

Virtual Laboratories (VLs) within the context of Dynamic Geometry Systems (DGS)

Maria Kordaki¹ and George Alexiou¹

¹ Dept. of Computer Engineering and Informatics
University of Patras, GREECE



ABSTRACT

This paper presents the concept of VLs within the context of DGS. For the design of the proposed laboratories, a modelling methodology was developed. This methodology was based on the design of three models, namely: the learning model based on social and constructivist views regarding knowledge construction, the model of the knowledge domain based on the related specific literature and the student model describing his/her behavior while performing essential tasks for the learning of basic aspects of the previously mentioned knowledge domain. Various capabilities of DGS were combined so as to assist the construction of the proposed laboratories, e.g. a) presentation of information in Multiple Representation Systems (MRS), b) direct manipulation of the geometrical constructions formed using the tools provided, and c) formation of appropriate buttons for illustrating/hiding the specific constructions viewed as appropriate/inappropriate for the learning of specific aspects of the concepts in focus. As a result, an architecture and a typical interface of the said VLs were formed. To clarify the methodology and architecture proposed, a specific example regarding the design and implementation of a specific VL for the learning of the mathematical concept of angle is presented.

The significance of VLs

With the advent of modern computer technologies, web-based laboratories are used as an alternative or a supplement to physical labs. Diverse potential educational benefits can be provided by the adoption of VLs in both formal and informal education: potential use in "anytime, anyplace", accessibility and convenience, interaction, engagement and customization, formation of virtual learning communities, flexibility, allowing learners to take control of their learning, use of MRS

DGS: learning opportunities

- Cabri-geometry II It is a widely known DGS that provides students with potential opportunities:
- Means of construction, providing a rich set of tools to perform a variety of geometrical constructions referring to a variety of concepts concerning Euclidean Geometry.
 - To construct Multiple Linked and Dynamic Representations (MLDR) of the concept in question
 - Dynamic, direct manipulation of geometrical constructions by using the 'drag mode' operation.
 - The possibility of collecting large amounts of numerical data.
 - Interactivity and feedback; intrinsic visual feedback and extrinsic numerical feedback.
 - Presenting information in text form, for example, the presentation of the tasks at hand.
 - Capturing the history of student actions.
 - Extension by forming specific macros.

A modeling methodology for the design of VLs: a VL for the learning of the mathematical notion of angle

Three models were constructed:

- The learning model:** This model was constructed taking into account basic considerations of modern constructivist and social theories regarding knowledge construction exploiting the advantages and the features of the educational software Cabri-Geometry II.
- The subject matter model:** based on the various aspects that constitute the concepts in question as have emerged from the literature.
Angles have been defined: 1) as a part of the plane included between two rays meeting at their endpoints (the static definition) and 2) as the amount of rotation necessary to bring one of its rays to the other ray without moving out of the plane (the dynamic definition)

In the course of schooling, students need to encounter multiple aspects of the mathematical notion of angle, including:

- angle as: a movement, a geometric shape, a measure,
- classification of angles in terms of size,
- clarification of specific kinds of angles,
- appropriate estimation of the size and the relationships among the pairs of angles constructed when 2 parallel lines are intersected by another straight line,
- specific statements related to the angle properties' used in common geometrical shapes

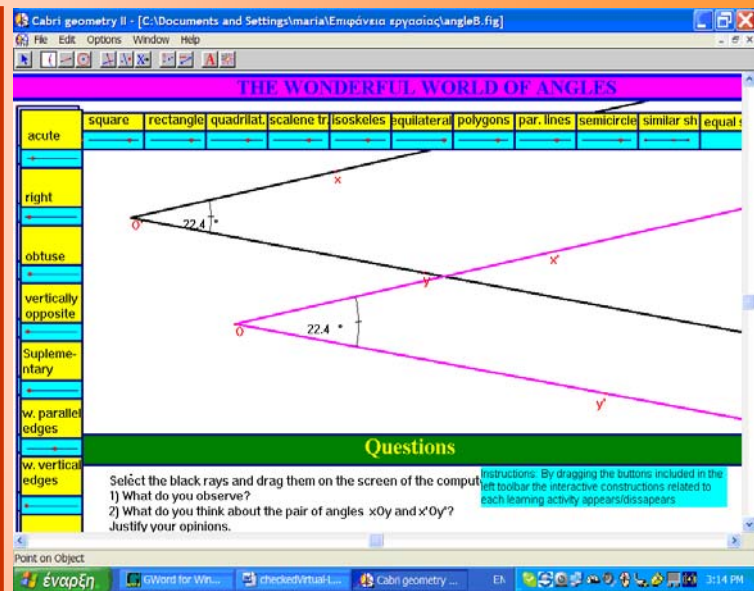
Based on the analysis above, all the mathematical aspects of the notion of angle referred to the literature were integrated into the proposed VL to be explored by the students.

- The learner model:** It's construction is based on the literature on both the scientific meaning of the concepts in focus and the learners' misconceptions and difficulties regarding these concepts. The role of this model is dominant in the modelling process.

Student difficulties regarding angles:

- Confusion of angle measure with area
- Students typically believe that angle measures are influenced by the lengths of the intersecting lines or by the angle's orientation in space.
- little or no conception of angle as a measure of rotation.
- In recognising relationships between angles

As a result of the modelling process various aspects of the concepts in focus have been specified as essential for students to grasp. To help students grasp the diversity of these aspects, various interactive constructions were formed, each of which is dedicated to the learning of a specific aspect through the performance of a specific learning activity.



VLs: Architecture and Interface design

- The interactive construction at hand appears in the centre of the screen and can be managed through both; direct manipulation and a navigation bar.**
- For each interactive construction, diverse information is presented, such as: a) Description of the sub-activity at hand; b) appropriate questions, and c) instructions to manage the construction in focus. Possibilities for expressions of the related concepts in MRS are also formed.**
- The network of interactive constructions was implemented using the tools of Cabri Geometry II and all specific constructions were placed in the same interface. This network of constructions was transformed into Java Applets.**
- These Applets constitute the VLs proposed and were placed in a specifically-designed environment - using MOODLE - so that they could be used remotely.**
- As regards the formation of the specific VL dedicated to the learning of the notion of angle, various interactive constructions were formed to allow students to explore all aspects determined as essential during the modelling process.**

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