

Extended Abstract: Using Archetypes to Teach Systems Thinking in an Engineering Master's Course

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Systems Thinking can help to solve complex problems in different domains including engineering. Roughly, it can be defined as “a paradigm for viewing reality based on the primacy of the whole and relationships” (Maani 2020 p. 418). Training in Systems Thinking is recommended for individuals of all ages and all stages of professional and personal development, and it is strongly advocated that decision-makers (in business, politics etc.) are trained in Systems Thinking. Accordingly, there are extensive efforts to teach, promote and apply Systems Thinking as early as kindergarten and school age (Fisher 2018, Forrester 1994, 2016), in Higher Education at universities throughout the world (<https://systemdynamics.org/degree-courses/>), as well as in a wide range of professional fields (Hossain et al. 2020). Richmond (1993) identifies seven distinct Systems Thinking skills in his highly influential article, and different frameworks have been proposed for the development and assessment of competencies towards proficiency in Systems Thinking (e.g. Plate and Monroe, 2014; Schaffernicht and Groesser, 2016), which typically reflect learning outcomes related to both qualitative and quantitative competencies' aspects. While such development frameworks enable an in-depth skills assessment, they do not necessarily prescribe a path for teaching. Kunc (2012) distinguishes two approaches to develop improved understanding of dynamically complex problems: One is *Using Models* (e.g. microworlds as interactive learning environments) and the other is *Modelling*, as in creating both qualitative and quantitative models, which is often the focus of System Dynamics courses.

For an engineering master's program, we designed a seminar course to teach Systems Thinking based on qualitative modelling. The seminar spans a time of 15 weeks, encompasses 180 hours of students' workload and is a follow-up to a 360 hours workload System Dynamics lecture course that is to a large extent based on the textbook by Sterman (2000). For the seminar we use archetypes as conceptual models and the Covid-19 pandemic as problem context.

In this paper we describe design considerations based on existing Systems Thinking teaching literature and on theory on students' motivation to learn (Deci and Ryan, 1993; Prenzel, 1997) as well as on our own experience with running seminar courses. We then describe the details of the course design which consists of nine distinguishable stages, and we report findings from running it.

Based on students' evaluation and the materials they produced throughout the course, our findings (1) support our design assumptions regarding student motivation, (2) give insights on students' struggling with understanding and applying archetypes, and (3) suggest further development of course design. With this we want to provide a course blueprint and contribute to the discussion of how to teach Systems Thinking in Higher Education.

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