ABSTRACT. Good conceptual understanding of physics is based on understanding what the key concepts are and how they are related. This kind of understanding is especially important for physics teachers in planning how and in what order to introduce concepts in teaching; connections which tie concepts to each other give direction of progress—there is “flux of information” so that what was learned before provides the basis for learning new ideas. In this study, we discuss how such ordering of concepts can be made visible by using concept maps and how they can be used in analysing the students’ views and ideas about the inherent logic of the teaching plans. The approach discussed here is informed by the recent cognitively oriented ideas of knowledge organisation concentrating on simple knowledge organisation patterns and how they form the basis of more complex concept networks. The analysis of such concept networks is then very naturally based on the use of network theory on analysing the concept maps. The results show that even in well-connected maps, there can be abrupt changes in the information flux in the way knowledge is passed from the initial levels to the final levels. This suggests that handling the information content is very demanding and perhaps a very difficult skill for a pre-service teacher to master.

KEY WORDS: concept maps, knowledge organisation, teacher education, teaching plans

INTRODUCTION

Scientific knowledge—in particular physics knowledge—is quite often described as webs or networks where concepts are linked to other concepts and principles (Anderson, 2001; Wilson, 1999; Thagard, 1992). The relational structure of concepts plays an essential role also in establishing the meaning of concepts because they cannot be conceived as isolated entities but instead as parts of the whole system of knowledge (diSessa, 2008; Thagard, 1992). In such a picture of knowledge, it is evident that the existing structure and relations within it also affect how the new concepts can be introduced as parts of the networks (Thagard, 1992). Moreover, the content-based relations between concepts also guide the ordering in which concepts can be approached in learning and teaching.
Understanding the relational structure of physics concepts is important for physics teachers and therefore among the issues that physics teacher education should address. Of course, there are many equally important aspects, like paying attention to students’ qualitative understanding, preconceptions, motivation and the context of teaching (Duit, Gropengießer & Kattman, 2005). But it is very difficult to imagine successful and well-planned teaching that does not pay attention to the organisation of the subject content. Consequently, in this study, we concentrate on the problem of how the relational structure of physics concepts can be represented for purposes of organising the subject content for teaching and instruction.

The context of organising the subject content for purposes of teaching is interesting because then, the relational structure of concepts must be approached from the viewpoint of how to justify the introduction of new concepts on the basis of concepts which have already been learned. This kind of knowledge is valuable for the teacher because it is an important part of the teacher’s as well as the learner’s conceptual knowledge (Tiberghien, 1994; Duit et al., 2005). In order to construct teaching approaches and plans, where content knowledge is properly organised, the teacher needs to know how the concepts can be introduced in teaching in a logically justified manner. The well-organised content for teaching physics can be recognised from some very basic features: clear exposition of new concepts; clear direction of progress, where new concepts learned are based on previously explained concepts; and clarity in how concepts become related. Consequently, the connections which tie concepts to each other quite naturally provide a comprehensible direction for progress—there is “flux of information” so that what was learned before is the basis for learning new ideas. This kind of inherent logic is a prerequisite for providing a solid structure and sound basis for physics teaching, and it prevents content from breaking into disconnected and unrelated pieces.

The organisation of physics knowledge and the logical progression in the ways the concepts are introduced need, however, suitable resources for making these aspects visible and recognisable in pre-service teachers’ representations. In this study, we discuss how specially designed concept maps, which pay attention to the experiments and models in linking the concepts (for more details, cf. Koponen & Pehkonen, 2010), can be useful in making this organisation visible and how such maps can be used in analysing the pre-service teachers’ views and ideas about the inherent logic of the plans. It is well known that the relational structure of knowledge can be presented as a network of concepts, whilst the structure of the network (concept map), in turn, reflects the conceptual understanding