



## Inquiry-based science teaching competence of primary school teachers: A Delphi study



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### HIGHLIGHTS

- A Delphi study validated the findings of an earlier literature study using experts.
- The necessity of science teaching competencies was confirmed and refined.
- Distinction was made between requirements for novice and experienced teachers.
- Attitude toward science should be positive from pre-service level onwards.
- Content knowledge and pedagogical content knowledge may grow through experience.

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### ABSTRACT

Earlier, extracted inquiry-based science teaching competency elements and domains from the international literature were compared to the United States' National Science Teaching Standards. The present Delphi study aimed to validate the findings for the Netherlands, where such standards are lacking. Experts ( $N=33$ ) were asked about the importance of 23 identified competencies. They confirmed the importance; proposed to add one competency and to differentiate between novice and experienced teachers. They suggested that teachers be provided with opportunities to integrate competence development regarding science knowledge, attitude and teaching skills throughout their career.

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### 1. Introduction

During the past decade, considerable attention has been devoted to the improvement of primary science education. As a result of research advocating inquiry-based education, inquiry-based science teaching and learning has become a focus of policy documents (Akerson & Hanuscin, 2007; Dietz & Davis, 2009; Howes, Lim, & Campos, 2009; Luera & Otto, 2005).

Nonetheless, research illuminates the many pedagogical, organizational and didactic difficulties teachers face in providing

inquiry-based education (Kim & Tan, 2011). If teachers are convinced that inquiry-based science is more powerful than direct teaching, they need competencies in order to guide the inquiry process. Without these competencies, qualitatively poor or insufficient guidance and feedback might be offered during the discovery process, which is both less effective and less efficient (Kirschner, Sweller, & Clark, 2006).

However, recent formal agreement between professionals is lacking regarding what competencies teachers need to teach inquiry-based primary science (Kim & Tan, 2011). Alake-Tuenter, Biemans, Tobi, Wals, Oosterheert, and Mulder (2012) identified twenty-three elements of competence. These competencies were categorized in the groups subject matter knowledge (SMK) elements, Pedagogical Content Knowledge (PCK) elements, and Attitude elements (see Fig. 1). The purpose of this Delphi study was to

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<p><b>SMK 1: Teachers' knowledge of facts and concepts related to living, technological and physical systems; earth and space systems; mathematical systems</b></p> <p>1-1 Understanding of the meaning of isolated facts and concepts</p> <p>1-2 Understanding of the relation between facts and concepts of:</p> <ul style="list-style-type: none"> <li>- 1.2.1 different science sub-disciplines</li> <li>- 1.2.2 the same science sub-discipline</li> </ul> <p>1-3 Understanding of when and how to apply facts and concepts</p> <p><b>SMK 2: Teachers' understanding of inquiry skills</b>(Observe; pose questions and predictions; examine books and other resources of information to see what is already known; plan investigations; carry out investigations using tools to gather, analyze and interpret data; propose answers, explanations and predictions using data; communicate and justify results)</p> <p>2-1 Understanding of the meaning of isolated research skills</p> <p>2-2 Understanding of the relation between the research skills</p> <p>2-3 Understanding of when and how to apply research skills</p> <p><b>Science PCK 1: Pedagogical design capacity – Lesson preparation and adaptation of curriculum</b></p> <p>1-1 Understanding and response to an individual pupil's interests, strengths, experiences and needs in order to teach meaningful content and context (taking into account prior knowledge; cognitive developmental stage; learning style; interest and language level related to age, gender, socio-economic, cultural and/or linguistic background; formal science lessons and experience)</p> <p>1-2 Understanding and response to context: time, space, location, materials</p> <p>1-3 Understanding and response to aims mentioned in standard document</p> <ul style="list-style-type: none"> <li>- Ministry of education final curriculum goals for final year pupils (Kerndoelen)</li> <li>- Detailed curriculum goals for each age group of primary school (Tussendoelen Stichting Leerplan Ontwikkeling )</li> </ul> <p><b>Science PCK 2: Teachers' facilitation of scaffolded inquiry</b></p> <p>2-1 Ability to ask pupils to make their prior ideas explicit</p> <p>2-2 Ability to ask (divergent) questions about facts and concepts, and encourage and help pupils to apply this knowledge</p> <p>2-3 Ability to ask questions about appropriate use of research skills, and encourage and help pupils to apply this knowledge</p> <p>2-4 Ability to stimulate discourse, debate and discussion in small groups about research questions and predictions, answers and explanations</p> <p>2-5 Ability to discuss and/or visualize pupils' thinking (including mistakes) to generate class discussion in order to enhance meta-cognitive awareness</p> <p><b>Science PCK 3: Teachers' evaluation and assessment</b></p> <p>3-1 Ability to connect new knowledge and understanding to prior knowledge</p> <p>3-2 Ability to connect new knowledge and understanding to real life context</p> <p>3-3 Ability to connect new knowledge and understanding to the overarching science concepts</p> <p><b>Science PCK 4 and 5: Teachers' attitudes toward science education</b></p> <p>4 Attitudes toward teaching science</p> <p>5 Attitudes toward learners and learning science</p> <p><b>Teachers' attitudes 1, 2 and 3</b></p> <p>1- Attitudes toward science</p> <ul style="list-style-type: none"> <li>- importance of science for society, pupils' daily life and environment, economy</li> <li>- pleasure</li> <li>- nature of science</li> </ul> <p>2- Attitudes toward themselves as science teachers – self efficacy</p> <p>3- Attitudes toward competence development of science and science teaching</p>
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Fig. 1. Preliminary teachers' inquiry-based science teaching competence profile.

determine the extent of agreement among experts on the importance of those previously identified competencies, and to distinguish between the importance of mastering these competencies for novice and for experienced teachers.

Two research questions were formulated in accordance with the research purpose:

- 1) To what extent do Dutch experts agree or disagree with the importance of inquiry-based science teaching competence elements as derived from the literature (Alake-Tuenter et al.,

2012) and the United States' National Science Teaching Standards (NRC, 1996)?

- 2) According to experts, are there any differences between the importance of competencies for novice and for experienced teachers?"

Significant differences between novice and experienced teachers would suggest the need for continued competence development programs in the field of inquiry-based science teaching.

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