Framework for Designing an Online Interactive Learning Environment for Complex Dynamic Systems

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Research shows the world is facing a wide range of increasingly complex, dynamic problems in both the public and private sectors. Despite that, this body of research documents that the public at large has difficulty to understand complex dynamic systems and on how to manage these systems effectively and efficiently to reduce the severity of or avoid the problems (Davidsen 1996; Jonassen, 2000). Research, on the other hand, shows that formal educations that focus on systems thinking (holistic perspectives) would help minimize such difficulties (Sterman, 2010). The questions remaining are how can we educate the public to solve such complex and dynamic problems? Particularly, when the experts that could facilitate the teaching/learning are not physically available.

Educational programs that focus on complex and dynamic problems often break down the barriers among fields such as natural science, engineering, political science, economics, law, education, medicine etc. Furthermore, students who register to such programs often come with diverse academic, cultural, and experiential backgrounds and perspectives. How could we educate these students under the same table and help them go with the same pace?

In face-to-face instructions, it is difficult for a teacher to identify a student who is struggling with her/his learning material, particularly if there are many students, unless either the student goes to the teacher on its own or until exam results are published. How could a teacher track the progress of each student, while (s)he helps the learners learn their learning materials on their own time and their own pace?

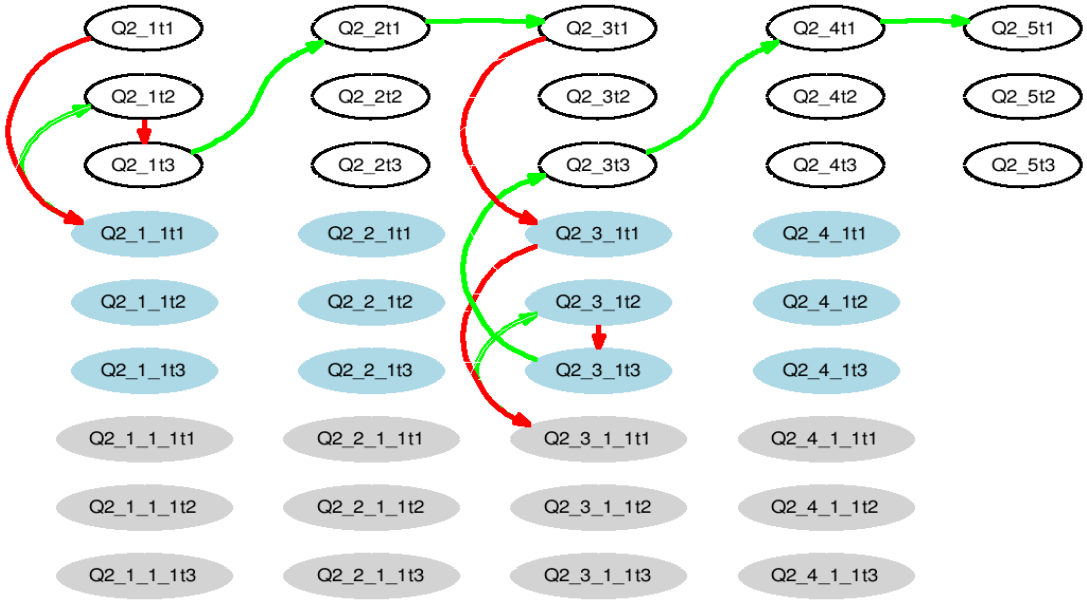
This paper presents a framework underlying the design of an online interactive learning environment (OILE) for complex dynamic systems. The OILE is designed on the bases of holistic instructional design principles, which "deals with complexity without losing sight of the interrelationship between the elements taught" (van Merriënboer & Kirschner, 2017, p.5).

The paper discusses in detail the design framework, including the rationale for the design and its research underpinnings. The three key domain elements of importance for the design: a fading scaffolding instructional method adopted in the design, instructional techniques used to implement the chosen method - storytelling, repeated trial, intensive feedback & item branching, and a web based instructional tool developed to integrate the chosen method and techniques are discussed in the paper.

The general structure of the learning environment, its online delivery and its assessment strategies are described, including the user interface and feedback formats employed. The distributions of tasks and items by problem nature and context, and according to cognitive process are specified. Sample learning tasks and items are also presented with commentary, including an illustration of how students' log on data (captured by the online-delivery system) is used to evaluate students understanding of complex dynamics systems.

First year System Dynamics master program students of University of Bergen have used the OILE during the autumn semester of 2017 in a blended learning set up. The students have used the OILE to address a case study, which is a mandatory assignment in their program. The case study is about a hypothetical bicycle repair shop, Mr. Wang's Bicycle Repair shop, which aims to teach students about the causes of oscillation. The case study is an adaptation of the Causes of Oscillation exercise published by the System Dynamics Group, MIT, Cambridge, Massachusetts, USA.

We have collected data from students, who have used the OILE, to assess their cognitive and affective learning domains. Students' learning paths, which are sequences of learning tasks students have passed through, the amount of time each student has spent in a given question and the kind of support and/or feedback students have received determined the cognitive aspect of the learning. The figure below represents a learning path of a student who has worked on the OILE from question number "Q2_1 to Q2_5". The green lines represent successful performances of the student and the red lines represent unsuccessful attempts.



The affective learning domain is assessed through surveys administered to the students. The overall result of the students show that students had statically significant changes in their learnings, both in their cognitive and affective domains.

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