Identifying threshold concepts in learning nano-science by using concept maps and students' responses to an open-ended survey

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Abstract

Since Feynman invited (1960) us to the room at the bottom, studies about areas at atomic/molecular levels have been accelerated and we have made enormous improvement in the field of science. In recent years, science in atomic/molecular levels has extended into the Nano-regime along with developments in technology. Nano-science/technology has attracted interests not only from scientists/engineers but also from the general public as a new potential field in science. However, compared to the attention given to and development in the field of science and technology, there are not many studies about its educational perspectives.

In realizing the importance of Nano-science education, this study explored students' conceptions of learning in an introductory Nano-science unit by analyzing student concept maps and through identifying potential threshold concepts. Data were collected from 21 college students who were taking an introductory thermodynamics of materials science course including a lesson unit for Nano-science concepts. Additionally, the course required developing a learning tool for teachers to help their students learn property changes in nanometer range. In order to better understand student conception and the learning difficulty understanding Nano-concepts, pre- and post-concept maps including students' responses to open-ended survey questions were explored in detail. Based on an interview with the instructor and his concept map, 11 key Nano-concepts were selected and provided for students' mapping. In addition, the survey asked students

to select concepts from their own maps and to provide reason for their responses in three different categories of an important, difficult, and threshold concept.

As expected by the instructor, a larger % of students (43%) pointed out “surface area to volume ratio at Nano-scale” as a threshold concept understanding the Nano-unit of the course. In addition, “size at Nano-levels” was also addressed as potential threshold concept in this course by some of students (19%). The change in students’ maps indicates that students made more links or concepts for size-dependent property changes on the Nano-scale by including “surface area to volume ratio at Nano-scale. Although many students pointed out the concept as a threshold concept, it was not a difficult concept to understand. This suggests that it is not a conceptually difficult concept but, it integrates isolated concepts and helps students to make transformative understanding from science on a macro-scale (visible range) to science on a nano-scale (invisible range). In particular, addressing “size at Nano-levels” as another threshold concept suggests that the troublesome nature of the threshold concept “surface area to volume ratio at Nano-scale” may lie in the understanding of the concept of “size” at Nano-levels. The size conception within the “surface area to volume ratio at Nano-scale” could be counter-intuitive to students who are familiar with macro-scale in a visible range.

Identifying threshold concepts from students’ and instructor’s concept maps will help us to better understand student learning, conceptual difficulty, and conceptual development in Nano-science education. In particular, comparing the different perspectives on threshold concepts from the instructor and students can provide useful information for the preparation of Nano-science education.