A CROSS-SECTIONAL STUDY OF THE UNDERSTANDING OF THE RELATIONSHIPS BETWEEN CONCENTRATION AND REACTION RATE AMONG TURKISH SECONDARY AND UNDERGRADUATE STUDENTS

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ABSTRACT

This research describes a cross-sectional study, which will give insights into the development of students' understanding of chemical kinetics (at key points, in relation to relevant teaching) from secondary to university level, in Turkey. The study is based mainly on the written responses given by school and undergraduate students to a series of written tasks involving concepts and phenomena in chemical kinetics. A small-scale interview study was also carried out with a number of students to obtain further information regarding students' ideas about chemical kinetics and to check for appropriate interpretation of the written responses. In this paper, our focus is on the students' understanding of the relationships between the concentrations of reactants/products and reaction rate. Analysis of students' responses on written probes and in interviews indicates that, after instruction, many students use conceptions not consistent with scientific perspectives, and have conceptual difficulties in understanding the relationships between concentration and reaction rate. Furthermore, the results show that students did not frequently use "particulate" and "mathematical" modelling, and in most cases such modelling was not used as intended by the curriculum. The results indicate a need to review curricula, and instructional practices, in the light of the students' difficulties in understanding chemical kinetics.

1. INTRODUCTION

Chemical reaction rates and the factors that affect them constitute an important area of the chemistry curriculum (Cachapuz & Maskill, 1987; Ragsdale *et al.*, 1998).

Given the importance of chemical kinetics and the diverse nature of the concepts and relationships that comprise it, it is surprising that "the development of students' understandings of chemical kinetics in relation to teaching" has not been the focus of educational research over the years (Justi & Gilbert, 1999; Cakmakci, 2004). There are very little data available on how understanding of chemical kinetics progresses as students move through the curriculum. It is intended that this study will provide empirical evidence about students' understanding of chemical kinetics. Since students experience difficulties in understanding in chemical kinetics both at

K. Boersma et al. (eds.), Research and the Quality of Science Education, 483—497.

school (De Vos & Verdonk, 1986; Justi, 2002) and university level (Lynch, 1997), further research is required in order to give insights into the ways in which students conceptualise chemical kinetics at school and university level.

Longitudinal and cross-sectional studies have been undertaken to identify how understanding of specific ideas progresses as students move through the curriculum. In order to evaluate the success of a curriculum at achieving its objectives, it is necessary to look at some aspects of students' learning. Several longitudinal and cross-sectional studies have been undertaken on students' domain-specific reasoning in other areas of science, and the data from these studies have provided important information when decisions are made in planning and sequencing the curriculum (Abraham *et al*., 1994; Driver *et al*., 1994).

This study is aimed at identifying and characterising the development of students' understanding of the relationships between the concentrations of reactants/products and reaction rate, at key points, in relation to relevant teaching at secondary and university level, in the Turkish educational system. It is intended that findings of the study can be used to inform teaching interventions by highlighting possible mismatches between the objectives of the curriculum and students' level of understanding in chemical kinetics at school and university level.

2. METHODS

This study is part of a continuing research project (Cakmakci, 2003a). It is based mainly on the written responses given by 191 school and undergraduate students to 11 open-ended diagnostic questions (termed 'probes') involving concepts and phenomena in chemical kinetics. The sample includes 108 secondary school students (Grade 10, ages 15-16) in three classes from two different schools, 48 first-year (age 17+) and 35 third-year (age 19+) pre-service chemistry teachers. Data were collected 5-6 weeks after secondary school students had been taught chemical kinetics; data were collected immediately after teaching for university students. The same diagnostic tests were conducted on secondary school and undergraduate students. By using the same probes, we would be able to compare the development of student reasoning as a result of instruction at school and university. A sub-sample of the students (10 SS, 7 UF and 7 UT)[1] was also interviewed in order to obtain further information regarding their ideas about chemical kinetics and to check for appropriate interpretation of the written responses. This sub-sample was chosen to represent diversity in responses to the written probes. The probes used in interviews were the same as those used in the diagnostic tests. The interview, therefore, could improve the credibility and validity of the data and findings. In order to identify the intended development of the subject of chemical kinetics within the school and university courses, the science curriculum, chemistry textbooks, and students' notes were analysed, based on a conceptual analysis of the domain.

[1] 'SS' refers to secondary school students; 'UF' and 'UT' to university first year and university third year students, respectively