**Professional development**

Professional development is an important aspect of educational life of teachers ([Avalos, 2011](#_ENREF_3); [Duffee & Aikenhead, 1992](#_ENREF_33)). Additionally, professional development is a necessary component in all educational improvement efforts. In every attempt to reform, restructure or transform education the role of the teacher as the main stakeholder in bringing about needed changes is emphasized. Teachers therefore need to be professionally prepared. One of the challenges in science education is to design professional development programmes for teachers that can lead to fundamental changes in their practice ([Loucks-Horsley et al., 2003](#_ENREF_76)). Various conceptual approaches provide tools such as different development strategies for designing such professional development programmes, with a focus on changes in teacher practice or on changes in teachers' professional content knowledge, their attitudes and beliefs ([Bell & Gilbert, 1996](#_ENREF_7); [Coenders, 2010](#_ENREF_22); [Jeanpierre, Oberhauser, & Freeman, 2005](#_ENREF_63); [Loucks-Horsley et al., 2003](#_ENREF_76); [Luft, 2001](#_ENREF_78); [Stolk, De Jong, Bulte, & Pilot, 2011](#_ENREF_110)).

Guskey ([2000](#_ENREF_50)) defined professional development as “those processes and activities designed to enhance the professional knowledge, skills and attitudes of educators so that they might, in turn, improve the learning of students” (p. 16). According to this author, there are three important factors that influence the quality of professional development: context, process and content. Context characteristics refer to the ‘who’, ‘when’, ‘where’ and ‘why’ of professional development. Process variables refer to the ‘how’ of professional development. Content characteristics refer to the ‘what’ of professional development. Similar components have also been described by Loucks-Horsley et al. ([2003](#_ENREF_76),), in their design framework for professional development for teachers of Science and Mathematics, and by Garet et al. ([2001](#_ENREF_43)) in their analysis of characteristics of professional development that focuses on ‘structural features’ and ‘core features’.

In addition to what is stipulated above, research has shown that professional development is most effective when it is long-term, collaborative, and school-based. It should focus on the learning of all students, be linked to teachers' daily school practices, and connected to teachers’ prior knowledge as well as to the curriculum guidelines teachers need to keep an eye on. Adjusting the professional development programme to participants' diversity of behaviors and beliefs increases its effectiveness ([Borko, 2004](#_ENREF_13); [Desimone, 2009](#_ENREF_31); [Garet et al., 2001](#_ENREF_43); [Hunzicker, 2011](#_ENREF_62); [Lieberman & Pointer Mace, 2010](#_ENREF_73); [Vescio, Rossa, & Adams, 2008](#_ENREF_121)).

**Research about effective implementation**

A completed matrix, as shown in Table 1, contains the implementation characteristics for a NLT module for a particular school: the choices made by the teachers and their considerations. To determine which characteristics need to be covered by a professional development programme, the elements for effective implementation as identified in research are relevant. In the process of curriculum implementation, many aspects play a role that can be either stimulating or hindering. Factors influencing the implementation of a curriculum can be categorized into four areas (Figure 1; ([Van den Akker, 1998](#_ENREF_113))). Each area will be briefly explained below.

Student characteristics

Contextual variables

*Figure 1* Categories influencing implementation (from Van den Akker ([1998](#_ENREF_113))

Curriculum-intentions

**Curriculum-implementation**

Curriculum-effects

 Context

Teacher characteristics

*Curriculum Intentions*

During the introduction of a new subject, teachers will especially find support from specific student learning material ([Desimone, 2002](#_ENREF_30); [Van den Akker, 1998](#_ENREF_113); [Waslander, 2007](#_ENREF_130)). The learning material largely determines the content, knowledge, and skills students acquire at school. The quality and the usability of the learning material therefore are important for teachers and students alike. Learning materials guide teachers in their teaching but this does not mean that teachers use the materials exactly as the developers had in mind. Teachers adapt and supplement learning materials to their own situation and needs, and this promotes ownership. Teacher ownership is necessary to change teachers routines in order to try something new ([Bergen & Van Veen, 2004](#_ENREF_8)). Several studies show that teachers’ sense of ownership is a stimulating condition for implementation ([Ogborn, 2002](#_ENREF_90); [Wikeley, 2005](#_ENREF_131)). There are indications that teachers’ sense of ownership contributes to higher student achievement ([Caprara, Barbaranelli, Steca, & Malone, 2006](#_ENREF_19)).

*Curriculum Effects*

Curriculum effects include student experiences and learning outcomes. Student characteristics such as capacity and motivation determine curriculum implementation effectiveness and learning outcomes ([Lepper, Corpus, & Iyengar, 2005](#_ENREF_70)). Contextual variables such as the home situation, media, and friends also affect student achievement through informal learning ([Van den Akker, 1998](#_ENREF_113)).

*Context*

The context includes policy, school organization, and external support for the curriculum. Policy entails the decisions about testing programmes and the attainment targets for the subject. Cooperation between teachers and coordination within departments are part of the school organization. Collaboration between colleagues is a stimulating condition for the implementation of an innovation. Usually teachers only cooperate with colleagues in their own departments ([Van Wessum, 1997](#_ENREF_118)). Multidisciplinary collaboration can provide motivation and introduce teachers to a broader variety of ideas and teaching methods ([Leliveld, Van Tartwijk, Verloop, & Bolk, 2008](#_ENREF_69); [Meirink, 2007](#_ENREF_84)). Teachers can assist colleagues by sharing information and experiences whereby new knowledge can be developed ([Ball & Cohen, 1996](#_ENREF_4)). The teachers who implement the innovation must be given time and feel supported by the school management ([Geijsel et al., 2001](#_ENREF_44); [Wikeley, 2005](#_ENREF_131)). The external support includes collaborative activities between colleagues in the same school and between schools. This can be stimulated in a professional development programme ([Andrews & Lewis, 2002](#_ENREF_2); [Desimone, 2002](#_ENREF_30); [Waslander, 2007](#_ENREF_130)).

*Teacher Characteristics*

Various studies report and discuss the important role that teachers play in the implementation ([Fullan, 2007](#_ENREF_41); [Geijsel et al., 2001](#_ENREF_44); [Kwakman, 2003](#_ENREF_68)). Teachers’ knowledge and beliefs are determined by their education and experiences. Beliefs about what is feasible and valuable for their students, preferences for certain teacher roles, and preferences for teaching methods will influence any implementation ([Beijaard, Meijer, & Verloop, 2004](#_ENREF_6); [Pajares, 1992](#_ENREF_94); [Van den Akker, 1998](#_ENREF_113); [Van Veen & Sleegers, 2006](#_ENREF_117))

**Essential characteristics for a professional development programme**

Five characteristics that should be incorporated into a professional development programme to promote the implementation of a NLT module. In the actual design of the professional development programme, these essential characteristics can be interpreted as follows (Visser, Coenders, Terlouw & Pieters, 2010):

* *Teachers should develop their knowledge.* Teachers should be given ample opportunities to acquire new knowledge and skills, for example science content, instructional strategies, and assessment methods. Experts, colleagues, and specific literature can provide this knowledge.
* *Teachers should cooperate with colleagues.* Teachers should first be given opportunities to exchange and discuss experiences and ideas with colleagues.
* Discussion topics can be teaching methods and content, but also practical issues such as how to use a specific activity in class. Cooperation can be intensified by having teachers develop additional material or assessment instruments.
* *Teachers should network.* The result of the professional development programme should be a well-organized network in which teachers from different schools participate in collaborative activities.
* The module should be made *relevant and attractive for students*. Teachers can design stimulating curricular elements to increase students’ interest and motivation.
* *Teachers should be well prepared and organized for their lessons.* In the professional development programme, teaching and learning difficulties can be discussed, and good practices exchanged. How to prepare practical activities and where to obtain certain equipment and materials also needs to be addressed.

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