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Using Concept Mapping Method for Assessing Students' Scientific Literacy

Priit Reiska[a]*, Katrin Soika[a], Aet Möllits[a], Miia Rannikmäe[b], Regina Soobard[b]

[a]*Tallinn University, Narva mnt 25, Tallinn 10120, Estonia*
[b]*University of Tartu, Ulikooli 18, Tartu 50090, Estonia*

Abstract

The Natural Science Education Standards (NSES) has defined scientific literacy as knowledge and understanding of scientific concepts which helps us to make personal decisions, participate in cultural and civic speculation and take part in economic productivity. In order to assess students` cognitive components of scientific literacy we need a reliable and valid instrument, appropriate for the survey and easily usable by students, teachers and researchers. The aim of the study is to evaluate concept mapping as an assessment tool for determining cognitive aspects of scientific literacy. Students` concept maps can be assessed by different measures, for example, number of concepts, number and quality of propositions, concept centrality, size and hierarchy of the concept map, clusters in the maps. Our aim is to identify measures which are relevant and valid for assessing students` cognitive components of scientific literacy. Concept mapping was used as an assessment method in an Estonian large scale study (LoteGym, 2011-2014). The results from the PISA-like test were compared with the results obtained from the concept maps. The correlation analyses showed that as a predictor for students' cognitive components of scientific literacy are better suitable the quality measures of concept mapping (e.g. number of high quality propositions). The analysis of the concept maps also showed, that students intend to create more propositions inside the "everyday life" cluster than inside the "subject" cluster or between these two clusters.

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Keywords: concept mapping; scientific literature; assessment tool; cognitive learning.

* Priit Reiska. +372 640 9101; fax: +372 640 9116.
E-mail address: priit@tlu.ee

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1. Introduction

The main goal of the current study is to find an assessment tool to investigate cognitive aspect of students` scientific literacy. However the term “scientific literacy” has become an internationally well-known slogan from educators, researchers, politics and parents and it is still difficult to give an unambiguous meaning (Laugksch, 2000). The importance of the scientific literacy is revealed in school curriculums standards in many countries (including Estonia) and in international studies (e.g. Program for International Students Assessment (PISA) study, OECD).

Concept mapping is not only a learning method, but also used as an assessment tool (Novak, 2007). An assessment related question which can be considered - how to measure students` cognitive components of scientific literacy using concept mapping techniques? To evaluate the responses obtained PISA-like test results are compared with the results of the concept maps. This is the first large scale study, where a concept mapping technique is used together with another testing approach (PISA-like test for assessing scientific literacy).

A large scale study was carried out in a representative sample of 46 Estonian high schools. Initially students were asked to solve PISA like multiple choice items and free response explanation questions. Then they were asked to create concept maps based on a subject-specific focus question. The results from the PISA-like test were compared with the results obtained from the concept maps.

2. Theoretical overview

2.1. Scientific literacy

Holbrook and Rannikmäe (2009) define scientific literacy as “Developing an ability, to creatively utilize appropriate evidence-based scientific knowledge and skills, particularly with relevance for everyday life and a career, in solving personally challenging yet meaningful scientific problems as well as making, responsible socio-scientific decisions”. Roberts (2007) in here consideration of scientific literacy consider this to over two types, labeled type I and type II. While type 1 related to cognitive achievement in science, type II related to competence about science and its interrelationship with everyday contexts, in terms of problem solving, decision making, attitudes and values. These types are often mixed as can be seen by statements on what a scientifically literate students is expected to be able to do (NSES, 1996):

- ask or determine answers to questions derived from curiosity about everyday experiences;
- describe, explain, and predict natural phenomena;
- read with comprehension articles about science in the popular press and to engage in social conversation about the validity of the conclusions;
- identify scientific issues underlying national and local decisions and express positions that are scientifically informed;
- evaluate the quality of scientific information on the basis of its source and the methods used to generate it;
- evaluate arguments based on evidence and to apply conclusions from such arguments appropriately.

On the other hand, the PISA 2015 framework simply suggests a scientifically literate person is able to participate in reasoned discourse about science and technology (OECD, 2013), in type I aspects (Roberts, 2007):

- explaining phenomena scientifically - students recognize and offer explanations for a range of natural and technological phenomena.
- evaluating scientific enquiries - students describe scientific investigations and propose ways of addressing questions scientifically.
- interpreting data and evidence scientifically - students analyze and evaluate data and draw appropriate scientific conclusions.