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ASPECTS OF SCAFFOLDING IN A WEB-BASED LEARNING SYSTEM FOR CONGRUENCY-BASED PROOFS IN GEOMETRY

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This paper focuses on the pedagogical underpinnings of the design of a web-based learning support system for lower secondary school pupils who are just beginning to learn how to tackle deductive proving in geometry. In particular, we explain how the key features of our web-based system can scaffold learners' learning of congruency-based proofs in geometry.

Keywords: web-based learning system, scaffolding, congruency, geometry

WEB-BASED SYSTEM FOR CONGRUENCY-BASED PROOFS

In an on-going research project we are developing a web-based learning support system (currently available in English, Chinese and Japanese) that is designed for lower secondary school pupils who are just starting to tackle congruency-based proofs in geometry; see Miyazaki et al. (2011, 2013) and our project website: http://www.schoolmath.jp/flowchart_en/home.html

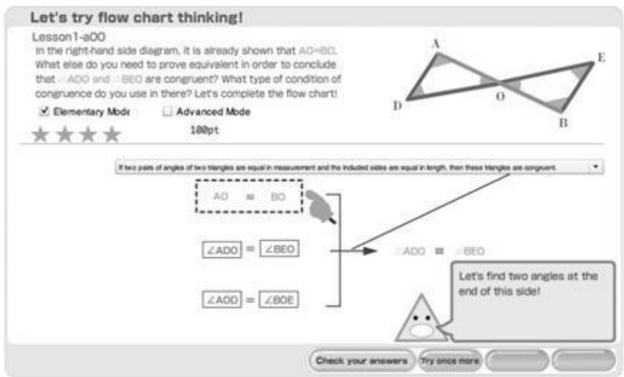

Figure 1: proof task within the web-based learning support system

To design the proof tasks in our web-based learning support system we are using two pedagogical ideas: the format of flow-chart proofs, and forms of 'open problem' proof tasks. A flow-chart proof provides a 'story line' of the proof and have been shown by McMurray (1978) and others to help students to visualize the structure of geometrical proofs. 'Open problem' situations are tasks where students can construct multiple solutions to the proof problem by deciding the assumptions and intermediate propositions necessary to deduce a given conclusion.

When using this learning system, pupils can tackle geometric proof problems by dragging sides, angles and triangles to on-screen cells. As this happens, the web-based system automatically translates the figural elements to their symbolic form. Pupils also select from a choice of congruency conditions. From each set of actions, feedback is provided from the system. In trying to find other solutions in open problems, the pupils can review their previous solutions. Thus the system offers opportunities for students to learn geometric proofs in a way that is different from traditional textbook-based learning.

SCAFFOLDING IN TECHNOLOGY-BASED LEARNING ENVIRONMENTS

Since the introduction of the notion of instructional scaffolding by Wood, Bruner and Ross (1976), recent studies have suggested that technology-based learning environments can function as scaffolding to support learners' learning progression (eg Sherin, Reiser, & Edelson 2004). Here we follow Sharma and Hannafin (2007, p. 29) in considering scaffolding to be "a two-step process of supporting the learner in assuming control of learning and task completion". In the first step the learner is provided with "appropriate support to identify strategies for accomplishing individually-unattainable learning goals or tasks" (ibid); in the second step the assistance gradually fades as the learner becomes increasingly competent. As such, in technology-based learning environments, scaffolding can be conceptualized as "the provision of technology-mediated support to learners as they engage in a specific learning task" (ibid).

SCAFFOLDING FUNCTIONS OF THE OPEN FLOW-CHART PROVING SYSTEM

In terms of technology-mediated support our web-based support system provides the following: a) automatic translation of figural to symbol elements, b) reviewing learner's previous correct answers, c) arranging geometric proof tasks according to their complexity, and d) automatic feedback in accordance of different types of errors.

Using the framework proposed by Sherin, Reiser, & Edelson (2004) we have undertaken an analysis of the scaffolding functions of our web-based system as compared to classrooms without the system. We found that in classroom situations without our web-based learning system, pupils learnt how to construct (simple) formal proofs by following the teaching sequence suggested by an approved textbook. Compared to classrooms with our system, there was less chance to utilise flow-chart proofs and usually less use of 'open problem' tasks. In contrast, when learning with our web-based system, pupils had the opportunity to learn how to construct (simple) geometric proofs through constructing flow-chart proofs in open situations with the technology. By considering the features of the web-based learning system we identified the following 'scaffolding functions:

- Students can drag and drop graphical representations into flow-char box, and the system automatically changes them to symbolic form so that learner can concentrate on logical relationships between each element
- Students can enhance their structural understanding of geometric proofs by visualizing two kinds of deductive reasoning and their combination within the flow-chart proof format
- Students can be encouraged to think forward/backward interactively when constructing a proof using the web-based flow-chart format
- Automatic feedback and reviewing answers enriches learners' thinking by encouraging them to construct different valid proofs for the same 'open' proof problem

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