

# Scripted Collaboration to Leverage the Impact of Algorithm Visualization Tools in Online Learning: Results from Two Small Scale Studies

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## ABSTRACT

*This work presents research evidence on the impact of a collaboration script to leverage the use of an Algorithm Visualization (AV) system as a tool for experimentation and reflection in the context of online collaboration. The objective of the authors' effort is to improve the learning conditions when AV systems are used as online learning tools, avoiding situations where unguided collaboration may result in suboptimal peer interaction. Results from two studies are reported, where university students collaborated online following the steps of a reciprocal peer tutoring script and using two different AV systems to visualize their solutions on specific algorithm-related learning tasks. Discourse analysis based on an appropriately extended IBIS model and further statistical analysis indicate that the use of the collaboration script enhances the task-related peer interaction and consequently the intrinsic feedback that peers receive from interacting with the AV system, something expected to lead to improved learning outcomes. The implication for AV system designers is that the inclusion of a collaboration script component in the system design is strongly encouraged as a means to augment the expected benefits from online collaborative learning tasks.*

*Keywords: Algorithm Visualization (AV), Computer Supported Collaborative Learning, Interactive Learning Environments, Issue-Based Information System (IBIS), Reciprocal Peer Learning*

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## INTRODUCTION

Algorithm Visualization (AV) systems make available to learners multiple, dynamic and interactive visualizations of the changes that data sets undergo when some algorithm is ap-

plied on them. The main reason for developing AV systems is because there are significant limitations in the representations traditionally used for presenting algorithm operations (Duchowski & Davis, 2007; Khuri, 2001). Reviewing the literature in the field of AV

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systems has revealed that despite of the initial enthusiasm of the scientific community on the subject, AVs have not managed to deliver as positive results as expected (Hundhausen & Douglas, 2004). Certain impediments appeared on the practice of AV systems, as described in the next section, which prevented to meet the expectations in the teaching of algorithms. The plain involvement of an AV system in algorithm learning does not necessarily empower instructors and learners to overcome the challenges in AV learning (Hundhausen & Brown, 1998). Nevertheless, students who used interactive AV systems in active learning conditions (i.e., with the prospect to interact, predict and create mental models of the algorithms), in general, outperformed students, which simply watched a representation of the algorithm in a computer or a whiteboard (Khuri, 2001).

The focus of our research is to leverage the learning impact of an AV tool when used as support in online learning conditions. To guide students, get actively involved in the use of the AV system, when learning online, we resorted to the theory and practice of collaborative learning (Dillenbourg, 2003). Online collaborative learning activities in the computer science domain have been explored in many situations highlighting the need for group support and guidance to avoid detrimental peer interaction patterns (e.g., Liu & Tsai, 2008). It is strongly suggested that learning conditions can be improved when the collaborative activity is structured and guided by a collaboration script, which is a set of directions prescribing how the group members should interact, how they should collaborate and how they should solve a problem (Kollar, Fischer, & Hesse, 2006).

We expect that a guided collaboration will influence the students' discourse towards a more substantial use of the AV system for experimentation and reflection, thus increasing the intrinsic feedback that the students get from using the system. Towards this direction we conducted, some initial, small-scale studies to validate our expectations on the impact of the collaboration script. In the following, we present the theoretical background of our work, the

research method and results of the two studies. We further discuss our evidence indicating that an appropriate collaboration script can focus student discourse and activity in a way that increases beneficial intrinsic feedback relevant to the use of the AV system.

## THEORETICAL BACKGROUND

### Learning with Algorithm Visualization Systems

One of the most common problems in computer science education is how to describe and communicate terms and conditions that have no physical substance (Liu, Huang, & Brown, 2007). Consequently the difficulty increases when the concept is rather abstract, and fundamental in computer science, such as algorithms. Various approaches have been proposed to support teaching of algorithms, involving use of graphical and verbal representations of algorithms (Hundhausen & Douglas, 2004; Khuri & Holzapfel, 2001). Also the use of flowcharts seems to be effective in this context, as well as pseudocode (Hundhausen, Wingstrom, & Vatrapu, 2004).

Our research focus is on improving the learning impact of algorithm visualization tools, which is part of the software visualization techniques and methods (Price, Baecker, & Small, 1998). According to Amar and Stasko (2004), algorithm visualization is the visualization of the higher level abstractions, which describe software. As Price, Baecker, and Small (1998, pp. 4-5) explain, "visualization" means the "power of process of forming a mental picture or vision of something not actually present to the sight." The "represented world" in an AV system is the domain of data sets and algorithm operations. An algorithm animation creates initially an abstract graphical representation of the data set, mapping the current values of the variables used in the algorithm onto appropriate graphical elements (e.g., dots, sticks, circles etc.). Next these elements get animated, representing the operations between the succeeding states in the execution of the algorithm (Naps, 2005).

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