



## **Teaching sustainability science from a systems analysis perspective: MSc course at Utrecht University**

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Sustainability science has emerged as a key discipline that embraces both disciplinary depth and interdisciplinary breadth. The challenge is to design University courses that convey both properties without sacrificing either of them. Here we present the design of such course at Utrecht University (the Netherlands) for the MSc program 'Sustainable Development' and discuss the perceived learning and student evaluations. Our course (Sustainability Modelling and Indicators (SMI)) follows an introductory course on Sustainability Perspectives. SMI philosophy is that system thinking and system analysis is central to sustainability science. To convey this philosophy, we focus on four themes: the Anthropocene, Food security, Energy security and Agency and decision making. We developed four hands-on assignments with increasing complexity and make use of different software (Stella, Excel, IMAGE and Netlogo). The assignments aimed at: (1) teaching students the system components by using a pre-existing model in Stella, (2) challenge students to build their own coupled system in Excel, (3) assess outputs from the fully-coupled and dynamic model integrated assessment model IMAGE, and (4) understand emergent properties using an agent-based model in Netlogo. Based on detailed student evaluations ( $n = 95$ ) we found that the mathematics presented a manageable challenge to a part of the students. The student pool identified a priori having higher experience with Excel in comparison with other software. Netlogo was the highest ranked software in the student evaluations and this was linked to its user-interface with moving agents. The Excel assignment received the highest and lowest scores, and students found it challenging, time consuming but also indicated that they learned the most from this assignment. Students graded what we considered 'easy' assignments with the highest grades. These results suggest that a systems analytical approach to sustainability science can be operationalized in diverse ways that relate to students background and making use of of-the-shelf software. The key challenge is to teach students all the concepts of systems analysis and the applied mathematics behind it. If the goal is to demonstrate process, this portfolio approach with of-the-shelf software can be very successful. This course can be complemented with programming that provides skills to modify and customize software to student needs.