Drawing-Based Modeling for Early Science Education

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Abstract. Creating models is at the heart of any scientific endeavor and therefore should have a place in science curricula. We present three approaches, a collaborative drawing tool to support scientific dialogue, a domain specific tool providing intelligent support for learning about gear systems as well as a free-hand drawing tool to support learner created animation.

Keywords: simulation, modeling, sketch recognition, exercise selection.

The creation, modification and evaluation of models are core ingredients of a scientific world view [1]. Trying to grasp phenomena by modeling them and then investigating those models through reasoning and simulation is an important way of building scientific knowledge. Representations are the mediating link between mental models of the learners and real world systems. Consequently, an effective representation for modeling is one in which the properties of a phenomena and their relationships are made explicit and visible for learners. In the current poster we explore the benefits of *drawing* for modeling, in order to support learners in expressing their models and engaging in a realistic cycle of representing, executing and evaluating models. We present systems for collaborative drawing in a pre-modeling stage, for domain specific drawing-based modeling and a system in which the drawing "talks back" when the learner specifies drawing elements, their properties and relations.

As drawing facilitates idea sharing, disambiguation of conceptual understanding, and assists students in attaining a shared focus [2, 3], there is benefit in creating collaborative drawing environments. To fully benefit from *collaborative drawing*, it is important that students engage in task-focused [4] and elaborated meaning making activities. Two possible means of supporting the drawing and collaborative processes were investigated [5]: awareness support and scripting. In the first case the learners were prompted on missing elements in their drawings, in the second, the script made learners create individual drawings first, to serve as input for a joint drawing. Study findings indicate that students in the scripted condition perform significantly better on the concept recognition test and drawing quality than their peers in the control group.

With *GearSketch* [6] young learners can explore the domain of gears and chains by creating simulations. As such simulations require precision drawings, learners are assisted by converting circles to gears as well as automatic snapping of gears and shrinking of chains. GearSketch has an internal representation of gears and chains to compute turning speeds and directions of gears and chains. GearSketch offers learners

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integrated instructions, questions to answer and puzzles to solve. These offer students guidance in their exploration of the gears domain. Puzzle selection is done based on a Bayesian learner model. In a study with 78 fifth grade students, the effectiveness of a version of GearSketch with simulation-based support was compared to a version without this support. These results show that simulation-based support in a digital drawing environment can lead to higher learning gains.

Our drawing and modeling tool *SimSketch* bridges the gap between informal, sketch-based representations and formal, executable models. To this purpose, SimSketch can be used to draw strokes to externalize their learners' models of a phenomenon. Learners can then place "stickers" on their drawing, each representing a behavioral primitive, such as movements, reproduction, avoidance etc. The model that has been created by combining the learner's drawing and the behavioral annotations can be executed and simulated. SimSketch is targeted at learners in primary and secondary education and is suitable for numerous educational domains, since the behavioral primitives are highly generic and applicable to various phenomena, such as the movement of celestial bodies, predator-prey systems, swarming behavior, traffic systems and many more.

The three examples of the drawing-based approach to modeling presented here, illustrate both the potential and the research agenda in modeling research: the support for learners to create high quality drawings, creating challenging tasks within reach of the learner and providing smooth represent-run-revise cycles based on drawings. The presented tools are available from http://modeldrawing.eu.

References

1. Louca, L.T., Zacharia, Z.C.: Modeling-based learning in science education: cognitive, metacognitive, social, material and epistemological contributions. Educational Review, 1–22 (2011)
2. Brooks, M.: Drawing, Visualisation and Young Children's Exploration of "Big Ideas". International Journal of Science Education 31, 319–341 (2009)
3. Ainsworth, S., Prain, V., Tytler, R.: Drawing to Learn in Science. Science 333, 1096–1097 (2011)
4. Anjewierden, A., Gijlers, H., Kolloffel, B., Saab, N., de Hoog, R.: Examining the relation between domain-related communication and collaborative inquiry learning. Computers & Education 57, 1741–1748 (2011)
5. Gijlers, H., van Dijk, A.M., Weinberger, A.: How can Scripts and Awareness Tools Orchestrate Individual and Collaborative Drawing of Elementary Students for Learning Science? In: CSCL 2011. ISLS (2011)
6. Leenaars, F., van Joolingen, W.R., Gijlers, H., Bollen, L.: Drawing-Based Simulation for Primary School Science Education: An experimental study of the GearSketch learning environment. In: DIGITEL (2012)