Abstract
Web-based collaborative learning is becoming an increasingly popular educational paradigm as more individuals who are geographically isolated seek higher education. As such students do not meet face to face with their peers and teachers, support for collaboration becomes extremely important. Successful collaboration means asking questions to gain a better understanding of the main concepts, elaborating and justifying opinions and sharing and explaining ideas. When group members' combined skills are sufficient to complete the learning task, effective group work can result in greater overall achievement than individual learning. Intelligent Tutoring Systems (ITS) have been shown to be highly effective at increasing students' performance and motivation. They achieve their intelligence by representing pedagogical decisions about how to teach as well as information about the learner. Constraint based tutors are a class of ITSs that use Constraint-based Modelling(CBM) to represent student and domain models. Proposed by Ohlsson, CBM is based on learning from performance errors, and focuses on correct knowledge. In this thesis, we present COLLECT-UML, a collaborative constraint-based ITS that teaches object-oriented analysis and design using Unified Modelling Language (UML). While teaching how to design UML class
This paper presents COLLECT-UML, a constraint-based ITS that teaches object-oriented (OO) design using Unified Modeling Language (UML). We started by developing a single-user ITS that supported students in learning UML class diagrams. The system was evaluated in a real classroom, and the results showed that students' performance increased significantly. We then extended the system to provide support for collaboration as well as domain-level support. The enhancement process included implementation of the shared workspace, modification of the pedagogical module to support groups of users, designing and implementing a group-modelling component, and developing a set of meta-constraints which are used to represent an ideal model of collaboration. The effectiveness of the system was evaluated in two studies. In addition to improved problem-solving skills, the participants both acquired declarative knowledge about effective collaboration and did collaborate more effectively. The participants enjoyed working with the system and found it a valuable asset to their learning. The results, therefore, show that CBM is an effective technique for modelling and supporting collaboration in computer-supported collaborative learning environments.

Keywords
Collaboration support; Computer supported collaborative learning; Constraint-based modelling; Intelligent tutoring system; Evaluation; UML class diagrams; Problem-solving support

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approach for analyzing and designing an application, system, or business by applying object-oriented programming, as well as using visual modeling throughout the software development process to guide stakeholder communication and product quality. OOAD in modern software engineering is typically conducted in an iterative and incremental way. The outputs of OOAD activities are analysis models (for OOA) and design models (for OOD) respectively.