Preparing and supporting teachers for innovative STEM learning

Research Program 2015-2019 of the Eindhoven School of Education

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MISSION OF ESoE

The Eindhoven School of Education (ESoE) is the educational expertise center of the Eindhoven University of Technology (TU/e). ESoE’s mission is three-fold:

1. STEM teacher education (pre-service teacher education);
2. STEM teachers’ continuous professional learning and development: school & university;
3. STEM innovation in education in collaboration with teachers at both classroom and school/institute level.

Leading is ESoE’s vision on professional STEM teachers: innovative experts in their subject domain who design and develop (technologically) rich contexts for learning. They evaluate their education, including their own role, and demonstrate an inquiry and learning attitude towards their subject and work as teachers. As such they are a role model for their students. In innovative contexts they act as agents of change together with colleagues inside and outside their schools and demonstrate professional leadership needed for this. ESoE wishes to educate these academic professionals in close cooperation with schools. The ultimate goal of the ESoE research program is to contribute to the education of more and better STEM teachers. In turn, more STEM students will be attracted.

The research program on/in STEM education can be regarded as a permeating strand (linked to the three-fold mission). The program’s focus is STEM education (Science, Technology, Engineering, Mathematics), both as object and as context of research in secondary and higher education.

TEACHING INNOVATIVE STEM EDUCATION: BACKGROUND AND RATIONALE

There is now ample evidence that preparing students for becoming and being active participants of an innovative society goes well beyond preparing them for science-related professions. Regarding the STEM domain: new roles are required from engineers, as the world faces
grand challenges, which in particular pertain to the domains of health, energy and environment, mobility and safety. These “new” engineers and scientists must be professionals capable of thinking critically and independently, to keep developing and renewing their expertise, to use state-of-the-art technology, to contribute to solving societal problems, but also to create new opportunities and the ability to think interdisciplinary and to work in teams (Meijers & den Brok, 2013). Many of these skills are also mentioned so-called 21st century skills (Thijs, Visser & van der Hoeven, 2014). The new educational imperative is to equip a critical mass of workers and citizens with the skills to thrive in innovative societies (Mavareck & Kramarski, 2015).

This places high demands on teachers and their professional development in both secondary and higher/university education. Continuous professional development (CPD) throughout teachers’ career is needed in order to keep pace with societal and educational developments and changes.

More than ever before teachers are required to foster deep and meaningful learning with their students and develop appropriate learning environments for this (Martinez & McGrath, 2014). Meanwhile they have to take into account:

1. The influence of technology and interactive media on teaching and learning: it is often claimed that today’s learners are "new millennium learners" who have different expectations about education (OECD, 2012). Students’ use of technology and interactive media is transforming the ways they learn (cognitive skills development), their social values and lifestyles (e.g., Van den Beemt, Akkerman & Simons, 2011). An important factor here appears to be that they require competencies of careful selection of relevant information, and of judgment about the value of such information (cf. Ito et al., 2009; Walraven, 2008).

2. Changes with respect to their audience: in their classrooms and courses, teachers will face a greater diversity of students, with respect to ethnic background, values and beliefs, learning experiences, learning orientations, and engagement (e.g., Sierens, 2007; Leeman & Wardekker, 2013).

It is ESoE’s conviction that some of the most crucial skills necessary for students and future workers in the STEM domain are formed and developed through:

1. Effective science and engineering education, for example: giving shape to deep and meaningful learning through types of design-based and inquiry-oriented learning and making use of ICT (e.g., Gomez, van Eijck & Jochems, 2014). At a more general level, “new learners” will need to be able to constantly adapt in their future work and lives and must therefore learn to become more self-directive and life-long learners.

2. Motivating students for science and engineering education, for example: making instruction more context-based (‘concept-context education’), cooperating with companies, undertaking outreach activities, and doing justice to different bèta motivations as well as bèta identities (e.g., de Putter-Smits, Taconis & Jochems, 2013). At university level, it is important to create education trajectories that are attractive, engaging, and flexible in order to realize the higher and more diverse student population in science courses.

3. Integrative or interdisciplinary science education within the STEM domain and with other domains as well.
New competencies of teachers are required for both teachers in secondary and higher education, such as the following:

1. The expertise to adapt their curricula, resources, and learning environments to new insights and new teacher roles as coaches and facilitators of learning, for example when students do a design or research project (teachers as adaptive experts; cf. Bohle Carbonell et al., 2014). Teachers’ role needs more than now be one of “teaching for learning”. For teacher education this means a shift towards learning to teach from a student-centered learning perspective instead of a teacher-centered teaching perspective (Swinkels, Koopman & Beijaard, 2013).

2. The ability to effectively utilize existing curricular resources to design instruction (Brown, 2009). Teachers’ interaction with tools/resources is clearly a participatory (two-way) process, in which teachers and resources interact (Pepin, Gueudet & Trouche 2013). Making sense of and using these tools/resources to design and enact instruction places a demand on teachers’ beta-didactical design capacity (Pepin, 2015). This implies that teachers need to base their decisions on subject knowledge, knowledge of how to make subjects teachable and knowledge of how to evaluate curricula.

3. Teachers must be capable to organize, implement and monitor change, thus becoming managers of innovation and change (van der Heijden, Geldens, Beijaard & Popeijus, 2015).

New teacher competencies as those mentioned above are the basis for ESoE’s vision on professional teachers as expressed in the beginning of this research program under “mission”.

**Research Questions**

ESoE is committed to addressing the challenges for STEM education, both in secondary schools as well as in higher/university education. Since ESoE educates student teachers in the academic master “Science Education and Communication”, findings from research are thus of direct relevance to its own teaching and professional development activities and also to innovative work in schools. Furthermore, as one of the roles of ESoE is to take an active part in supporting other TU/e departments in instigating and investigating educational innovations, findings from the research are directly relevant to the departments, and TU/e at large. In order to realize these aims, research projects within the research program will be anchored in, and link to, the following research questions:

1) **What ways of STEM learning and learning environments contribute to preparing learners for the challenges of the 21st century?** This research question pertains to elements of these learning environments that play an important role in this, e.g.: shared vision by teachers, tasks or assignments, curriculum materials, tools, resources.

2) **What characterizes a professional STEM teacher’s professional identity in innovative contexts and schools and what are relevant issues that need to be addressed in teacher professional learning and development?** First, this question refers to the teacher as coach, using interactive media, dealing with diverse classrooms, and designing/developing curricula. Second, it refers to professional qualities (teacher knowledge, skills, and dispositions) needed for developing environments that foster deep learning and how teachers can be prepared for/supported in that in close collaboration with schools.
3) How can teachers’ professional development for these challenges (see question 2) be stimulated and supported? One important way of doing this is to engage teachers in design-based research. Other ways pertain to teachers participating in professional learning communities and carrying out specific interventions.

4) What are the various effects of (student) teachers’ professional development/learning processes? These effects may be discerned in classroom practices, departmental/school professional learning cultures, and eventually student learning/outcomes.

The research program of ESoE will investigate the above questions in contexts ranging from lower/upper secondary to higher/university education, covering the whole STEM domain.

**ESoE research**

All projects of the ESoE research program have been designed to have practical orientations. To explain, the criteria are the following:

1. For ESoE it is important that the research questions and topics often find their origin in practice, even though the research may take various forms: e.g. PhD or post-doc projects (often supported by grants); master thesis projects in teacher education; teacher practice-based research projects in school-based learning communities with researchers from ESoE; and innovation research projects (evaluative studies of current practices or new interventions). Studies may be performed by researchers, teachers, or other practitioners involved in research – often of their own classroom context – or teams consisting of both.

2. Where possible, research projects are characterized by collaboration with other partners. These partners may consist, in particular, of other TU/e departments; the 3TU Centre of Engineering Education; other academic universities and universities of applied science; (research-based) professional development schools and other schools, amongst them “technasium” and “brainport” schools.

3. Studies may be large or small scale, and can use different research methodologies, depending on the research questions central to the study. These may range from qualitative to quantitative, and from more traditional instruments such as paper or electronic surveys and interviews, to more specific and innovative methods such as electronic data collection apps, eye-tracking devices, networking instruments and data analysis tools, or real-time observation instruments. While designs may vary, many projects will have an intervention- or design-based character. Despite their varied forms, a crucial feature of studies conducted by ESoE is that they are of highly scientific – academic quality.

For more information about publications and research projects by staff, master and PhD students of ESoE: see [www.tue.nl/esoe](http://www.tue.nl/esoe)
REFERENCES


