

# ENHANCING PROGRAMMING EDUCATION THROUGH ALGORITHM VISUALIZATION: A FOCUS ON TEACHING DATA STRUCTURES

Oswaldo Vélez-Langs and Jose Gaspar-López

Departamento de Ingeniería de Sistemas Y Telecomunicaciones, Universidad de Córdoba, Colombia

## ABSTRACT

Our study explores the potential of algorithm visualization tools to support the teaching and learning of data structures in programming education. Interactive visual representations are presented as a dynamic solution to overcome the difficulties of traditional methods, fostering deeper understanding and student engagement through experimentation and manipulation of algorithms.

## INTRODUCTION

Teaching algorithms presents challenges due to the abstract nature of its concepts, and understanding. The implementation of data structures is essential for developers in training.

To address these challenges, we propose to integrate algorithm visualization tools into the curriculum and create immersive learning experiences that transcend traditional classes and books.

These approaches can significantly improve students' understanding and engagement, as well as increase their motivation and interest in the learning process.

## RELATED WORK

In the related literature we found some works that involve the aspect of design of tools or how to translate the abstract concepts of algorithms and data structures into graphical illustrations, animations, and interactive elements.

### Some popular tools:

- Visualgo: High precision, clarity and interactive exploration capabilities.
- Algorithm Visualizer: Easy to use and provides comprehensive algorithm coverage.

Algorithm Visualizer: <https://algorithm-visualizer.org/> - AlgoVis: <https://tobinatore.github.io/algovis/> - Visualgo: <https://visualgo.net/en> - Data Structure Visualization: <https://www.cs.usfca.edu/~galles/visualization/Algorithms.html> - Sort Visualizer: <https://sortvisualizer.com/>

## CODESCAPE3D

### Main Goal:

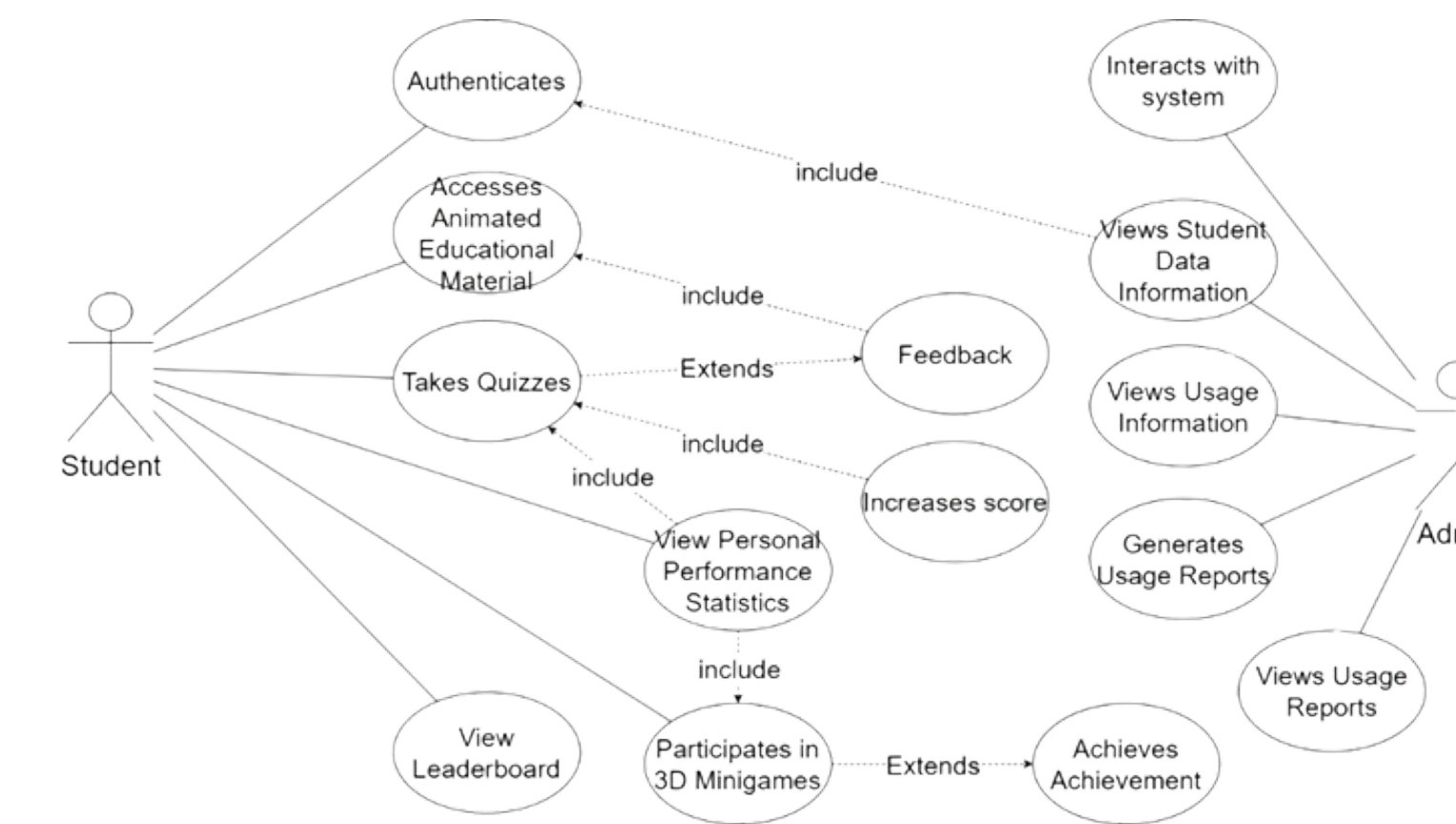
Develop a virtual learning object on the web (CodeScape3D) to teach, among others: fundamental programming concepts, graph theory and data structures.

### System Properties:

- Animations and clear explanations of fundamental concepts.
- Integrated quizzes to assess student understanding.
- 3D section with mini-games to reinforce concepts in a playful way.
- Cumulative scores system, badges and leaderboards to motivate users.

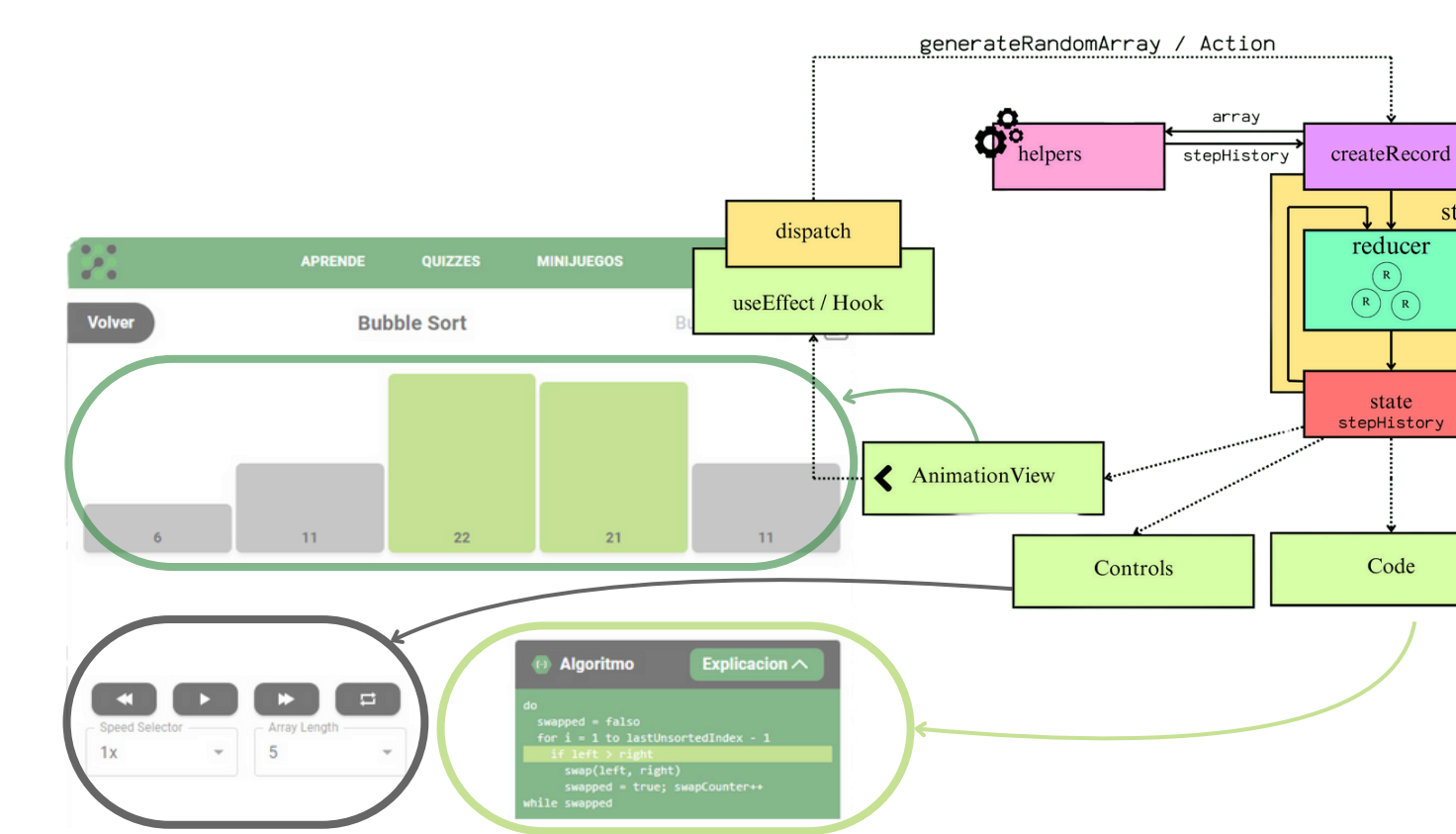
### Methodology

An agile development methodology, specifically the iterative and incremental approach, was adopted for its effectiveness in software projects that require flexibility and continuous adaptation. This methodology is ideal for educational interactive software projects, where needs and objectives evolve according to user feedback and the progressive discovery of educational and technical outcomes.



## CHALLENGES AND SOLUTIONS

- Handling of movement history in the execution of algorithms using auxiliary functions.
- Use of Redux pattern for intuitive access to global system status



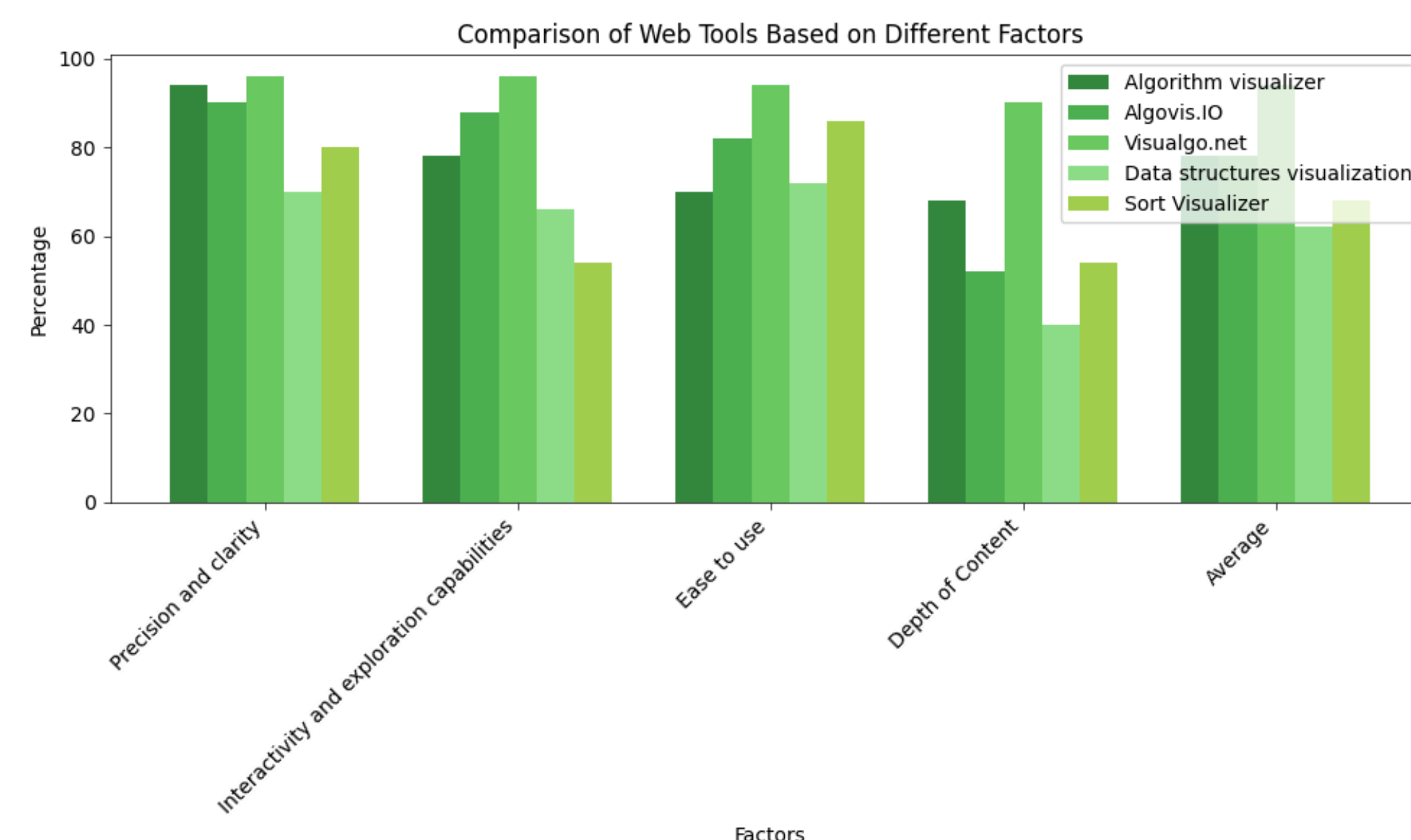
## FUTURE WORK

For future updates and improvements, we have identified several new requirements to enrich the learning experience, making the system more effective and attractive to students and the public interested in learning algorithms. Among others:

- Development of a 3D section: It will offer a metaphorical representation of the topics of programming, graph theory and data structures.
- Implementation of a system of cumulative scores, badges and leaderboards.
- Incorporate an automatic quizzes generation module.
- Experimental evaluation of the tool.

## CONCLUSIONS

- This project seeks to develop an algorithm visualization tool that supports the learning of data structures in programming students. Designed by students for students, it is available to anyone interested in learning programming.
- We are committed to the fact that the visualization of algorithms allows for immersive and dynamic learning experiences, improving the understanding and interest of students. CodeScape3D is an example of it.
- For next system versions, functionality will be expanded with a database to store scores and an automatic quizzes generation module, among other improvements.



TRY DEMO

