characterized as boundary crossers when they engaged in research that required them to focus on questions concerning how to realize good education (originally perceived as the objective of school leaders and teachers) and for instance keep in mind to offer teachers sufficient facilities in terms of time and space (originally tools of school leaders) or think along with which pedagogical approaches to choose in the classroom (originally tools of teachers). Additional

codes in the coding schemes were based on other elements of the research questions and interview guidelines, such as characteristics of cross-professional collaboration (reasons for collaboration, division of roles and tasks, communication). We used MaxQDA (version 10) for coding the interview fragments.

The next phase was to analyze the data in two steps to answer the first research question: Which learning mechanisms are characteristic of boundary crossers in collaborative R&D projects? The first step was to gather all interview fragments for each participant on experiences of boundary crossing, to which a relevant code was assigned (roles, tasks, tools, or objectives). We placed these fragments in within-site matrices by project. One row was used for each participant. The codes (roles, tasks, etc.) indicated the columns (Miles & Huberman, 1994). The second step was to interpret the information in the matrices in terms of one of the four learning mechanisms. We decided to characterize each participant with one learning mechanism that suited the situation at the end of the second year of the projects. We will explain this for each learning mechanism. (In Appendix C, we included a sample of the matrix.)

- *Identification*: School leaders, teachers, and researchers who discuss having become aware of the peculiarities of the other practice and how the other practice differs from their own practice are characterized with this learning mechanism.
- *Coordination*: This is the characteristic for school leaders, teachers, and researchers who describe their work on the project as temporarily using tools and objectives from the other activity system as well as their own. Using other tools and objectives does not lead to real changes in how these professionals do their own work.
- *Reflection*: Reflection is the characteristic learning mechanism for school leaders, teachers, and researchers who demonstrated understanding of the other and his/her activity system and to take the other into account. These professionals use their new understanding of others and their activity system during collaboration.
- *Transformation*: This learning mechanism is characteristic of school leaders, teachers, and researchers who expand their professional methods of working with new tools and objectives of another activity system.

A learning mechanism was designated for every boundary crosser—school leader, teacher, and researcher. This indicates that each project was characterized by three learning mechanisms.

In the next phase of data analysis, we examined data with regard to the second research question: How are the types of cross-professional collaboration and (combinations of) learning mechanisms of boundary crossers related? Utilizing the result of the first analysis, we performed a cross-site analysis (Miles & Huberman, 1994). We established a matrix in which the learning mechanisms for every project would be visible at a glance. For this purpose, we entered the learning mechanisms for every boundary crosser (school leader, teacher, and researcher) into the matrix and sorted them by project. Then, we clustered these data by prevailing learning mechanisms; for example, all projects that included boundary crossers who were transforming were placed together. Thereafter, we placed the types of cross-professional collaboration (resulting from analysis in a previous project, see Appendix D) next to the projects to answer the second research question (see Table 1 in the Results section). Finally, we selected five projects to be described as case studies to illustrate the combinations of learning mechanisms of school leaders, teachers, and researchers that occurred.

A researcher external to our research team performed an audit during the process of analysis. We discussed arguments for data selection and reviewed decisions concerning data analysis of interview fragments. The result of the audit provided us with a confirmation of the steps we took during the analysis. We accepted advice to select additional interview fragments of participants that concerned their perspective of the learning of other school leaders, teachers, and researchers in their project. Considering the perceptions of other participants enhanced the triangulation of the data. As a second form of audit, the research team discussed all the steps in the process of analysis and its outcome, and where necessary, the primary data were rechecked (Miles & Huberman, 1994).

RESULTS

BOUNDARY CROSSERS AND LEARNING MECHANISMS

In this section, we answer the first research question: Which learning mechanisms are characteristic of boundary crossers in collaborative R&D projects? We focus on the extent to which each learning mechanism occurs with the school leaders, teachers, and researchers and specifically what these mechanisms entail in the context of R&D projects in Dutch secondary schools.

School Leaders

All school leaders associated with the 19 projects were characterized as boundary crossers. Different learning mechanisms occurred.

Identification is a characteristic of three school leaders who were involved in an R&D project as project managers (Projects G, O, and P, see Table 1). These school leaders specifically chose to allow the researchers to perform the study and informed the leaders about the research without the leaders' being involved in the actual research activities. In the case of one project (G), this arrangement led to the dissatisfaction of the school board, particularly concerning the communication of research results:

> Last year, I noticed that the researchers had a very leading role in this project and that we did not have a huge say in it. In the past weeks, we have had conversations with the researchers and we actually told them: if there are research results, we would like to do something with the results [in our practice]. (Interview, school leader, Project G)

Coordination is typical of two school leaders (Projects F and Q). The primary task of the school leader in Project F was to encourage teachers to design new educational approaches for highly gifted students. He combined this task with collecting data on the intentions and actions of these teachers by recording conversations, taking notes during meetings, and conducting in-depth interviews. During the project, shifting back and forth between the objectives of school development and knowledge building, he encountered the problem of time management:

> The difficulty lies in processing the data. I am not able to do that now. It is too much work, and I am busy with developing the school at the same time. Developing the school is my priority now. (Interview, school leader, Project F)

Reflection is the primary learning mechanism of five of the school leaders. For example, the school leader in Project S explained his role in the project:

> I am more engaged in exchanging ideas with the researchers on methodology and those kinds of things than I used to be, though that is not my expertise, of course. However, I have some thoughts about this and certainly about how to improve this [making use of research] in our school. (Interview, school leader, Project S)

The Project S leader indicated that his perspective was expanded by the viewpoints of the researchers, and his learning process contributed to a better understanding of how research can be used for more than simply knowledge creation.

Transformation was characteristic of nearly half of the school leaders at the end of the second year of the project. These school leaders explained that they experienced changes in their knowledge and skills as a result of initiating research in their schools, using concepts derived from educational theory, and performing research activities themselves. As the project continued, they said that not only they had developed more knowledge regarding how to stimulate colleagues to conduct studies in school, how to use research results for school development and how to perform a study, but also the way in which they acted as a school leader had changed, as occurs with the project manager of Project C:

> I have learned that you should not search immediately for a solution, but that you should perform solid research: an accurate analysis of the problem, good desk research, research design, research question, research goal, how to collect data. Let's say, all steps in research. . . . If I compare this with one year ago . . . then it is an enormous development. I can see a huge difference in the way everybody is engaged in the project. (Interview, school leader, Project C)

Thus these school leaders in fact integrated tools and objectives into their practices that traditionally belong to the activity system of researchers. They developed a more inquiry-based attitude in their daily work: they began asking more questions and being more critical of their own actions. This was also expressed by the project managers of Project D:

> I have become aware of changes in my own research attitude, and that is, I must say, quite a strange sensation. I performed several studies myself earlier. Finally I came into a position in which I only "did, did, did" and actually asked a small number of questions. I have noticed that I get to use this research attitude, which I found again in part in this project, in the guiding and directing of the school, in conversations with Ronald [project member], in moments when I am in someone else's field . . . but also that you would like to be more systematic in making decisions. . . . I also become more critical of my own actions in the classroom. These are major gain points. (Interview, school leader, Project D)

Teachers

Nearly all teachers who were involved in the projects could be characterized as boundary crossers (see Table 1). In four of the projects, no teachers were involved in development or research activities; these teachers were not crossing boundaries to the activity system of research. In the other 15 projects, teachers were involved in tasks such as the construction of questionnaires and data interpretation.

> The learning mechanism of identification was not observed with teachers.

Coordination is typical of none of the teachers; there were no teachers who showed effortless movement between their teaching and their research activities during the project. Rather, some teachers saw their research activities as an extra activity on top of their school work where others integrated research' objectives and tools into their daily practices. Reflection is the characteristic learning mechanism of six teachers who assumed the perspective of a researcher as they participated in the project. An example of reflection was observed with the teachers in Project O. In the course of the project, the researchers proposed to increase the engagement of the teachers in the project by "letting them distribute and collect the questionnaires . . . and to involve them in the [construction of the] questions" (Interview, researcher, Project O). As part of the evaluation of the digital method implemented in their lesson programs, the teachers were also requested to keep a reflection log on what they had done and what they had learned from implementing the new lessons. One of the teachers mentioned in her interview that she was not used to asking questions and reflecting on her lessons; she rather used to accept things the way they were. She gradually changed to asking more questions because of the introduction of the reflection log. She also noted that she was becoming more interested in reading about education studies after participating in this project. However, she did not easily incorporate these new activities into her daily routines.

> I try to read more about education and education research as I am more aware of the possibilities of these studies. Unfortunately, I am not able to read everything as I am busy with other things as well. However, if I notice something related to educational studies or education in general, I try to read that and check whether it could be useful for myself. (Interview, teacher researcher, Project O)

These six teachers assume the perspective of researchers; however, their learning processes cannot be characterized as transformation because there are no indications that this perspective transfers to situations beyond the context of the particular R&D project.

Transformation is characteristic of eight teachers who all were involved in a project as teacher researchers. Working with the tools and adopting the objectives of the academic research field, they expanded their professional teaching methods. These teachers said they started using research results and educational literature to improve their own teaching and developed a more critical stance to their own teaching, e.g., by using test scores to analyze student progress. Also they mentioned developing a helicopter view of broader school issues. The teacher researcher in Project S explained explicitly,

> You become more critical of what is happening in school and you say less easily you can´t change things. So you remind yourself to introduce this for the agenda of the next meeting. (Interview, teacher researcher, Project S)

Another example is the teacher researcher in Project A who was challenged in the project to think about things other than her daily classroom work, in this case, about a school-wide policy on language and mathematics. Her research role encouraged her to "become more than a mathematics teacher." She applied new (research) tools in her daily work, for example by considering the test results of her students as data she could analyze. This altered her objectives for her students, particularly the students with lower test scores. She decided to design additional lesson materials for these students on the basis of her interpretation of the test scores. She also became more aware of "what is happening" in the educational field regarding language and mathematics and developed the habit of asking questions about what works and what is effective for students.

Researchers

All researchers in the R&D projects can be characterized as boundary crossers (see Table 1).

Identification is the typical learning mechanism of four researchers, for example, the researcher on Project R who initiated a collaboration with a supervisor whose role was to provide the school with advice. Using this strategy, the researcher was able to remain apart from school development issues and work at a distance from the school during the period of data collection and analysis. The role and practice of the researcher remained as they were before the project.

Coordination is characteristic of two researchers. In their perception, "The role of a researcher is close to the role of an adviser" (Interview, researcher, Project P). These researchers shifted smoothly from the role of providing advice to the role of conducting the research. The learning process for these two researchers is not perceived as reflection or transformation because the tools used and objectives aspired to in their role as researchers did not change. In their role as researchers, they were collecting data in the schools, and in their role as adviser they were thinking along with school leaders and teachers about teaching and learning issues.

Reflection is typical of five researchers. These five indicated that they view themselves primarily as researchers but in the course of the project learned to understand and consider the school's perspective. In the interviews, these researchers shared what they learned from the school, such as the specific abbreviations that are used in schools. They also mentioned that they realized it may be necessary to adjust deadlines for teachers who have urgent school matters. In fact, the researchers came to know the needs of the school. The skills these five learned are skills required for conducting practice-based research, e.g., being flexible in making plans and adjusting the use of language to the level of what is understood in the school. When these researchers were requested to provide the school with advice during the project, however, they chose not to become involved in codirecting the development in the school. Transformation is the characteristic learning mechanism for six researchers who chose to become involved in decision-making processes concerning curricula and teaching methods in the school. For these researchers, research and development became interconnected processes. These six wanted to think along with school leaders and teachers about the design of an innovation, e.g. a new pedagogical approach in lessons. They started seeing innovations as operationalizations of a theoretical principle, e.g., concerning improvement of teaching, that could thus be studied and knew a shared vision was necessary for an adequate implementation and a valid evaluation of the innovation. These researchers also made preparations with the school leaders on, for example, the content and form of meetings with teachers, because they were aware of the importance of support within the school team to implement an innovation.

LEARNING MECHANISMS AND CROSS-PROFESSIONAL COLLABORATION IN THE PROJECTS

After characterizing learning mechanisms for categories of boundary crossers, we now focus on patterns in the occurrence of the learning mechanisms of school leaders, teachers, and researchers at the level of the R&D projects and on how (combinations of) learning mechanisms relate to different types of cross-professional collaboration. Thus, we answer the second research question: How are types of cross-professional collaboration and learning mechanisms of boundary crossers related? First, we relate the four types of cross-professional collaboration to the occurrence of the learning mechanisms, and second, we present five case studies that illustrate how different learning mechanisms may function in R&D projects.

Cross-Professional Collaboration and Learning Mechanisms

Table 1 shows the type of cross-professional collaboration and the (combination of) learning mechanisms for each project. Table 1 reveals the following patterns:

- School-directed collaboration co-occurs in four projects, with the combination of transformation for school leaders and teachers and reflection for researchers. In school-directed collaboration, school leaders and teachers took responsibility for conducting research in their schools. This implies learning processes for school leaders and teachers that involve mastering tools that are used in research and developing objectives aimed at understanding and evaluating the development in schools.
- School- and researcher-directed collaboration is related to two combinations of learning mechanisms. In three cases of school- and researcher-directed collaboration, we see transformation for all professionals, and in three cases, reflection for school leaders and teachers and transformation for researchers. Researchers in all of these projects had active roles as sparring partners for school leaders and teachers and provided support for decisions to be made on school issues. School leaders and teachers whose learning mechanism is characterized as reflection created a good understanding of the perspective of researchers on the project, for example, when discussing the research plan. School leaders and teachers whose learning mechanisms are characterized as transformation additionally adopted research tools and objectives, such as an inquiry-based attitude and drawing substantiated conclusions on students' results.

- School- and adviser-directed collaboration is related to the combination of identification for the leaders and teachers and coordination for the researchers. In these two projects, the researchers combined their roles in performing research with the role of adviser. The school leaders' learning mechanism is identification because they were informed about the research but were not involved in any research activity.
- Researcher-directed collaboration is related in three projects to the learning mechanism of identification for researchers, who were not involved in stimulating or thinking about school development processes. Identification is combined with the learning mechanisms of reflection and coordination on the part of school leaders and teachers, who demonstrated less time investment and had little input into the research compared with other projects.

Table 1. Boundary Crossers, Learning Mechanisms, and Types of Cross-Professional Collaboration

Project code	Presence of learning mechanisms in the R&D projects			Type of cross-professional collaboration
	School		Research institute	
	School leader	Teacher	Researcher	
	Transformation with all participants			
Project C	T	T	-	School-directed
Project H	T	T	T	School- and researcher-directed
Project I	T	T	T	School- and researcher-directed
Project J	T	T	T	School- and researcher-directed
	Transformation and reflection			
Project A	T	T	R	School-directed
Project B	T	T	R	School-directed
Project D	T	X	R	School-directed
Project E	T	T	R	School-directed
Project N	T	R	R	School- and adviser-directed
	Reflection and transformation			
Project K	R	R	T	School- and researcher-directed
Project L	R	R	T	School- and researcher-directed
Project M	R	R	T	School- and researcher-directed
	Coordination and identification			
Project F	C	X	-	School-directed
Project Q	C	X	I	Researcher-directed
	Identification and coordination			
Project O	I	R	C	School- and adviser-directed
Project P	I	X	C	School- and adviser-directed
	Other combinations			
Project G	I	?	I	School-directed
Project R	R	R	I	Researcher-directed
Project S	R	T	I	Researcher-directed

Note: I = identification, C = coordination, R = reflection, T = transformation, X = no boundary crossing,–this role is not present in this project, ? = no information available.

Combinations of Learning Mechanisms in Five Projects

In this section we illustrate five combinations of learning mechanisms by introducing five case studies: one project from each cluster of learning mechanisms as shown in Table 1.

Identification and coordination: Project P. The schools involved in Project P all have a large proportion of learning-supported students. These schools qualify for extra funding to realize specific interventions for these students such as creating smaller class sizes or implementing digital systems for test scores. The goals of the R&D project were first to provide an overview of the efficient interventions in the schools and second, to collect and analyze data of students in a systematic manner.

This project is an example of a school- and adviser-directed collaboration. In group meetings, both researchers and advisers met with the school leaders four times a year. In total, four researchers and advisers were involved during the project. The researchers and advisers made decisions regarding the goal of the research and research activities in close alignment with the wishes of the school leaders. Between the group meetings, the researcher had short meetings with school leaders in their school. The school leaders were involved in this project as experts regarding their school situation, and the researchers interviewed them. The leaders made decisions on the school level, for example, on types of interventions and funding issues. Teachers were not aware of the research activities in the school; in fact, the teachers were not crossing boundaries. The school leaders were not involved in research activities either; however, the leaders were informed of the progress of the study by the researchers.

Teachers were scarcely actively involved in the project, and no boundary crossing of teachers occurred. The learning mechanism of the school leaders can be characterized as identification. As one of the school leaders explained, he deliberately did not intervene in the work of the researchers: "'They operate autonomously; I won't interfere in that" (Interview, school leader, Project P). It was a conscious decision to remain true to his own role and tasks. However, when the research results were available, the school leaders made plans to use these results to further develop interventions focused on improving conditions for their learning-supported students.

The learning mechanism of the researchers can be characterized as coordination; they demonstrate a smooth transition from their own activity system to the activity system of the school. Melissa[1] one of the researchers, illustrated her vision on advice and research, which is a typical example of coordination:

> Advice and research were not so strictly separated. There are differences between schools in which the research role was more emphasized and schools in which the adviser role was more emphasized. . . . While collecting information, we also wished to set the schools in motion. This involves providing advice to the school. You don't watch at a distance to what happens on the school, but you are more or less steering the school by asking critical questions to make them clear [about] what they actually want. (Interview, researcher, Project P)

Another manifestation of coordination is that researchers and advisers took responsibility for translating the research results to the specific situation of each school involved in the project.

Coordination and identification: Project Q. The school involved in Project Q implemented special lessons to motivate students to read books. Project manager Bart—a school board member accountable for education quality in the three locations of the school—was responsible for the integration of the reading lessons into the school curriculum and for the communication with his colleagues and the researchers. The researchers were involved in evaluating the reading lessons, which was the question of the school. Simultaneously, the researchers were concerned with the development of a new reading instrument and were anxious to receive test results for this instrument. To achieve this research purpose was the researchers' primary concern, which is a characteristic element of a researcher-directed collaboration.

The learning mechanism of the researchers can be characterized as identification. In fact, researcher Linda was working at a distance from the school practice:

> When it was really necessary for the research, I was there. However, I did not visit the school very often to follow them. That would not be in line with the character of this research. No, it was not a case study research; in that case, you would be more closely involved. (Interview, researcher, Project Q)

Project manager Bart's learning processes can be characterized as coordination. He played an active role in the translation of the research results to teachers and school leaders:

> I am fortuitously a mathematician, so I am able to tell something about numbers and statistics. Well, I know of course the practice of our school much better. I know from the people in our school what their background is and what they are doing, so in this sense I can establish a link. (Interview, school leader, Project Q)

Bart was shifting back and forth from the activity system of the academic field to the school field while translating the results of the study for his school colleagues. Bart was aware of using tools other than those he was used to using, such as the interpretation of difficult-to-read research results.

Reflection and transformation: Project K. Project K is the follow-up project to Project S. The goal of Project S was to examine effects of physics on students' knowledge in the implementation of two digital games. This project ended after one year, and both school leaders and researchers considered the results of interest primarily for the knowledge base of the researchers. The school board realized at that point that a new study on games could also stimulate the professional development of teachers and school development as well. The researcher-directed collaboration in Project S evolved into a school- and researcher-directed collaboration in Project K.

The school leaders had a better understanding of the options of research tools and objectives in their school than the leaders had had one year earlier; school leaders realized how research could be used for more than simply knowledge creation. Their learning mechanism can be characterized as reflection.

The researchers, in the meantime, experienced a learning process that can be characterized as transformation. The researchers were already involved in Project S. The decision of the school board changed the expectations of the researchers. One of the researchers, Jim, explained his new role:

> I am actually, for the most part, supervisor and adviser on this project. On the previous project, I was more a co-researcher. On this project, performing the research is the main task of Kathryn. Supervising and bringing in the theoretical frameworks lie with me, as do supervising and creating the games. (Interview, researcher, Project K)

At first, Jim was hesitant and experienced minor conflicts with his changing role:

> Sometimes I think we have to direct the process more tightly. However, then we see that that does not work, so we try more personal supervision [of the teachers]. These are all different perspectives, which we could not have predicted, but those came on our path simply by experiencing this in practice. (Interview, researcher, Project K)

He learned from his experiences and also about the behavior of teachers and their daily work:

> I learned a bunch from this, especially in a practical manner. We have been thinking a lot and trying to puzzle out how to place this creative process in the hectic pace of the day. My beliefs and ideas about research and practice have altered because of the experiences that you encounter. (Interview, researcher, Project K)

Jim's beliefs and ideas about research and practice were still changing at the time of the interviews; however, several changes were already visible in his actions. He changed, for example, an institute-based course on games to a course in which teachers' concerns and questions were the starting point. The typical processes associated with transformation can be observed: At first, the researchers were confronted with a new situation, i.e., the wish of the school board to foster professional development of teachers, and they realized a shared vision with the school leaders and teachers was needed at this point. The researchers had to develop a new balance in the relationship with the school leaders and teachers. Therefore, they responded to questions that were raised by the teachers and adopted a more supporting role. They, indeed, used a teacher tool by being attentive to the need of learners (in this case the teachers) and altered the institute-based course in a learner-based course.

Transformation and reflection: Project A. The research purpose for Project A was to enhance the students' skills in the Dutch language and mathematics by implementing specific curricula designed by teachers. In this project, school leaders and teacher researchers conducted the majority of the research and also stimulated research activities in the school. The type of cross-professional collaboration was school-directed collaboration. At the beginning of the project, a project team was created comprising school leaders and teachers Randy, Iris, Laura, and Manuela and researcher Helen. Randy was project manager in the first year and again in the final months of the second year. He had studied Dutch language education, and he had worked for more than fifteen years at this school. He was also involved as a teacher researcher with Iris and Laura. Manuela was a member of the school board.

The learning mechanism of the school practitioners in Project A can be characterized as transformation. The project manager learned from his attempts to place research in a more central position in his school. He contributed to changes in the school, for example, by analyzing data on students and encouraging colleagues to interpret the results and formulate consequences for their own teaching of these students. Important in this context was his ambition to move responsibility and the performance of research tasks from the research bureau to the school.

> Yes, that is one of the goals we have set: to be able to perform research tasks on our own after three years with the research bureau. This entails actively approaching the research bureau to teach us how to perform research. Not only performing research but also to make sure this research will be integrated in our school policy. It involves a research attitude and educating people on this issue. That is something more than just calculating some figures. (Interview, school leader, Project A)

This move required research skills and a research attitude on the part of teachers, such as having a critical and reflective stance toward school interventions. Randy's objective was to have teacher researchers assume more research tasks, for example, utilize the instruments initially introduced by the researcher. Researcher Helen observed that the teachers involved in the project began asking critical questions regarding the research and were thinking about the results and actively reading research reports.

In the first year, Helen's own professional attitude toward her work could be characterized as identification. She said, "I am a researcher. I prefer to stay that way" (Interview, researcher, Project A). She said that knew the school quite well. She had been closely connected with the school for more than 5 years. The contact began during a former R&D project at the same school, when another researcher was leading the project and she was conducting the research.

> We know the way to school; we are familiar with the school culture; you are a familiar face. For example, with the interviews and consultation, you are familiar with the people. You are used to the working manners; you know the background and context, the differences between school locations. We have former experiences with distributing questionnaires, and now we are able to do it right away. (Interview, researcher, Project A)

After 2 years, Helen's learning processes can be characterized as reflection. She still did not want to interfere directly in school issues but felt connected to the situation in the school. Her strategy was to use the perspective of the school board, stimulate school leaders and teachers to reflect on the research results and let them make decisions based on the results.

Transformation by all professionals: Project H. Project H had been started with three interconnected research and development goals in mind: to increase the level of students' reading skills, to increase the research skills of teachers by facilitating their conducting a study on the Dutch language, and to document effective elements in the training the teacher

researchers would receive. One teacher of the Dutch language was invited to join in the project from five different school locations. These teachers were trained to become teacher researchers with a central focus on research skills: the teachers learned how to read academic literature, formulate research questions, and collect and analyze data. The primary concern of the researcher, Paula, was assisting the school with the goals that were established for the project. She advised teachers in their studies by providing input from recent literacy studies. Paula worked at a university in the department of teacher education and was experienced in educating student teachers. This project is an example of school- and researcher-directed collaboration.

We characterized the learning of the school leaders, the teachers, and the researcher as transformation. Susan was managing the project in both development and research activities. She was a staff member on the school board. Susan was working with Paula on this project as a team: Susan saw Paula as a sparring partner on all types of issues concerning the project:

> We really work closely together. Together we prepare the new group meetings for the teachers. Between every meeting, we have an appointment. I make the agenda and she complements it if necessary. After this, we talk about what we are going to do. Often, we agree on this very quickly. It is very pleasant. (Interview, school leader, Project H)

Researcher Paula agreed. She reported that they shared tasks such as supervising teachers and organizing the project:

> We still prepare the meetings together and determine the agenda, and well, we do a debriefing together. (Interview, researcher, Project H)

Paula noted in her interviews that her primary role was as a researcher but that she also provided advice to the project manager and supervised the teacher researchers. Paula's objective was to encourage teachers to become good teacher researchers who would design substantiated lessons and evaluate these lessons. She used several tools, such as academic literature, discussions, and evaluation methods. Susan supported this process. In the first year of the project, Susan was not truly involved in the studies of the teacher-researchers. This changed during the second year, as she explained:

> I really have helped one of the three [teacher researchers]. I have conducted four out of eight of her interviews. Also to experience . . . that I just knew for myself exactly . . . well, what is happening in such an interview. (Interview, school leader, Project H)

Susan was convinced that teachers conducting research is important for the school because research skills will enhance teachers' professional attitudes and their work as teachers. After 2 years, Susan was generally satisfied with the process the teacher researchers had experienced. Teachers had developed a research attitude, by being critical and reflective in preparing their lessons and in evaluating these. They began analyzing data the teachers themselves had collected. In the meantime, Susan had also engaged colleagues in the studies by informing them about the progress and results of the studies.

CONCLUSION AND DISCUSSION

At the core of this study are the notions that several learning mechanisms may occur when school practitioners and external educational experts in R&D projects cross boundaries. To create a better understanding of the learning of boundary crossers in these projects, we interpreted their learning in terms of learning mechanisms: identification, reflection, coordination, and transformation (Akkerman & Bakker, 2011). An initial result of this study is the observation that nearly all school leaders, teachers, and researchers in the 19 R&D projects in secondary education in the Netherlands indeed crossed boundaries between academic research and the school and the reverse. Crossing boundaries contributed in different manners to the learning of the school leaders, teachers and researchers (Edwards et al., 2010).

CONCLUSIONS

Looking through the lens of learning mechanisms generated a better understanding of the processes in which the learning of professionals occurred in R&D projects. Our first research question was "Which learning mechanisms are characteristic of boundary crossers in 19 collaborative R&D projects?" About half of the school leaders' and teachers' learning mechanisms were characterized as transformation. Performing research in their schools and engaging other colleagues in the research expanded their professional methods of working with the tools and objectives that are common in research. These teachers, generally serving as teacher-researchers, mentioned, for example, using test scores to analyze student

progress and generally developing a more critical stance toward school policy. School leaders began using the tools and objectives of researchers as well. School leaders mentioned, for example, making decisions in a more systematic, substantiated manner.

We observed that reflection is characteristic of the majority of the other teachers involved in the projects and for a few school leaders. Such teachers and school leaders mentioned having developed a better understanding of the value of research. For example, they began reading about educational research and are asking more questions regarding their own practices now. In addition, they continue to investigate how to fit research tools and objectives into their daily routines.

Coordination and identification were less common learning mechanisms among school leaders and did not occur with teachers in the R&D projects. Coordination for school leaders entailed shifting between their role as a school leader and performing research tasks without integrating the two. These school leaders were able to translate research results to colleagues. Identification for school leaders entailed being interested in research results that are relevant for school development without becoming involved in the research itself.

The learning mechanism of most researchers is characterized as transformation. The researchers adopted the schools' objective of providing conditions for a good education and became involved in developing new pedagogical approaches. Some of them learned how to integrate the learning needs of teachers in collaborating with these teachers, and all learned to perceive research and development as interwoven processes.

Reflection is characteristic of a third of the researchers in the 19 projects, including researchers who considered the perspective on school development issues as these participants performed research, for example, by moving up deadlines for teachers with urgent school matters. These researchers have decided not to guide or direct the development in schools.

Coordination and identification are characteristic of several researchers. Coordination for researchers entails using tools and objectives for conducting research and adapting tools and objectives to stimulate school development. However, using the tools and objectives of school leaders and teachers did not influence the tools and objectives they used as researchers. Identification for researchers entailed working at a distance from the school and being aware of school issues; simultaneously, the researchers chose not to be involved in these school issues.

The learning of boundary crossers occurred in R&D projects in secondary education that we characterized by different types of cross-professional collaboration. This notion leads to our second research question:

How are types of cross-professional collaboration and learning mechanisms of boundary crossers related? Distinct combinations of learning mechanisms occur according to type of collaboration. School-directed collaboration appears to relate to the learning of school leaders and teachers that can be characterized as transformation and a researcher's learning mechanism of reflection. School leaders and teachers were responsible for guiding and directing the research during these projects. School- and researcher-directed collaboration is a type of collaboration in which teachers and school leaders have the primary responsibility for performing research in their schools and with researchers who provide support for decisions on pedagogical matters. This type of collaboration is related to two combinations of learning mechanisms: reflection of school leaders and teachers, transformation of researchers, and transformation of school leaders, teachers and researchers. School- and adviser-directed collaboration, in which advisers share the responsibility of the research-and-development activities in the project, is related to a combination of identification of school leaders and teachers and coordination of researchers. Researcher-directed collaboration is related to the learning mechanism of identification of researchers, which is associated with the role of these researchers who have additional reasons for the collaboration and work at a distance from the school. Thus, depending on how school leaders, teachers, and researchers are collaborating, they are encouraged to cross boundaries between the school field and the academic research field, allowing different learning processes to emerge.

DISCUSSION

The results of our study indicate that collaboration between educational practitioners and researchers in R&D projects can entail more than a temporary alliance or even switch of roles. Our study shows that many teachers who were involved in R&D projects not only performed research tasks but also, and maybe more importantly, learned to approach their teaching with a more inquiry-based attitude. They incorporated new concepts developed in educational theory in their thinking about teaching and used methodological techniques in evaluating it. School leaders integrated such perspectives in the way they were leading the school. Similarly, researchers not only did research that served the goals of a particular school, but also became more practice-oriented as a researcher more generally. They developed an eye for the complexities of educational practice and for the importance of context in designing education. Also the objective to contribute to good education and development of students through their research became more prominent.

The learning mechanism of identification was least associated and transformation was most associated with alterations in professionals' thinking and methods of working, alterations that were described as an enrichment. This may suggest that the learning mechanisms are hierarchically related. However, we think *continuum* is a better characterization of how the learning mechanisms are positioned in relation to each other than hierarchy. In the context of our study, schools and researchers could choose for different types of collaboration that offered different opportunities for learning and in which different learning mechanisms occurred. In some cases, for example researcher-directed collaboration fitted the research aims and questions best. This meant that researchers remained apart from school development issues and the learning mechanism of identification occurred for the researchers. Nevertheless, identification is related to traditional characteristics of collaboration between researchers and school practitioners, whereas transformation may contribute to a shift of authority from researchers to school leaders and teachers, i.e., school leaders and teachers are taking decisions and directing research in R&D projects.

Our study has several implications. As the examination of 19 Dutch R&D projects shows, crossing boundaries contributes to the learning of school leaders, teachers, and researchers. These professionals adopt new tools and objectives as they engage in the project, particularly in the case of transformation. In other contexts, these results on boundary crossing are found as well. An example is the study of Max (2010) in which several student teachers become cocreators and coresearchers, being involved in projects in their schools with colleagues. These results indicate the student teachers were shifting roles as they cross boundaries, comparable to the teachers in our study who become teacher researchers. As these teacher researchers develop new roles and tasks, they integrated tools and objectives belonging to the activity system of research. In the search for solutions for the perceived gap between the academic research field and school practices, other studies on teachers and teacher researchers viewed this gap from different perspectives, for instance, Rust (2009) who demonstrated that teacher researchers may well be able to translate knowledge from the research field to the school field, whereas Janssen, Westbroek, Doyle and Van Driel (2013) examined teachers' ability to connect practical knowledge to the more theoretical knowledge derived from research. Taking the perspective of learning through boundary crossing, our study adds to the discussion on this gap. Closing the gap between research and practice also implies focusing on how cross-professional collaboration is shaped. Strong links between researchers and practitioners are required to create a good understanding

of one another's tools and objectives, as is also mentioned by other authors (e.g., Hora & Miller, 2011; Tsui & Law, 2007; Williams, 2002). Coburn and Stein (2010) emphasized the need for all parties to communicate goals and strategies to create a shared framework and commitment during a project. Our study shows that researchers can work closer to the school practices or decide to work at a distance when they are involved in R&D projects. The work of van de Ven (2007) on engaged scholarship provides insight into an approach for researchers to building a relationship with practitioners to obtain a better understanding of complex school practices. The researchers' decision to spend time in schools and provide greater accountability to the practitioners is an important element of engaged scholarship, that contributes to a shift of authority between researchers and practitioners (van de Ven, 2007).

The implications for both schools and research institutes in our study are based on R&D projects that were part of the same funding scheme. One of the goals of the funding organization was to enhance and stimulate the exchange of knowledge between the research field and the school field. The funding application itself could have been an indirect incentive for some of the professionals to cross boundaries during the project. Thus, it is important to consider the funding of the R&D projects when interpreting the results. In addition to this, it is not known whether other colleagues in the schools in which R&D projects occurred learned from the boundary crossers in the projects.

In future studies on R&D projects, it would be interesting to integrate more perspectives on the changes into the practice of schools and research institutes, for example, by asking colleagues their opinions on perceived changes in the activity systems. In the current study, we concentrated on the learning of individuals and how their professional methods of working changed. However, actions of individual educational practitioners and researchers are situated in their activity systems. The objective of an activity system as a whole may also be called into discussion as subjects, tools or other elements of the activity system alter. This may also lead to cultural changes either in the school or in research institutes, for example a move towards a more research-engaged culture in schools and more practice-engaged approaches in research institutes. Such possible cultural changes could be the object of future studies. This would involve taking other aspects of Engeström's model into account, such as community and rules (Engeström, 2001).

Regarding the inclusion of all perspectives, it might be interesting to consider more systematically two other groups in a future study on learning mechanisms: advisers and supervisors who are involved in R&D projects. As a component of their daily work, advisers and supervisors are

crossing boundaries from their activity systems to school practices (e.g., Akkerman, Bronkhorst, & Zitter, 2013). Examples of these roles for R&D projects are providing advice to school leaders and supervising teachers in their developing of work or research activities. However, in addition to crossing boundaries to school practices, advisers and supervisors might also cross boundaries to the academic research field while they are involved in an R&D project. A future study that includes these professionals might provide insight into the types of learning mechanisms that are present in these cases.

A final suggestion for future research is to investigate the long-term learning effects of boundary crossing of the professionals in the projects to provide insight in differences in cases in which professionals have a temporary alliance or in which long-term relationships are established.

In this study, we have demonstrated that boundary crossers can pass through several learning processes that contribute to a growing awareness of others' tools and objectives. School practitioners and external educational experts assumed new tasks and included new perspectives in their actions by collaborating on an R&D project. These actions resulted in several combinations of learning mechanisms during the projects that played out differently for the professionals and their collaboration in the project. The combination of transformation for all parties is the most far-reaching manner of crossing boundaries. These school leaders and teachers developed a research attitude and began analyzing student data they themselves collected, and the researchers incorporated contributing to educational improvement as an objective in their research. Transformation entails a closer interaction between school practitioners and external educational experts in which tasks such as supporting teachers in their professional development and organizing an R&D project were shared. The findings contribute to an understanding of boundary crossing in the context of R&D projects, because school leaders, teachers, and researchers learn from the other professionals' activity systems in relation to their own situations. By examining the learning potential of boundary crossing, this study has further opened up the perspective of boundary crossing in educational research as a promising framework with which to explore how professionals can learn from participating in each other's worlds.

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NOTES

1. All names of participants are pseudonyms.

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APPENDIX A

INTERVIEW QUESTIONS

Used for the interviews with the project managers of the R&D projects, interview Round 3.

1. Project activities and output
   - What research and development activities have been undertaken? What is the role of research in this project?
   - Has the project developed according to plan? What changes are there and why?
2. Reasons for collaboration in project
   - What connects the school and the research institute?
   - What are the purposes of the collaboration and the project goals?
   - Is there a common vision and focus on research and development from school and the researchers? Do you speak the same language?
   - How do you evaluate the collaboration so far?
3. Changes in project team
   - Are there any changes in the composition of the project team?
   - How are knowledge and experiences transferred to new project participants?
   - What are expectations for next school year in the composition of the project team?
4. Division of roles and tasks in project
   - Which project participants are involved in the project?
   - How do you perceive the role of the external expert: researcher/adviser/supervisor?
   - Who is responsible for the course of the research process? And who for the development activities?
   - Has every project participant his/her own input according to a specific expertise?
   - How do you evaluate the division of roles and tasks in the project?
   - What are expectations regarding roles and tasks in the further course of the project?
5. Boundary crossing
   - How do you perceive your own role? E.g. project manager/school leader/teacher/teacher researcher?
   - What tasks and responsibilities do you have in the project?
   - What changes in your role, tasks, responsibilities and actions have you noticed by participating in the project? Can you illustrate this with an example?

- What changes in the roles, tasks, responsibilities and actions have you noticed with other project participants? Can you illustrate this with an example?

6. Communication structure in project
   - What is the available time for research and development in hours per week?
   - Which ways of communication are specifically used? E.g. consultations, meetings, e-mail, telephone, walkway.
   - When in contact with other project participants, what is mostly discussed: making agreements or in depth-discussions on content?
   - Have there been arguments, about what? How and with whom are they solved?
7. Involvement of researcher
   - To what extent is the external researcher involved in development and research in school? Do you perceive it as indirectly involved or closely involved? Can you illustrate this with an example?
   - At what point do you involve the external researcher in taking decisions?
   - Do you consider input from the external researcher in your decisions about research and development?
   - Do you think you are dependent on each other to bring the project to success?
   - To what extent is the development in school attuned to the rhythm of research?
   - To what extent are needs of the school taken into account in the project?
8. Vision on research
   - What is your vision of who should carry out research in school? External researchers and/or teachers and/or school leaders?
   - What is your vision of the purpose of research? To increase academic knowledge and/or to improve practice?
   - For which party do you think is the research performed? For school (contextual) or as a contribution to the academic world (generalized)?
   - What is the vision of the school to performing research in school? What is the vision on research engagement of teachers and school leaders? What is the support from the organization to performing research in school?
9. Advancing and restricting factors
   - What do you see as factors that advance and that threatens the success of the project? Concerning output of the project, activities, and conditions, and collaboration.

APPENDIX B

CODING SCHEME, USED FOR ANALYZING INTERVIEWS

Code	Explanation
R&D project team	
Project team; development	Composition of project team on the issue of development: names and tasks of project participants
Project team; research	Composition of project team on the issue of research: names and tasks of project participants
Changes in project team	Changes in project team; expectations for next school year; ways of transferring knowledge to new participants in case of changes in project team
Project activities and output	
Development activities	Progress in project activities on level of development and judgment on this issue; with attention to, e.g., an innovation, professional development of teachers
Research activities	Progress in project activities on level of research and judgment on this issue; with attention to e.g. tests, questionnaires, analysis and reports
Role of research in the project	Role of research in the project, for instance informing school development and judgment on this issue
Progress in project	Project progress as planned or reasons for changes in planning
Cross-professional collaboration **Reasons for collaboration in project**	
Connection research institute-school	What connects research institute-school, e.g., research theme, previous history
Reasons for collaboration	Reasons for collaboration research institute-school in this project; interests of parties
Project goals	Project goals; research and development
Convergent or divergent reasons	Convergent or divergent reasons for collaboration and project goals; vision on development and research
Opinion on collaboration	Opinion on how collaboration research institute-school works out
Division of roles and tasks in project	
Role of project manager	Role, tasks, actions undertaken, and responsibilities of project manager in research and development
Role of school leader	Role, tasks, actions undertaken, and responsibilities of school leader in research and development
Role researcher/adviser/ supervisor	Role, tasks, actions undertaken, and responsibilities of researcher, adviser, supervisor in research and development

Code	Explanation
Role teacher(researcher)	Role, tasks and responsibilities of teacher(researcher); training and time and space facilitations; capable of performing research
Boundary crossing	
Crossing boundaries	Project participants who become aware of (new) tools and objectives that are common in other activity systems and as a result have the opportunity to expand their professional methods of working (e.g., a teacher or school leader who engage in research activities; a researcher who focuses on questions raised in school practice)
Changes in roles and tasks	Changes in roles and tasks through crossing boundaries (e.g., a teacher who becomes teacher researcher; a school leader who starts to stimulate research engagement in school; a researcher who becomes engaged in practice)
Changes in tools and objectives	Changes in tools and objectives through crossing boundaries (e.g., a teacher or school leader who becomes involved in designing questionnaires; a school leader a researcher who becomes active in assisting school board in providing conditions for students to be able to learn)
Communication structure in project	
Workplace researcher	Frequency of working at school or at institute by researcher
Contact person	Contact person at school for researcher
Time investment	Time investment in project in hours per week/month
Communication means	Means of communication between research institute-school: consultation, e-mail, phone
Involvement of researcher	
Distance of researcher	Researcher is closely involved or working from a distance
Decision making	Decisions on project issues taken by school or researcher
Dependence	Extent of interdependence between school and researcher
Trust	Building on each other's opinions and visions
Conflicts	Conflicting issues or disagreements in the collaboration
Rhythm	Tuning the rhythm of school issues and research activities, e.g., planning questionnaires outside school exam periods
Needs	Tuning needs of school and researcher in research and development
School leader's vision on research	
Vision on research, research engagement, performing research in school	Vision on research engagement, on who has to/can perform research in school: academic and/or school participants

Code	Explanation
Vision on research; goal and audience	Vision on practice-based research: enhancing academic knowledge and/or contributing to improvement of practice; audience for practice-based research (academic world and/or practice)
Vision of institute	Vision of school/institute on performing practice-based research in school; support on performing research
Advancing and restrictive factors	
Advancing factors	Factors that are seen as advancing success, concerning output, activities and conditions, and collaboration

APPENDIX C

SAMPLE OF THE MATRIX THAT WAS USED FOR THE ANALYSIS

The first four columns are a sample of the matrix that was used for the analysis; they include interview data on roles and tasks and tools and objectives from two interviews: one with a researcher in Project K and one with the school leader in project K. Text in italics is placed as quote in the article. The last column contains the result of the next step in the analysis: a characterization of the learning mechanism of the interviewee and an explanation of why this learning mechanism was assigned.

Project code	Role and pseudonym	Interview data on roles and tasks	Interview data on tools and objectives	Characterizing learning mechanism
K	Researcher Jim	*I am actually for the most part supervisor and adviser in this project. In the previous project I was more a co-researcher. In this project performing the research is the main task of [name colleague]. Supervising and bringing in the theoretical frameworks lies with me, as is supervising and creating the games.* Though I have also written the second research proposal, so that again is research. I think we have had five meetings. Yes, at some point we have abandoned the plenary meetings and we took some one-on-one time with the teachers. So we have divided the teachers between me and [name colleague] and held personal conversations with them and coached them via e-mail.	*I learn a bunch from this, especially in a practical manner. We have been thinking a lot and trying to puzzle out how to place this creative process in the hectic pace of the day. My beliefs and ideas about research and practice have altered because of the experiences that you encounter.* *Sometimes I think we have to direct the process more tightly. But then we see that that does not work, so we try more personal supervision. . . . These are all different perspectives, which we could not have predicted, but those came on our path simply by experiencing this in practice.* And in the meantime we monitor what is happening. We hope to say afterwards what things were very smart to do and what we should never have done that way. That will be the yield of the study.	*Transformation*: Jim's beliefs and ideas about research and practice were still changing at the time of the interviews, but several changes were already visible in his actions. He changed for example an institute-based course on games to a course in which teacher's concerns and questions were the starting point. The typical processes associated with *transformation* can be seen: at first the researchers were confronted with a new situation, i.e., the wish of the school board to foster professional development of teachers, and they realized a shared vision with the school leaders and teachers was needed at this point. The researchers had to develop a new balance in the relationship with the school leaders and teachers. Therefore, they responded to questions that were raised by the teachers and adopted a more supporting role. They, indeed, used the tool of teachers by being attentive to the need of learners (in this case the teachers) and altered the institute-based course in a learner-based course.

Project code	Role and pseudonym	Interview data on roles and tasks	Interview data on tools and objectives	Characterizing learning mechanism
K	School leader Roy	I have to some extent positioned myself in the role of researcher you could say, but only slightly. [Last year] much less, because at that time a teacher was involved of our school, just as [name researchers] were also there. . . . So these progress meetings were organized tighter. It was really about planning.	So I am more substantively busy eh, just sparring with researchers on methodology and stuff, and of course that is not my expertise, but I have ideas. Of course I have certainly got ideas on how to organize research in school. We wanted to make it broader [in school]. We actually want more teachers to be involved in the research and that more teachers will apply the games within their lessons. And we also wanted to further expand the research. So the idea was to build a sort of double victory by involving teachers in designing game lessons, that is one of the major development issues from the research.	*Reflection*: The school leaders had a better understanding of the options of research tools and objectives in their school than one year before; they realized how research could be expanded in school, and be used for more than knowledge creation only. Their learning mechanism can be characterized as *reflection*.

APPENDIX D

CHARACTERISTICS OF CROSS-PROFESSIONAL COLLABORATION IN R&D PROJECTS

Project code	Reasons for collaboration	Division of roles and tasks and communication								Type of cross-professional collaboration
		Direction and guidance		Role in research and time investment						
		Development	Research	School leader	Time investment	Teacher researcher	Time investment	External party	Time investment	
Projects ABCDEFG	Congruent	School	School and external party	Project manager	High	Present	High	Project manager, researcher, supervisor	High, sometimes low	School-directed collaboration
Projects HIJKLM	Congruent	School and external party	School and external party	Project manager	High	Present	High	Project manager, researcher, adviser, supervisor	High	School- and researcher-directed collaboration
Projects NOP	Congruent	School and external party	School and external party	Project manager	Low	Not present	Low	Project manager, researcher, adviser, supervisor	High	School- and adviser-directed collaboration
Projects QRS	Additional	School and external party	External party	Attune to development	Average	Present	Low to average	Project manager, researcher, adviser, supervisor	Average to high	Researcher-directed collaboration

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