Fostering systems thinking in geography education: effects of an intervention study

Marjolein Cox*†[1], An Steegen[2], and Jan Elen[2]

[1]KU Leuven – Belgium
[2]KULeuven – Belgium

Abstract

An increasing interconnectedness of people and goods enhances the complexity of many geographical problems. For students to understand geography, systems thinking is a promising approach. It helps to understand increasing complexity by looking at the entire system and at the interconnectedness between the elements in the system. Encouraging students to use tools to handle complexity may help them to understand that complexity. Despite the advantages claimed by the proponents of systems thinking, the implementation into education has not been spread widely (Plate, 2010). Similarly, research on how to foster systems thinking in secondary education in general and in geography education in particular is limited (Assaraf & Orion, 2005). Previous research demonstrates improving learning outcomes in science education via computer-based modelling (Smetana & Bell, 2012) and conceptual representations (Hmelo-Silver, Jordan, Eberbach, & Sinha, 2016). However this research is rather limited in geography education in which space and timescales have to be taken into account. The overall aim of the study is therefore to better understand how systems thinking ability of students in a geography course can be fostered. The following research questions are guiding the research: What is the effect of the use of causal diagrams in geography lessons on the ability to systems thinking of students in upper secondary education? Is this effect different according to their study program, grade or gender?
A quasi-experimental research design in the form of a classroom intervention was used. In total twelve teachers of eleven different schools implemented a lesson series, developed in consultation between the researcher and these teachers. The students in the experimental group (n=552) were trained to retrieve information (e.g. determining variables) from all kinds of sources and combine them into causal diagrams which visualize the relations between these variables in the system. The construction (and accompanying discussion) of these diagrams was crucial in grasping the problems as a whole. Furthermore, students used these diagrams to examine the effect of certain interventions into the systems. The interpretation of the data from a geographical, and thus multidimensional perspective in which complexity is fully recognized, is at the core of the inquiry-based instruction aiming to foster systems thinking. The students in the control group (n= 195) learned the same content without the use of these causal diagrams. Both student groups took a pretest and posttest to measure their systems thinking ability. Content validation of both tests was performed by expert panels, while the reliability was statistically analyzed.

Quantitative results from the tests show a positive impact of the intervention. The experimental group has a significantly higher mean score on the posttest. Qualitative observations

*Speaker
†Corresponding author: marjolein.cox@kuleuven.be

do reveal a deeper reasoning by students while constructing a causal diagram. However, the processing of the information in the texts, graphs and maps in order to select variables and to understand the connections in the systems is rather difficult for certain students. Differences in study program have an impact on their systems thinking ability. Particularly in study programs with a higher success rate in higher education a higher ability to create causal diagrams was observed in the pretest. Despite these positive effects observed in the intervention, some concern has risen about the attention students have for spatial patterns and spatial embeddedness of the variables. Indeed, students seem not to be aware of the fact that some variables on one place cause an effect in a different place, nor that this effect is on a global or a local level. In short, students do not realize that every variable has its own spatial pattern. In future research, more attention should be paid at embedding a spatial and temporal component in the study of the variables.

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