PROFESSIONAL LEARNING

Research Program of the Eindhoven School of Education (ESoE)

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1 INTRODUCTION

Research is one of the three core tasks of the Eindhoven School of Education (ESoE). The other two relate to teacher education in the domain of science and to contributing to the innovation of education[1]. The connection between the three core tasks forms the basis of ESoE's research program, which is described below. It also adds dynamics to the program, making it necessary to adapt it frequently on the basis of input obtained from innovation and teacher education. The research program focuses on teachers' learning, with specific attention paid to science and technology education. Both focal points are closely connected with ESoE's position as a collaborative venture between Eindhoven University of Technology (TU/e) and Fontys University of Applied Sciences (*Fontys Hogescholen*). In the first instance, ESoE organizes teacher education in the subjects of Physics, Chemistry, Mathematics, and Computer Science within the TU/e, while general teacher education is the core business of Fontys. In the second instance, in and around the city of Eindhoven, there is a concentration of knowledge in the field of science and technology at TU/e, at the Fontys Pedagogical Technical School, and at the High Tech Campus Eindhoven, for example. Furthermore, ESoE is in charge of the research carried out at the Kenniscentrum Wetenschap en Techniek Zuid (KWTZ), the center of expertise for science and technology, which was established by the elementary teacher education colleges (*Pabo*) in the southern part of the Netherlands to support the introduction of technology in primary education. In addition to these pragmatic reasons, there are also conceptual reasons, which we will explain below, for paying particular attention to "the teacher" and to "science and technology education".

1.1 THE TEACHER AS A PROFESSIONAL

[1] For more information about the ESoE, please refer to the document in which the institution's mission is described.

Teachers occupy a central place in the research program. The guiding concept is that of *the teacher as a professional*: namely, one who takes his or her own responsibilities, makes his or her own choices, and takes on his or her own professionalization. The quality of teachers is highly significant for the quality of education (Jochems, 2007, Day, 1999). Furthermore, the role of the teacher as a professional is also essential for innovations to succeed (Duffee & Aikenhead, 1992). In addition, appealing to the fact that teachers are responsible for their own professionalism may be of great importance for motivating teachers who are, in fact, often confronted with a lack of recognition and the demotivation that attends it. The image presented above of the teacher as a professional is an idealized one not currently fitting every teacher. In the literature, today's teachers are more generally characterized as semi-professionals. Consequently, considerable work still needs to be done for a teacher to achieve the status of a professional. One of the focal questions of this research program therefore concerns how teachers could be supported in their further development as professionals, and how the initial education of teachers could anticipate ongoing professionalization.

The fact that the teacher as a professional was chosen as a starting point, means that a central place has been created in the research program for active professionals learning throughout every phase in their careers. This is expressed in the theme of professional learning, which refers to learning in the workplace. However, professional learning encompasses more than the fact that it involves current teachers and that learning in one's own work environment is a major aspect. It also involves a professional attitude towards profession-oriented learning and learning to become a professional. The basic premise of the teacher as a professional also has consequences for the initial training, which will need to create a basis for continued professionalization. In addition to the teaching of teaching skills, the initial training will also prepare prospective teachers to experiment with, and to look into new forms of education and educational contents in their own classrooms. Furthermore, the teacher education institution will need to make its students aware that ongoing professionalization is an indispensable component of the teaching profession.

The literature on the professionalization of teachers distinguishes two processes that are referred to as "teacher learning" and "teacher change". Teacher learning refers to situations in which the needs of the teachers themselves, within their own teaching practice, form the driving force of the learning process. Teacher change is linked more with external directing by the school, by the environment, or by education policy. In practice, teachers will come across both. On the one hand, teachers - in particular novice teachers - will need to work on improving and refining their own teaching practice. On the other hand, teachers will also need to be led by school policy and developments in society. However, we do not view the former and the latter as two disjunct processes. After all, an improvement in the teachers' own teaching practice will need to take place within the frameworks defined by the school and society, while changes initiated from outside may only have a chance of succeeding if the teachers involved adopt the objectives of adaptation. There are also intermediate forms such as innovations that involve substantial changes that require teachers to take the initiative. However, even if it involves an external initiative for innovation, the teaching practice and teachers' perspectives will form the starting point for learning and change. This means that in the event of innovation teachers' practical knowledge should be recognized. Moreover, as professionals they should always have a major say in structuring a reform. After all, teachers' involvement in a reform is an important factor.

1.1.1 LEARNING FROM EXPERIENCE

As referred to above, learning is a self-evident component of the teaching profession. Teachers learn by experience and by working independently on improving and refining their own teaching practice. This may involve an improvement in what they already do, but also experimenting with new things. It is clear that teachers are changing their own teaching practice while experimenting by gathering new things here and there, which they try out and may integrate into their own practice. A characteristic feature in this respect is the fact that the teachers' knowledge increases but, at the same time, becomes narrower. As a result, after a certain period teachers may be less inclined to exceed this well-developed practice.

As well as learning from experience, we also distinguish two other learning situations, which we discuss in more detail below. They involve learning in the context of an educational innovation, and teachers learning in the context of curricular innovation.

1.1.2 LEARNING AND EDUCATIONAL INNOVATION

As is evident from what has been said earlier, the basic premise of the teacher as a professional is not only significant for the development of the teachers themselves but is also of great importance within the context of educational innovation. Educational innovation occupies a major place in ESoE's research program because there is a wide range of ongoing general-educational developments that render innovation necessary, and because curricular reform is high on the agenda of education in science and technology. Educational innovation could include aspects such as transference of the training to the school, academic training institutes, "technasia"[2], the introduction of new educational views, and new types of learning environments such as competence-based education, natural learning, issue-driven education, design-orientated education, and so on. Or it could involve curricular reform in the field of science and technology, which should provide a solution to the problem of the perceived unattractiveness of science subjects, the inadequate yields of science education, the absence of a research culture, and the need for adapting education to the economic and technological developments in society. For that matter, it should be noted that a distinction can be made between general-educational and curriculum-specific reasons for reform, but both aspects play a role in the actual development. A reform of a general educational nature will usually also require curricular development, while curricular reforms normally have a general educational component. However, one research question that has still not been answered satisfactorily is how can externally initiated reforms be accomplished in practice.

By now it is a known fact that traditional strategies for educational reform, which are based on the RDD model, fail to be effective. These strategies are grounded on a chronological

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[2] A "technasium" is a new concept within the Dutch education system, developed for students at *HAVO* (senior general secondary school) and *VWO* (pre-university education) levels, who prefer to study science and technology subjects.

succession of Research, Development and Diffusion (RDD). The starting point is scientific knowledge; this is converted by developers into useful instructions, and these are distributed among teachers, who, in turn, apply them consistently. Generally this approach has not proved to be successful. Although this was initially blamed on the fact that teachers failed to implement the innovation consistently, it is now thought that the problem lies with the model itself. In the RDD model, teachers' views, knowledge, ideas, intentions, and attitudes are not taken sufficiently into account (Van Driel, Beijaard & Verloop, 2001). Educational innovations demand a change in the teachers' way of thinking. The term "cognitive change" is also used in this respect. In this way, emphasis shifts from construing and implementing educational reforms to organizing teachers' learning as the basis for educational innovation.

To bring processes of change in motion from outside, teachers will need to be motivated and inspired to adopt these changes and to give shape to them themselves. In this context, this is referred to as "the teachers' own practice as a starting point for professional learning". Ideally, the latter would take place in cooperation with colleagues and with the support of experts. A crucial element in favorable innovative processes is that teachers visit each other's classrooms and feel jointly responsible for an ongoing process of educational improvement. Interesting in this respect is the "lesson study" model, which is currently the vogue in Japan (Stigler & Hiebert, 1999). The starting point of this approach is that a group of teachers assumes responsibility for working out a reform, or for educational improvement in general. The common procedure is that the teachers jointly develop a lesson that is given by one of the group members. The others observe the lesson after which an in-depth discussion follows, focused on analyzing and improving the lesson but also on considering the lesson in a wider context of the intended improvement or reform. Subsequently, a new or improved lesson is developed, which is given by one of the group members, and the cycle repeats itself. The power of the lesson study model is that it makes educational reform and professionalization an ongoing and incremental process. Moreover, it correlates with something that Fullan (2006) regards as one of the essential points for innovation to be successful: feedback on actual changes in the practice within the teachers' own class.

Of course, a number of variations on and supplements to this model are possible and desired - there is no silver bullet that works for everyone. Thus, teachers can also analyze and discuss each other's classes, participate in supervised study groups, or conduct research into their own practice.

Mark, however, that although teachers may learn most effectively together with colleagues (through exchange, feedback, obtaining input, and so forth), input from outside (experts) proves necessary as well. In this context, the idea of forming networks should also be mentioned, whereby professionals of different backgrounds collaborate on the improvement of education. In addition, "learning from and in one's own teaching practice" can also be fostered by attending workshops or conferences, or by taking up a study. Moreover, successful progress should meet all sorts of conditions such as facilities, time, the possibility of sharing knowledge and experiences, and interest shown and support given by school management, and so on.

1.1.3 LEARNING AND CURRICULAR INNOVATION

The basic premise of the teacher as a professional also has implications for a view of curricular innovation. One of the consequences is that curricular materials may play a significant role in curricular reform, but the image of "the teacher solely as the implementer of education developed by others" does not fit in with this context. In line with the idea of the teacher as a professional, the teacher rather than the curricular material should carry an educational reform, even if it involves a renewal of curricular content. In addition to developing insights and materials to create renewed education, curriculum developers and researchers should also focus on strategies and materials that could facilitate professional learning with a view to curricular reform. Design-oriented research could play a valuable role in this respect, especially because of the inherent interwovenness of designs and research and in particular when such research focuses on the development of empirically-grounded theories on how the new education works. In that case, teachers can regard the outcome of developmental research as potentially adaptable theories, which they may assess and adapt in their own teaching practice. In this way, the concept of the teacher as a professional can be justified optimally. Another interesting aspect in this context is the concept of "dual design research" (Gravemeijer & Eerd, 2009), whereby research not only focuses on students' learning but also on the learning process of the teacher who carries out the educational experiment. This would facilitate the conversion of research results into inservice- and preservice teacher education.

1.2 SCIENCE AND TECHNOLOGY EDUCATION

The research program devotes special attention to science and technology, a field of education that receives a great deal of attention for different reasons. Few students opt for science and technology subjects and few for a science-oriented profession, even though science and technology occupy an increasingly prominent place in our society. Different sources stress the significance of boosting a positive attitude towards science and technology and of developing scientific literacy among the current generation of students. However, not only do most students consider science subjects irrelevant to their future, there are also problems with the yields of science education. It is clear that mainstream science education generally results in isolated knowledge that is not suitable in the situations of application. Moreover, the nature of this form of education does not correlate with the needs and self-image of secondary school students, for whom it is important that they have a say in the development of knowledge. To face these problems, changes in science education will be necessary. These changes will involve a review of the objectives of science subjects, whereby more attention is demanded for usefulness and relevance, and insight into the science culture is also regarded as an educational objective.

In this respect, there is a discrepancy between sciences in practice and the nature of education in these subjects. Because students come into insufficient contact with the scientific culture of asking questions, doing research and experimenting, and fail to familiarize themselves with this culture, the associated products also remain inaccessible to them. The rules and formulas are regarded as meaningless and separated from reality. To face this problem, it is important to gain experience in participating in the science culture. This is different from identifying with this culture, which, of course, cannot be the objective of this education. Overcoming this deadlock is not easy: First, because schoolbooks are not tailored to the enculturation of science education, and second, because teachers have no experience with actual research-oriented education. They are not experienced in creating

and maintaining a research-oriented classroom culture and lack the pedagogical content knowledge (PCK) that this type of education requires. An important aspect in this respect is the ability to anticipate ideas and solutions that students might put forward, and to respond to these constructively. An additional question concerns how to handle the differences between students, which concern issues of ethnicity and gender. Finally, a complicating factor is that the required conversion demands a simultaneous change on different fronts.

With this kind of educational reform, changing the manner in which teachers teach will always be a vital element. In this respect, emphasizing science and technology education fits well with the theme of professional learning.

1.2.1 GLOBALIZATION AND COMPUTERIZATION

As we mentioned above, structuring science and technology education cannot be considered separately from the role of science and technology in our society. However, if we disassociate ourselves a bit more from the daily teaching practice and include social developments in our considerations more emphatically, a new perspective will emerge, which demands a fundamental review of the objectives and structure of science and technology education: namely, that of an increasing globalization and rapidly developing computerization of society.

Education will have to prepare students for a society that they will be part of in the future. Of course, we do not know exactly what this society will be like, but we can predict that computerization and globalization will play a major role in it. According to American economists Levy and Murnane (2006), the effect of computerization and globalization will be that tasks that can be subdivided into routines will disappear from Western economies. These tasks will be transferred to employees in low-wage countries or to computers. What will remain are jobs that, in addition to creativity, flexibility, and social skills, require the ability to work with computers or computerized equipment. Many publications refer to the significance of problem-solving and communication (Partnership for 21st Century Skills, 2008). These are actually the elements that emerge insufficiently in current education, and in which the reform of science subjects should make a change.

Furthermore, to make students creative and flexible in a society dominated by science and technology, computers should be more to them than black boxes. Computers and computerized equipment increasingly function as intermediaries between human beings and their physical environment. It is therefore important to gain insight into the processes described, controlled, or analyzed by computers. Preparing students for this should be one of the objectives of elementary and secondary education. This demands that special attention be devoted to working with models, and to discuss relations between variables. Within this framework, the KWTZ conducts research based on the assumption that this aspect can already be initiated at the level of elementary school.

1.3 STRUCTURE OF THIS RESEARCH PROGRAM

In the following chapters, we will elaborate the aforementioned point by discussing the theoretical knowledge available with regard to teachers' learning. Next, research into science and technology education will be discussed more extensively and several methodological considerations will be highlighted. This will be followed by a brief explanation of the scientific and social relevance of the research program. We will conclude with an overview of ongoing research projects.

2 THEORETICAL BACKGROUND WITH REGARD TO TEACHERS' LEARNING

When considering the entire field of professional learning, we observe that there exists a wide range of theoretical diversity (Jochems, 2007). Paradigmatically speaking, we note cognivistic as well as constructive and social constructivist approaches. From a theoretical point of view, this leads to a variety of small and large theories. Examples include those involving communities of practice and of learning, deliberate practice, adult learning, activity theory, knowledge creation and knowledge engineering, networking theories, development of expertise and competence, theories that use changes in the workplace as a basis for learning, change and innovation theories, and so on. The origin of these theories varies significantly. Some have emerged bottom-up from observational studies within communities, while others have a more prescriptive nature and have been subjected to empirical testing over the years. Another striking aspect is that many theories originate from the practice of a particular profession or type of profession, and that their conversion into the reality of other professions often happens in an insufficiently adequate manner. Furthermore, it is also striking that because of their context-related and individual nature, change and improvement theories often do not, or insufficiently, link up with professional learning as it takes place in professional practice (eg. Jarvis, 2004; Van Eekelen, 2005).

The research program on "professional learning" does not focus on one or several theories and paradigms in advance, but determines the theoretical perspective on the basis of the approaches chosen for research, and on the associated questions. Recent studies support the idea that professionals learn from experience, that reflection plays a significant role, and that learning is mediated by context as well as by the individual, which makes professional learning complex (Webster-Wright, 2006). Research has shown that teachers also learn without reflecting on their experiences: that is, they learn subconsciously, which is evident from an increase in action tendencies (cf Hoekstra, 2007; Korthagen, …).

2.1 LEARNING FROM EXPERIENCE

Learning from experience can be regarded in two ways: (1) learning from active involvement in practical experiences within specific learning situations and (2) the integration of what is new in experiences gained on an earlier occasion. Professionals learn from experience in either case (cf Wagenaar, Scherpbier, Boshuizen & Van der Vleuten, 2003). The extent to which professional learning from experience takes place for teachers is co-determined by:

- The meaning constructed by teachers on the basis of experience. The constructing processes depend on the teachers' learning history and on the importance they attach to the experience within a specific learning situation. Experiences that are situated "far from" the matters in which people are interested, and/or what they consider significant for their own functioning, lead to a lesser extent to changes than experiences that are closely related to aspects about which people are concerned or care a great deal. This distinction in the significance of experiences of the learners in specific learning situations also partly determines their involvement;

- Teachers' involvement in shaping and organizing learning situations, contributes to the obtaining "ownership" of the learning process and of the experiences gained throughout the process. It is assumed that this is of great influence to the extent to which a change occurs on the part of the teacher. Teachers' involvement increases when, what and how they learn, correlates with their personal interests and learning preferences.

In practice, both aspects of experiential learning are closely connected: namely, with experiences that are considered important to learn from, there is usually also a large degree of involvement in the learning situation within which these experiences are gained, and vice versa. The extent to which a person is involved in a learning situation and the experience gained is considered significant for the individual's own functioning is sometimes also associated with the distinction between "deep learning" and "surface learning" (Marton & Saljö, 1984).

Involvement and the construction of meaning are major ingredients for professional learning in the context of educational innovation. Moreover, the way in which teachers appropriate an innovation depends on the attitude they adopt towards it. An innovation imposed from outside often results in the incorporation of something new without anything actually changing. An innovation that is primarily brought about by the teachers themselves is more likely to succeed where changes among teachers are concerned. However, the teaching practice often involves a "dissonance" between what stakeholders consider desirable for teachers and what teachers themselves consider important. It is striking that teachers rarely express this, which is partly due to the power relationships that teachers experience between themselves and school management (Webster-Wright, 2006).

Teachers' engagement and commitment are essential elements for professional learning within the context of educational innovation. Both aspects can be encouraged by placing the responsibility and initiatives for innovation with the teachers themselves: giving them agency. In this respect, is becomes clear from literature that learning from and with each other is important in a climate that is characterized by mutual respect and trust (Nias, 2005). Examples of strategies that do justice to teachers' agency, dialogue, and cooperation between teachers included action research, action learning, learning in teacher networks, and entering into co-generative dialogues (Roth & Tobin, 2005), whereby teachers more emphatically assume the role of researchers. Roth & Tobin (ibid) further emphasize the significance that learning has with regard to the context.

2.2 LEARNING THROUGH REFLECTION

However, active involvement in practical experiences in learning situations is insufficient for truly effective learning, since this type of learning is dependent on reflecting on one's own practical experiences. The significance of reflection for professional learning is described in much research literature (cf Hatton & Smith, 1995; Korthagen, 2001; Schön, 1983). Teachers are increasingly referred to in terms of "reflective practitioners". However, at the same time, there is considerable uncertainty about how reflection should be understood and how it might improve professional learning. The literature refers to levels, functions, scope, and depth of reflection, but there appears to be a great deal of rhetoric involved. In fact, reflection is usually nothing more than looking back on experiences and evaluating the activities undertaken (Mansvelder-Longayroux, Beijaard & Verloop, 2007). In this respect, reflection mainly focuses on the improvement in handling and, to a lesser extent, on processes of constructing meaning on the basis of the experiences gained. These processes are characterized by interconnecting the experiences gained, and supplementing them by theoretical insights. As a result of this, new views emerge with regard to the practice (also referred to as a change in understanding). It is assumed that these processes of constructing meaning are improved when the teacher feels personally involved with the topic of reflection and operates within an appropriately stimulating learning environment.

Traditionally, the training of prospective teachers mainly focuses on the application of technical-instrumental skills and knowledge, which are regarded as a standard for "good" or competent teaching. Teachers are asked to familiarize themselves with external knowledge and skills, whereby the question as to whether and to what extent the knowledge and skills are actually appropriate to the teacher as a person is barely taken into account: namely is it appropriate to me? Am I able to become such a teacher? When reflection does more justice to the personal dimension of learning, it may be assumed that it will also lead to meaning-oriented learning to a greater extent than at present. We have observed increased attention being given to the above at the teacher education institutes. Critical reflection is part of this, and includes questioning and challenging assumptions, and moral and political issues, as well as matters that are considered self-evident and so on (cf Brookfield, 2005).

However, this does not mean that external knowledge and skills are irrelevant. Research into arithmetic and mathematics at the lower learning levels of elementary education has shown that informing teachers about the students' thinking clearly contributes to an improvement in the teaching practice (Carpenter & Lehrer, 1999; Franke, Kazemi & Battey, 2007; Bobis, Clarke, Clarke, Thomas, Wright, Young-Loveridge & Gould, 2005).

In conclusion it can be stated that the teacher as an autonomous professional is emphatically responsible for his or her own learning. Self-evaluation is essential in this respect, because it may be a significant source of reflection on the teacher's own functioning when it takes place under favorable, non-threatening circumstances, and if certain conditions are being met (Boud, 1995). Self-evaluation is not an individual activity: usually peers are involved who act as co-assessors or peer assessors and with their feedback support the process of self-evaluation (cf Ross & Bruce, 2007). In addition, students' perceptions of their teachers' functioning may also be an important source of reflection within the framework of self-

evaluation. Little is known yet about the effects of such approaches of professional learning, or with regard to the conditions that should be met.

2.3 INFLUENCE OF THE CONTEXT ON LEARNING

Professional learning always takes place in a context. In the past, however, the impact of the context on learning and reflection was rarely an issue, although the workplace may improve or obstruct learning. Modeling and coaching, for example, are strategies that improve learning (Billet, 2002), and the same applies to certain forms of cooperation between teachers and to learning from each other, such as the lesson studies mentioned previously (Hiebert --). Lack of time, little interest on the part of school management, and limited options for cooperation with colleagues and for learning from each other are factors that may obstruct learning in the workplace, for example (Day, 1999). In addition, the relationship with students and the use of educational resources are decisive factors for teachers' learning.

Over the past decades, increasing attention has been devoted to context-based professional learning - referred to as workplace learning (Billet, 2001). The focus on workplace learning emerges from, among other things, research that has shown that such learning, and the knowledge and skills needed for this, is often situational and is systematically underestimated (Scribner, 1986; Smith, 2001). It has also become evident that for individuals in a professional organization, learning cannot be considered separately from that organization's collective learning (Engeström, 1987). Permanent behavioral changes involving individuals are therefore difficult to explain without taking into account the systematic changes within the organization as a whole. This can be found reflected in more heed being paid to holistic approaches of professional learning, both in the field of workplace learning (Engeström, 2005) and of education more specifically (Roth & Lee, 2007; Cobb & McClain, 2006).

Dutch legislation stipulates that schools need to have an Integrated Human Resources Policy (Integraal Personeelsbeleid, or IPB for short), of which the professional development of teachers is an integrated part. Tools used in this respect include, among others, Personal Development Plans (Persoonlijk Ontwikkelingsplan, or POP for short) in conjunction with career-planning interviews. These tools are implemented at many schools and institutions on the basis of internally formulated or externally obtained frameworks such as the competence matrix of the Dutch Association for the Professional Qualities of Teachers (Stichting Beroepsbekwaamheid Leraarschap, or SBL for short), or the quality care framework of Q5[3]. From the perspective of professional learning, little is still known about the effects of such tools in terms of learning yields and of appreciation by teachers (Velthuis, 2007). It is known, however, that teachers utilize possibilities in their workplaces quite differently in order to learn

[3] Q5 was a non-commercial project organization which, independently of the Dutch Ministry of Education, Culture and Science, stimulated schools, school management, and boards at the level of secondary education, and supported them with the implementation of quality care. On 1 January 2009, this organization discontinued its activities.

from them (Hoekstra, 2007). Context-based possibilities that the literature explicitly relates to learning include teacher autonomy, cooperation between teachers, reflective dialogue, the giving and receiving of feedback, and shared standards and responsibilities in the school (for a detailed description of these possibilities, refer to Bakkenes et al., 2006; Hoekstra, 2007).

Context is not only a social structure with a variety of interactions; it also contains all sorts of expectations from school management, the professional association, and the wider political environment. These factors have a strong impact on the enculturation of novice teachers, for example, and on the type of learning that is considered important in this respect. This often involves self-evident aspects that remain undiscussed but strongly influence the functioning of professionals in terms of dilemmas and conflicting constraints for professionals (Beijaard, 2006). One important question concerns how teachers' personal growth and development can be connected to school-organizational interests (see also Verbiest, 2003).

2.4 THE INDIVIDUAL'S INFLUENCE ON LEARNING

What, how and to what extent people learn depends, first and last, on the learner as a person. Professional learning takes place on the basis of a continuous interaction between, on the one hand, who the professional is and, on the other, the possibilities for learning and the dilemmas and constraints experienced under the influence of context. Teachers experience problems in relation to learning in their work environment, as their work has become more intensive and they experience a lack of time to reflect upon it. The work culture is characterized by increased regulation and control, and by the focus on achieving effective student learning outcomes. The way in which many teachers in this culture acquit themselves of their tasks involves the acceptance of some sort of need to "take part in the game" (Webster-Wright, 2006). Teachers express their concern about the game, but usually offer little criticism of the rules.

Professional learning is not only a matter of adapting to the wishes and expectations of others, including familiarizing oneself with the associated knowledge and skills. It also implies the ontological dimension of learning; what and how a person learns varies according to what extent he or she considers himself or herself a professional, and the type of professional he or she seeks to become. For example, research has increasingly shown that teachers, on being asked about their learning experiences, indicate how they perceive themselves in their capacity as teachers (Connelly & Clandinin, 1999; McCormack, Gore & Thomas, 2006). This involves the teachers' identity which, on the one hand, is formed by the complex interaction between personal views, preferences, feelings, and so on, and, on the other, by the values, standards, expectations, and so forth, which are considered important by others, including by the body of knowledge that is considered significant for professional functioning (Beijaard, Meijer & Verloop, 2004). "It is impossible for us to separate out who we are from what we do (…). Being is embedded in our practice of doing and, through the doing, as practitioners we continue to become who we are" (Ewing & Smith, 2001, p. 16). Hence it is a matter of a reciprocal relationship between learning, practice, and the development of a professional identity.

2.5 THE INFLUENCE OF TRAINING AND INDUCTION PROGRAMS ON TEACHERS' PROFESSIONAL LEARNING

The teacher education institutes educate beginning teachers who still need to learn a great deal after completion of their training. From the literature on expertise development, it is evident that the process takes about five to eight years (Berliner, 2001). This outcome is supported by studies into the process of developing from a novice into an experienced teacher. Support provided by teaching staff to the professional development of novice teachers at institutions is largely characterized by novice teachers learning to apply the knowledge and skills acquired during the educational program through assignments and feedback on their results. Practice supervisors support the learning process in the workplace itself, whereby major differences occur in the nature and quality of the feedback, which usually focuses on technical-instrumental skills and practical issues. Although this form of support is important with a view to learning to maintain one's position in the classroom, supporting professional learning implies more: learning to manage one's own professional development, development of practical theory, critical reflection on existing practices, and the like. It is not easy to challenge student teachers to this by creating constructive frictions (Vermunt & Verloop, 1999) in their workplace. Furthermore, part of the learning process in the workplace concerns learning to contribute to it. Within the framework of professional learning, it is important that schools let their student teachers actively participate in educational and school development. To this end, schools have a responsibility that they should assume even more vigorously (cf Geldens, 2007).

The way in which teachers in training are being prepared for their future profession has a strong influence on their post-graduate professional learning. Schools increasingly introduce induction programs to support teachers during the initial period of their careers as independent professionals. An implicit assumption in this respect is that teachers in training still need to learn considerably more to be able to function competently. In practice, many of these programs fill gaps in the teachers' knowledge bases and in handling repertoires. Consequently, in-school induction programs are usually structured on the basis of a deficit view. Such a view of learning implies a limited view of professional learning. The preparation for the ongoing learning of independent professionals would benefit more from a view aimed at professional growth (Beijaard et al., in press).

A major question in this respect involves how teacher training as well as induction programs can give shape and meaning to both professional learning and to learning from it. In this respect, it is essential to provide continuity in teachers' learning in both development processes. These are currently two separate paths with different goals and expectations where the learning and functioning of teachers is concerned.

2.6 THE ROLE OF THE TEACHER IN EDUCATIONAL INNOVATION

In many innovations the teacher is regarded as the implementer of innovations that are developed by others (Verloop, Van Driel en Meijer, 2001). However, for changes to be successful they should focus on the teacher as such: teachers are key figures. Professional development is an essential component of educational improvement. Hawley and Valli (1999) stated that, in this respect, a symbiotic relationship is required between professional development and educational improvement. They feel that a number of criteria should be

met for the relationship to be effective. For example, the teacher should co-determine the content of the program and how it should be given shape. The professionalization program should be integrated into the school's activities. Furthermore, cooperative learning between teachers should be a component of the professionalization program. Finally, people should be aware that a long-term process is involved, requiring external support and organization.

3 SCIENCE AND TECHNOLOGY EDUCATION

The research program devotes particular attention to science and technology education. This attention is twofold, with, on the one hand, a significant part of the research conducted in the context of science and technology subjects in education, and, on the other, with science and technology education forming a content-specific object within another part of the research.

3.1 ESOE SCIENCE AND TECHNOLOGY EDUCATION

One of the reasons for a focus on science and technology education is the regional and organizational framework in which the Eindhoven School of Education (ESoE) is situated. More specifically, it involves the tasks and roles that the ESoE performs. ESoE organizes teacher education in the subjects of Physics, Chemistry, Mathematics, and Computer Science, for which input and support from research are needed. Furthermore, ESoE seeks to play a key role in supporting schools and educational institutions in teaching science and technology, and in this capacity it also needs research-based feedback and reinforcement. This connection is given shape in the Kenniscentrum Wetenschap en Techniek Zuid (KWTZ), for example, which was established with a view to support the introduction of technology in elementary education. Moreover, ESoE also cooperates in the development of new science and technology subjects such as *Wiskunde D*[4] (Mathematics D) and NLT (Nature, Life, Technology). The implementation of authentic and motivating contexts is at the core of the didactic renewal of science subjects at *HAVO* (senior general secondary education) and *VWO* (pre-university) level (Boersma, 2005; Commissie Nieuwe Natuurkunde, 2007; Stuurgroep Nieuwe Scheikunde, 2007). On the one hand, this renewal is aimed at organizing the curriculum and, in this way, avoiding its observed overburdenedness and fragmentation, and, on the other, it is a foundation for learning scientific concepts (Gilbert, 2006). This didactic approach is similar to the "Chemie in Kontext" (ChiK) approach applied in Germany, with regard to which ESoE cooperates with the University of Essen-Duisburg.

[4] In 2007, as part of a mathematics curriculum change that took place in the Netherlands, *Wiskunde D* was introduced as a subject for science-oriented students at *HAVO* and *VWO* levels.

3.2 SOCIAL DEVELOPMENTS AND SCIENCE AND TECHNOLOGY EDUCATION

In addition to the above-mentioned local reason for focusing the ESoE research program on science and technology education, the unsatisfactory situation that occurs in the Netherlands as well as in many other countries (OECD, 2006) is a good reason for conducting research into this field. On the one hand, science subjects are struggling in their capacity as general educational subjects, and, on the other, they fail as suppliers for technical and science professions, particularly with a view to the development of a science-oriented, knowledge-based economy as described in the Lisbon Treaty (European Council, 2000). The problem appears to involve two aspects. First, science as such is not popular with students and often considered difficult or too difficult, thus having quite a bad image. Students usually regard these subjects as boring and unmotivating. Second, students have a negative image of the possibilities in society and little appreciation of science graduates (Lyons, 2006; OECD, 2006). Most students do not opt for science or technology subjects, nor do they aspire to a career in these fields (Dekkers, & De Laeter, 2001). The curriculum itself is partly to blame for this limited interest. Research has shown that the subject content taught in science education is hardly relevant either for activities outside education, or for daily life or the workplace (Lave, 1988; Scribner, 1984; Traweek, 1988). This is partly due to the non-authentic and contextless nature of science and technology subjects (Brown, Collins & Duguid, 1989; Lemke, 1992). Furthermore, science subjects cause problems with regard to the transfer to higher education. Large groups of students therefore consider science and technology subjects to be an obstacle to their school career rather than something that is important in a society imbued with science and technology (Roth & Barton, 2004). Despite repeated, large-scale reviews of the curricula of science and technology subjects, the yields of these subjects still correlate poorly with the specific and context-bound demands that society makes on adolescents (De Boer, 2000).

The problematical nature of science and technology education is closely connected with a certain inaccessibility for specific groups of students. The group that actually opts for science and technology proves not to be an accurate reflection of society as a whole. Especially girls, children from ethnic minorities, and children from lower-level social environments appear to fail more often on their way to a career in science or technology (AAAS, 1998); this is not only due to their capacities or lack thereof. Detailed analyses of the subject content of science subjects and the way in which these are taught show that they contain elements that make science and technology less meaningful and, as a result, less accessible for these groups (Calabrese, Barton & Osborne, 2001). Particularly in these groups a vast number of potential future scientists and technologists are lost.

The special attention for science and technology education does not only relate to the present. ESoE emphatically aims to conduct research into "*science and technology education for the future*". In this respect, an inspiring program could contribute significantly to increasing an interest in science and technology, both with a view to one's future career and from the perspective of the interested citizen. This refers to, among other things, the role of science and technology in the "information society". A significant proportion of information is quantitative, which, by means of ICT, has come about through measuring and calculating.

ICT has also started to play an increasingly important role within science and technology, where automation and computerization are causing drastic changes. We may expect teachers to devote specific attention to the role of symbols and models in their teaching, given Latour's observation (1990) that visualization is a major, if not the most significant, characteristic of science and technology. Visualization facilitates a way of working that is characteristic of science and technology: working with a reduced reality. Information technology adds a new dimension to visualization. Computer screens increasingly function as an intermediary between human beings and their physical environment

As we indicated above, science and technology education for the future involves not only a possible career in this domain but also the significance of science and technology in other professions and for the common citizen. Today, an improvement in *scientific & technological literacy* is considered a major goal for science and technology education (Laugksch, 2000) worldwide. Working on scientific & technological literacy should prevent the emergence of an increasing group of scientifically and technologically "illiterate" citizens in a society that is actually becoming progressively more demanding in this field. For this purpose, research should be conducted into which competences modern society actually demands, and into how education may contribute to this.

3.3 CURRICULAR REFORM AND PEDAGOGICAL CONTENT KNOWLEDGE (PCK)

In the Netherlands and in neighboring countries such as France and Germany there is a deeply rooted tradition of instruction theories aiming at, among other things, making science education more meaningful for students. Although positive results have been achieved in experimental settings, it is sometimes difficult to convert the emerging domain-specific instruction theories into the teachers' professional practice. And this conversion, which leads to recognizable practical knowledge for the teachers' profession, is actually a critical factor for successful changes in science and technology education (Van Driel, Beijaard & Verloop, 2001). In this respect, one obstacle is in the textbooks (and teacher guides) that usually present a non-authentic, contextless, and ideological image of science and technology (Aikenhead, 2003; Knain, 2001; Roth, Bowen & McGinn, 1999). Most teachers mainly organize their way of teaching on the basis of their textbooks (Weiss, 1993), which, generally, have been worked out in great detail and, as a result, significantly narrow the teachers' margin for action. It mainly limits the options of teachers who, instruction theories, try to anticipate the students' own contributions. This results in a vicious circle. The textbooks available obstruct teachers in enacting more meaningful, challenging, and authentic educational aproaches. While publishers bring no new textbooks on the market, because many teachers lack the competences needed for realizing meaningful, challenging and authentic science education. The solution should therefore be looked for in changing the educational resources and the teachers' role at the same time. In doing so, the teacher needs to acquire the required pedagogical content knowledge (PCK) (Beijaard, & Verloop, 1996; Shulman, 1986; Van Driel, Verloop, & De Vos, 1998). In addition, a new generation of textbook series has to be developed, aimed at flexible usage and with which teachers can gain experience and professionalize themselves at the same time. New textbooks that will have to offer possibilities for anticipating flexibly to students could include a combination of the following elements:

- information about how the learning process of a particular subject matter content may take place;

- information about how this learning process can be stimulated and supported;
- a collection of potentially useful and adaptable educational activities and resources.

Teachers and prospective teachers would have to develop competences that are in line with such a methodical structure. These could include the ability to develop and evaluate hypothetical learning trajectories (Simon, 1995) on the basis of the information and resources referred to above, which anticipate students' mental activities when executing the planned tasks.

3.4 ENCULTURATION AND CLASS CULTURE

The approach described above, however, will demand more from teachers. For example, it is assumed that the problems in science and technology education are a result, on the one hand, of the discrepancy between students' "cultural baggage" and, on the other, of the cultural characteristics of science and technology such as goals, modes of thought, values of "what is valid knowledge", convention, and language (Aikenhead, 1996). The question that emerges concerns how teachers can be equipped to actively bridge the cultural gap between students and science and technology and to enculturate them effectively in this domain (Hodson & Hodson, 1998; Taconis, in preparation). In this respect, for example, it appears necessary to devote attention to identity development (Schreiner & Sjøberg, 2007), which relates to the students' self-image and to what extent '"being a scientist/technician" is part of it. By analogy with mathematical interest (Cobb, 1994), in this context it seems important to cultivate a scientific interest among students, which means that they do not limit themselves to solving concrete problems but also become motivated to answer more theoretical questions. One aspect that deserves specific attention is that of *agency* (Greeno & Boaler, 2000). It proves important that students - in particular older students - have the feeling that they play an active role in the development of knowledge and are not solely imitators of what others feel and think.

Furthermore, creating an appropriate classroom culture is an important component of enculturation-oriented science education. This relates to the views and expectations students have with regard to their own role and that of others. In this context, Brouseau (1984) refers to an implicit "didactic contract" between students and the teacher. In this respect, Cobb & Yackel (1996) distinguish general classroom social norms in addition to subject-specific ones, which refer to the characteristic methods and forms of reasoning within a certain field of study. Students should be willing to continue anticipating in the activities offered; the class culture as well as the nature and level of the assignment should lead to involvement (Turner, Meyer, Cox, Logan, DiCintio & Thomas, 1998). One factor that plays a role in this respect is the students' task and ego orientation (Nichols, 1984; Boekaerts, 1999). On carrying out an assignment, ego-orientated students sometimes freeze because they are more focused on the image that others may have of them than on the assignment itself. However, task and ego orientation are not invariable characteristics of students and can be influenced by creating a non-competitive class culture.

4 METHODOLOGICAL CONSIDERATIONS

The research program distinguishes three forms of research: namely, (1) analytical research aimed at describing and exploring professional learning in the workplace; (2) intervention research into the effects of certain methods, approaches, programs, instruments, and so on, of professional learning; and (3) development-oriented or design-based research that takes place in close cooperation with teachers and therefore has an impact on teachers' learning and functioning. The latter form of investigation could also be regarded as intervention research, but because of its specific nature it is justified to state it separately.

The effects of intervention research into teachers' professional learning relate to changes in cognition, attitude, and behavior. After all, interventions are intended to improve teachers' teaching practice by means of the targeted support of professional learning with the introduction of innovations or, for example, by putting into practice intentions to act. A major criterion for determining improvement is the impact of an intervention on students and student learning outcomes, in any shape or form. Preferably, besides learning outcomes, the students' perceptions and characteristics are also included in the assessment of improvement, wherever possible and relevant.

The first two forms of research can be carried out in a single study. For instance, it is quite possible to set up and conduct intervention research after the phenomenon in question has been defined. The opposite is also possible: to further describe and explore certain results of an intervention study in order to increase insight into it and to further define it.

Within the framework of innovation, in the present program, a development-oriented or "design-based" investigation is an important form of research, in particular where science and technology education is concerned. This type of research aims at well-founded educational improvement in close, systematic cooperation with the field (cf van den Akker, Gravemeijer, McKenny & Nieveen, 2006). Design-based research involves an iterative process from design to theory and vice versa, which often runs through several cycles and pursues practical usefulness as well as the formulation of theories. Because of the systematic interaction between the researcher and the teacher or teachers involved, and the practical improvement explicitly expressed in this type of research, it has a great impact on teachers' learning and functioning.

No preference is expressed for qualitative or quantitative research. Insofar as a preference exists, it will be based on a balanced combination of both aspects. Choices that are connected to this are primarily determined by the research question. The same applies to the methods and techniques applied. The choice of a certain method or technique should be substantiated in relation to the theory on which the research is based.

5 RELEVANCE OF THE RESEARCH PROGRAM

5.1 SCIENTIFIC RELEVANCE

In comparison with students' learning, little attention up to the present has been paid to teachers' learning and particularly to teachers' leaning in professional practice. Until recently, the underlying thought was that teacher education institutions could provide a

sound basis for practicing the profession and, if necessary, there would be plenty of continuous training opportunities to learn more and to realize any changes in the teaching practice. In the meantime, both assumptions have become outdated. Research shows that the development into a good or an "expert" teacher is a process involving many years of learning from experience, and that continuous training rarely contributes, if at all, to actual changes in the educational practice (Borko, 2004). Learning is increasingly becoming a responsibility of the teachers themselves, usually in connection with school development. It relates to learning in the workplace. Little is known yet about how this learning process takes place, both in a general sense and with regard to the field of study in which teachers teach (in this research program it is science and technology), and what personal and contextual factors/influences increase or obstruct it. These aspects are interrelated, which makes professional learning a complex matter. The fact that all these aspects play a role in the research program enables us to study the aspect of professional learning over the respective studies from a holistic point of view. The results of the respective studies continue to build on and complement each other, so that, in the long term, a good overview of the professional learning of teachers can be obtained, including the way in which they are prepared for professional learning, and how such learning can be supported.

More specific to science and technology education is the challenge to develop this curriculum into something that appeals to students and prepares them effectively for continuing education and for the role of science and technology in society. Although important elements are specified above, in scientific circles there is still considerable doubt about how science education can be made more accessible and the consequences for educational practice (Lee, 1997). There are also clear signs that teachers, due to the pressure of the curriculum and prevailing traditions and views, subconsciously contribute to making science and technology education inaccessible for certain student groups (McGinnis & Pearsall, 1998; Tobin & McRobbie, 1996). However, given the multitude of interconnected factors that play a role in this process, no unequivocal, practical, useful solutions have been found as yet (Biachnini, Cavazos & Helms, 2000; Rodriguez, 1998).

5.2 SOCIAL RELEVANCE

Teacher education institutions and schools are struggling with the way in which they can give shape and content to teachers' learning in the workplace. At the moment, this topic is surrounded by a great deal of rhetoric. The workplace is increasingly described as a powerful learning environment that meets a large number of conditions, while many problems occur in practice. And these problems do not only involve obstructions that emerge from stereotyped views on learning and student learning outcomes, the nature of the teaching profession, and how school organizations give structure to this profession; to add to this, little is known about how teachers' learning in the workplace can be realized. Hence, this research program seeks to meet a need by providing alternatives that have proven to be useful and effective, including in the shape of approaches, arrangements, methods, and tools.

The social relevance of research into and with regard to science and technology education is self-evident. After all, social considerations are a major motive for investing in its improvement and reform.

6 OUTLINE OF PROJECTS

ESoE's research program incorporates a wide range of knowledge. It derives its theoretical and social basis to a great extent from general educational knowledge, know-how in the field of teachers' learning, and teacher education in a more general sense (chapter 3). At the same time, the program focuses specifically on the domain of science and technology education and makes use of knowledge that is of a more instructional nature (chapter 4).

The research projects worked on within the ESoE program differ in terms of the emphasis that is being put on developing the elaboration of both knowledge bases. Some projects aim more specifically at the development of general educational expertise, while others focus on the knowledge of teaching methods in the field of science and technology education. These differences in emphasis basically lead to three clusters of research projects:

- educational projects conducted outside the context of science and technology education;
- educational projects conducted within the context of science and technology education;
- projects relating to science and technology education.

Table 1 contains an overview of ongoing doctorate projects (from 1 November 2007) subdivided into educational projects, educational projects in the context of science and technology subjects, and projects that focus on the field of science and technology education. Table 2 contains an outline of miscellaneous research projects undertaken by staff. A more detailed description of each project is given in a separate annex.

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ANNEX 1 - DOCTORATE PROJECTS

Science, mathematics and technology (teacher) education studies			
Name Ph.D. student	Project title	Supervisors	Period
Ellen Rohaan	Primary technology education: from teachers' knowledge to pupils interests	Promotor: Wim Jochems Daily supervisor: Ruurd Taconis	1/11/2005 - 1/11/2009
Geeke Bruin	The ongoing fraction curriculum: fraction skills and strategies of Dutch children in primary school and lower pre-university education	Promotor: Wim Jochems Daily supervisor: Jacob Perennet	1/11/2005 - 1/11/2009
Martin Vos	Characteristics of the interaction between teachers and materials that promote a curriculum innovation based on the concept-in-context approach	Promotors: Wim Jochems, Albert Pilot (UU) Daily supervisor: Ruurd Taconis	1/1/2006-1/1/2010
Irene van Stiphout	Realistic mathematics education and cognitive load	Promotor: Wim Jochems Daily supervisor: Jacob Perennet	1/1/2007-1/1/2011
Lisette van Cuijk	The role of teachers' instructional strategies and lesson materials in promoting students' technology interest	Promotor: Wim Jochems Daily supervisor: Hanno van Keulen	1/7/2007-1/7/2011
Zeger-Jan Kok	The development of concepts in secondary school physics education	Promotor: Wim Jochems Daily supervisors: Ruurd Taconis, Sanneke Bolhuis	1/9/2007-1/9/2011
Lesley Smits	Participation of teachers in design teams: professional development of teachers in developing and teaching concept-context based materials	Promotor: Wim Jochems Daily supervisor: Ruurd Taconis	1/9/2007-1/9/2011
Lou Slangen	Impact of the educational use of DME's (mindtools) in primary schools	Promotor: Wim Jochems Daily supervisor: Hanno van Keulen	1/1/2008-1/1/2012
Jean Marie Kraemer	Strategies for addition and	Promotor: Koeno	1/1/2004-

	subtraction in the early grades of primary school	Gravemeijer Daily supervisor: Norman Verhelst (CITO)	1/7/2008
Francien Carsten	Numerical literacy for prospective teachers in primary education	Promotor: Koeno Gravemeijer Daily supervisor: Maarten Dolk (Hogeschool Drenthe)	1/1/2007-1/1/2011
Vacancy	Enculturation in secondary school science; an analysis of methods and dilemmas	Promotor: Wim Jochems Daily supervisor: Ruurd Taconis, Sanneke Bolhuis	

General educational studies in the context of science, mathematics and technology			
Name Ph.D. student	Project title	Supervisors	Period
Marjan de Corte	Prospective science teachers' learning at the workplace of academic schools	Promotor: Theo Bergen Daily supervisor: Perry den Brok	1/9/2007-1/9/2011
Kennedy Tielman	Collaborative learning in secondary vocational education (mbo) with ethnic diversity	Promotor: Douwe Beijaard, Elly de Bruin (UU) Daily supervisor: Sanneke Bolhuis	1/2/2007-1/2/2011

General (teacher) education studies			
Name Ph.D. student	Project title	Supervisors	Period
Gijs de Bakker	Instant messaging in education	Promotor: Wim Jochems Daily supervisor: Peter Sloep	1/1/2006-1/1/2010
Ralph Hooreman	Synchronous coaching of the teacher in training	Promotor: Wim Jochems Daily supervisor: Peter Sloep	1/11/2005 - 1/11/2009
Maureen Rajuan	Student teachers' perceptions of learning to teach as a basis for supervision of the mentoring relationship	Promotors: Douwe Beijaard, Nico Verloop (Univ. Leiden)	1/1/2004-1/1/2008
Kariene Mittendorff	The quality of career guidance conversations in vocational education and training	Promotor: Douwe Beijaard Daily supervisor: Perry den Brok	1/11/2005 - 1/11/2009
Maaike Koopman	The influence of goal orientation on learning activities and processes of integration of students in competence-based pre-vocational secondary education	Promotor: Douwe Beijaard Daily supervisor: Peter Teune	1/11/2005 - 1/11/2009
Cyrille Bragt	Students' educational career in higher education: determining key factors in study success	Promotor: Theo Bergen Daily supervisors: Peter Teune, Anouke Bakx	1/11/2005 - 1/11/2009
Evelien Ketelaar	Teacher learning in innovative contexts in vocational secondary education: the role of agency, sense making and dispositions to learn	Promotors: Douwe Beijaard, Els Boshuizen (OUNL) Daily supervisor: Perry den Brok	1/4/2007-1/4/2011
Judith Verkooijen	Effects of goal-directed teaching on students with behavioural problems	Promotors: Theo Bergen, Jan-Willem Veerman (UT) Daily supervisor: Anita Blonk	1/5/2007-1/5/2011
Frank Cornelissen	Action research as a tool for	Promotors: Theo	15/8/2007

	professional development of teachers and school development	Bergen, Douwe Beijaard	- 15/8/2011
Jannet Doppenberg	Collective teacher learning of primary school teachers	Promotor: Theo Bergen Daily supervisor: Perry den Brok	1/8/2007-1/8/2011
Migchiel van Diggelen	Effects of self-assessment on teachers' professional development	Promotors: Douwe Beijaard, Nico Verloop (Univ. Leiden) Daily supervisor: Perry den Brok	1/9/2007-1/9/2012
Vacancy	Dilemmas in the transition period from student to teacher	Promotors: Douwe Beijaard, Els Boshuizen (OUNL) Daily supervisor: Michiel van Eijck	

ANNEX 2 - ESOE STAFF PROJECTS

Science, mathematics and technology (teacher) education studies			
Name ESoE staff member	*Project title*	*Other universities involved*	Period
Jacob Perennet	Levels of thinking in computer science		1/1/2002-1/9/2010
Jacob Perennet, Ruurd Taconis	Mathematical enculturation and attitude change		1/1/2002-1/9/2010
Ruurd Taconis	Science education as enculturation	Freie Universität Berlin University of Aarhus	1/9/2006-1/9/2009
Ruurd Taconis	Physics influence and academic success	University of Harvard.	1/1/2007-1/1/2010
Michiel van Eijck	Authentic science experiences for students: Career awareness and internships	University of Victoria	1/11/2007-1/1/2010
Koeno Gravemeijer	Tool use in an innovative learning arrangement for mathematics (NWO)	Utrecht University	1/1/2006-31/12/2008
Koeno Gravemeijer	Boundary crossing between school and work for developing techno-mathematical competencies in vocational education (NWO)	Utrecht University	1/9/2007-1/8/2011

General educational studies in the context of science, mathematics and technology			
Name ESoE staff member	*Project title*	*Other universities involved*	Period
Perry den Brok, Ruurd Taconis, Theo Bergen	Running research on teaching from an interpersonal perspective	Utrecht University, Leiden University, Curtin University of Technology, University of Southern Queensland, Middle East Technical University, George Mason University, University of Arizona	1/1/2006-1/9/2010
Douwe Beijaard	Sustaining teacher quality: an investigation of associations between science teachers' commitment, professional identity	University of Nottingham	1/9/2007-1/9/2010

	and retention		
General (teacher) education studies			
Name ESoE staff member	*Project title*	*Other universities involved*	Period
Perry den Brok	Teacher-student interpersonal behaviour in multicultural classes	Utrecht University, Leiden University	1/1/2006-1/1/2009