Session 2220

A Multimedia Thermodynamics Courseware with GAME

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Abstract

GAME (Gestor-Autor de Multimedia Educativa) is a program that provides a teaching-learning environment designed as a tool to help authors to prepare materials to be used in the classroom in combination with the self-learning ability of the students. Its framework is based on the duality lessons-concepts to provide relevant material according to the author's criteria for establishing educational strategies that cover a double function: to organize the instruction in the classroom and to provide the correspondent material for self-learning by students. It is strongly oriented towards flexibility in designing these strategies that allow adapting the material for any specific situation in a very simple manner.

The developed authoring tool allows the assembly of any new electronic material in an open framework of hypermedia configuration so that instructors are able to create new conceptual relations to reinforce meaningful learning, providing very useful operative relations between concepts and the different materials included in the structure.

I. Introduction

The project was founded on some previous experiences[1,2,3]: Advances in both hardware and software have made it possible for simulations to provide students with a meaningful environment within which they can interact with physical objects or scenarios from the real world[4]. Therefore, a set of computer simulations for labwork was developed.

At the same time, some interactive multimedia courseware materials were developed for Eng. Thermodynamics. As materials increased, we foresaw the need for creating a system to organize and manage them as a whole, in order to avoid inefficiencies inherent to the development of hypermedia environments and to prepare a package for using in self-learning as it could help to get a high motivation level in our students. So, GAME is meant to as a didactic computer based environment that allows organizing the contents and materials of a course, optimizing the demands and the results of everyone involved in the educational teaching and learning process.

In contrast to the traditional approach to instruction, in which students are "consumers of Knowledge" [5] and concepts are abstracted from their use in the real world, we emphasized the notion that learning is a constructive process. It was therefore necessary to take into account cognitive theories to develop a model that allows the following:

- Students strive to gain a high-level understanding of the information, instead of being preoccupied with learning through practice drills or rote memorization[6].
- Teachers as mentors and coaches play, at the same time, the role of the learning facilitator, moderator, promoter and challenger of new experiences; and they are able to propose strategies and methods that encourage students to search and find answers, rather than acting as all-knowing dispensers of information[7].

As the constructivist theories indicate, students construct knowledge on the basis of that what they already know. It is also suggested that students' ability to remember and utilize what they have been taught depends on the level in which they process the material they have learnt. The learner's motivational or affective state, affects the way in which the learner selects, acquires, organizes, or integrates new knowledge. Finally, the new contents presented to the students must be organized in a meaningful way.

We assume that whenever people are intrinsically motivated to learn, they not only learn more, but they also have a more positive experience[8]. Traditional instructional design is concerned with issues different from those of motivation. Instructional design normally focuses on learning and assumes that good-quality instruction alone is motivating[9].

Instead, we should develop didactic methods and tools to provide an organized set of means and a shell system to be used by instructors and students to create a rich learning environment that allows the methodological change needed to allow users to become immersed in an educational activity, and to find the experience so challenging that they would do it for just for the sake of the challenge. Accordingly, we have selected Hypermedia-Multimedia systems as they are related to constructivist learning theories and the cognitive principles supporting them in a way that supposes the following:

1. The structural and functional characteristics of hypertext-hypermedia copy the structure and function of the human mind[10].
2. The use of the hypertext-hypermedia fit the instructional principles of the constructivist learning and the self-learning[11].
3. The hypertext-hypermedia fit the cognitive principles of the multiple modes for mental representation of knowledge[12].

In fact, there is a considerable compatibility between the multimedia materials developed according to certain design principles and the basically constructivist learning scheme, even though it is difficult to accept that only one methodology can fit all types of learning: There are sets of procedure-type skills belonging to different teaching concepts with which instructivist principles sometime fit quite well.

The latter is considered one aspect of the general process in the development of meaningful learning[13].

To create a wholly computerized courseware, the main goals of the project were:

- Development of an Author-Manager Hypermedia System, for very simple operations that organize the use of the different elements (materials, tools, etc.,) for any subject matter in a teaching-learning, open (and interactive) environment, characterized by a wide variety of instructional strategies.
- Development of a didactic methodology based on the relationships of the concepts and the duality lessons-concepts.
- Application of the system to Eng. Thermodynamics by developing some specific elements:
    - Expositive presentation of concepts (Unimedia materials)
    - Multimedia materials for self-learning
    - Problem solving tutorials
    - Specific courseware tools
    - Simulations programs

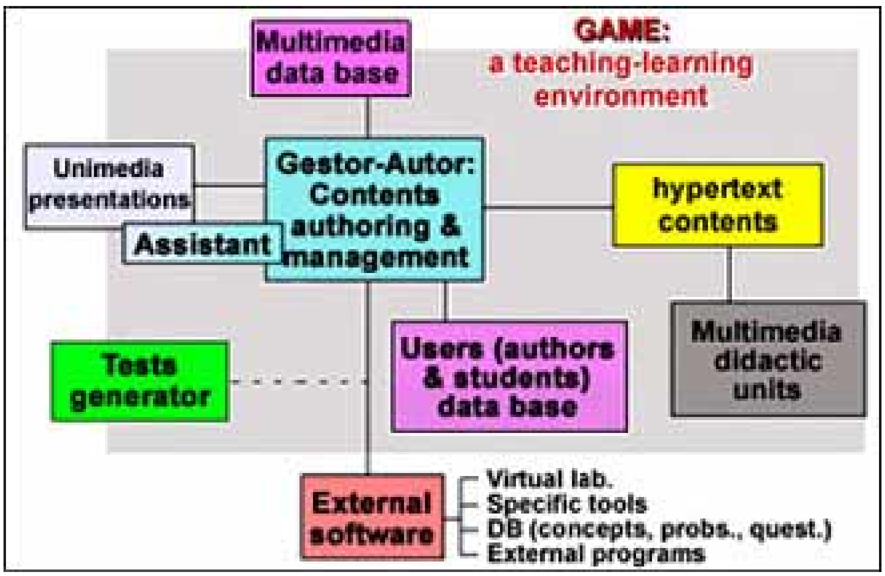

Figure 1. Architecture model of GAME.

II. GAME as an open environment.

a) The characteristics of the GAME environment are the following:

- An open architecture compatible with other resources.
- An authoring tool objet oriented for producing courseware materials.
- Interoperativity with other systems.
- Easy to use.
- Flexibility for being adaptive and modified at any moment of the course.

- A system that is user focused (in this case, instructor and student).
- A facility for implementing any external development.
- The possibility of gradual improvement by adding modifications "custom made" in the construction of the GAME environment materials.
- The software development should take into account the need for collaborative work.
- A highly intuitive, general interface design, and simple operation for user and author.

Basically, GAME consists of a shell, ***Gestor*** (the manager), and an additional set of auxiliary elements working together that define what it is called a teaching and/or learning environment depending on their function as shown in fig.1.

b) Elements of the teaching and learning environment.

1) Learning environment.

   Gestor includes the following elements available to the user.

   Hypertext: the central element, presented through the hypertext main screen. It is formed by the subject lessons as an electronic book, but with a much higher potential because of the connection system that is capable of connecting any text zone with the available elements, materials and tools relevant to the concepts under study.

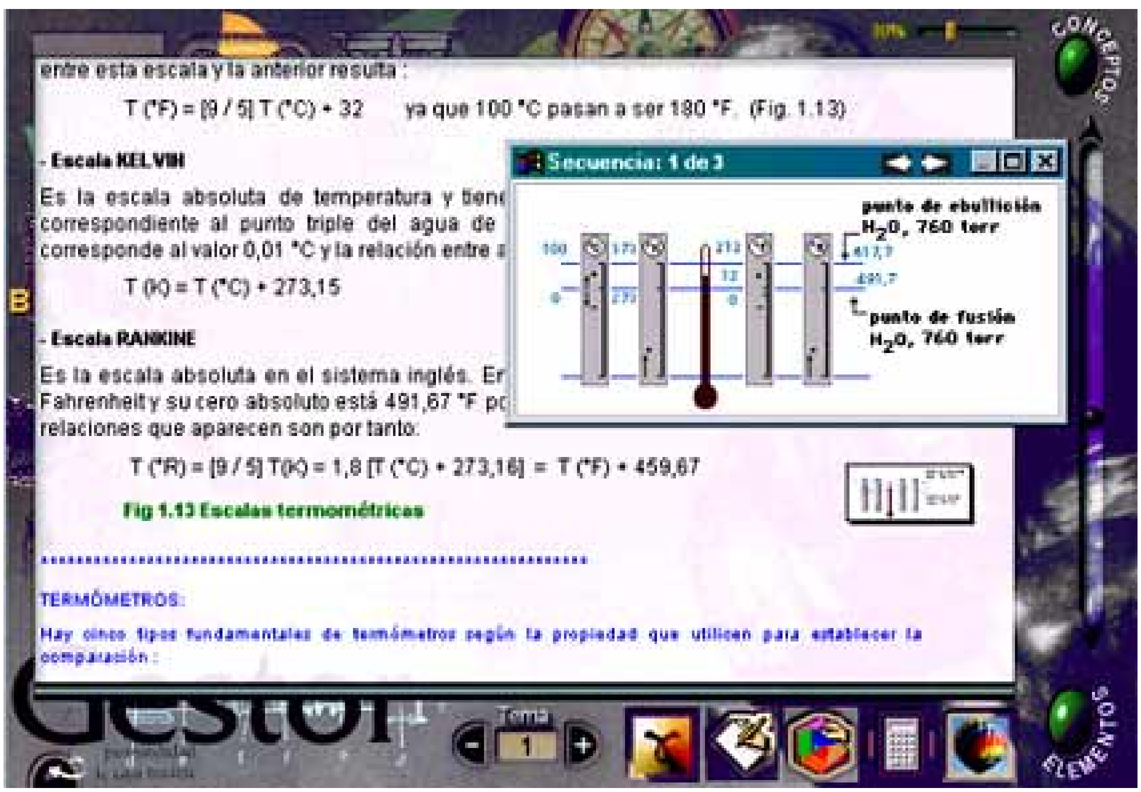

Figure 2. Hypertext main screen of GAME.

- **Glossary**: a list of concepts including 1) a selective search system, which is defined by the instructor depending on his/her didactic criteria to prevent students from becoming lost or disoriented in the hypertext space, and 2) a first level of links, or an elementary level, aimed at novice students who are working on the subject matter for the first time.

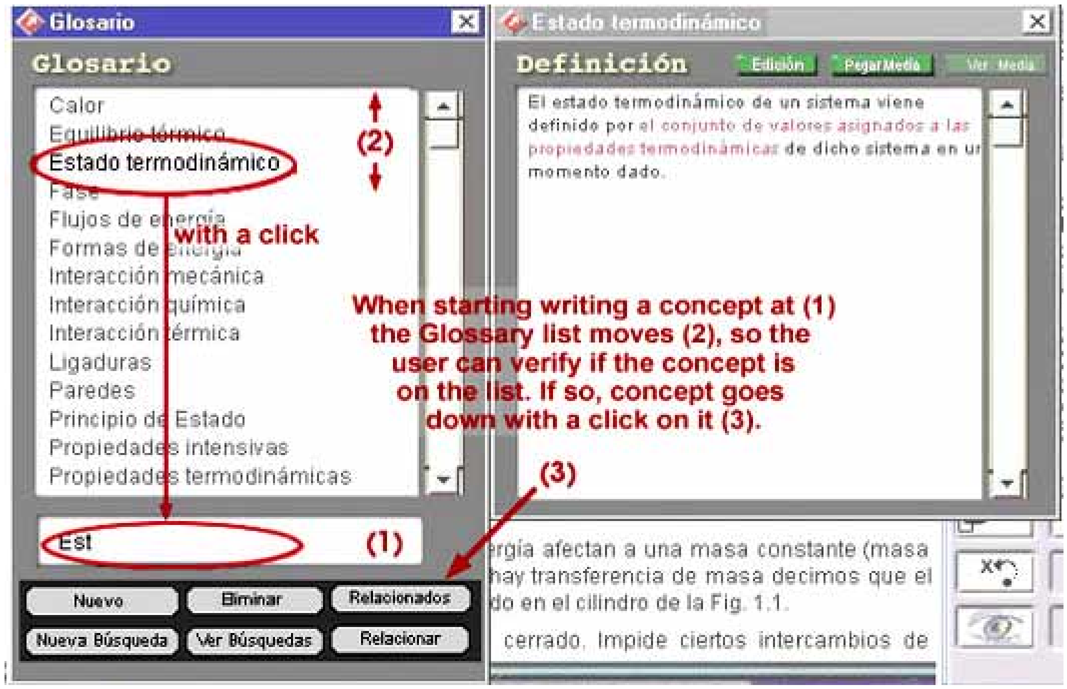

Figure 3. Glossary screen and seeking system.

- **Auxiliary Materials**
  - ***Integrated Materials***: those that have an algorithmic character, such as problems or questions, which are loaded into the program by means of an engine, developed by the authoring tool that governs the whole system. This is to speed the procedure of loading, so that they are implemented into the general structure.
  - ***External Materials***: those that retain their independent structure, such as multimedia units, lab simulations, tools, etc, so that *Gestor* performs merely as a resource launcher.

- **Screen of concepts and relations:** a tool that allows the establishment of relations and links for the concepts, with other related concepts and with elements or auxiliary materials such as exercises, questions, exams, etc. Links are broader in this case, aimed at students who are better familiar with the subject matter. These students will not get disoriented with such information. On the contrary, this tool will help them to carry out a much more dynamic and structured type of study or review, in a constructivist way, as well as to find the hierarchies underlining those concepts to elaborate the corresponding conceptual maps. The latter will help the students complete their own knowledge structure through those external interactions.

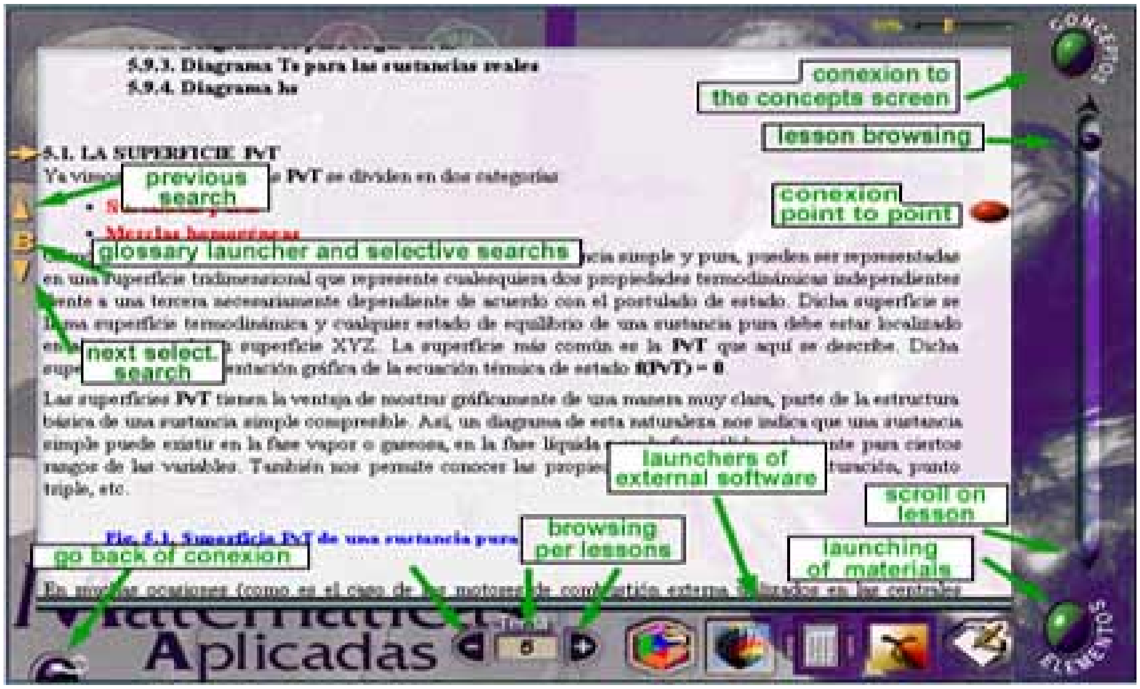

Figure 4. Main screen showing different possible access to connected elements.

Figure 5. Screen with the concepts-elements relations of GAME.

Student access to the system is through the User's mode, to work with it in a self-learning mode. Its high pedagogical potential is based on the duality lessons-concepts to present the contents, and on the connections structure for all the available elements noted above, which allows a different approach depending on the student's capabilities regarding the subject matter, i.e. whether or not it is his/her first time faced with the material (novice or expert students). They may study it in a conventional way, or they may take a much more conceptual approach by using the concepts-elements relations suggested.

2) Teaching environment:

In addition to the Gestor elements described above, the instructor may use the following tools in the Author mode.

- **Data Base:** a means to store and retrieve any materials (drawings, pictures, etc.) to be used in lessons, programs etc.
- **Visor:** a viewfinder to simplify the search for materials stored in Data Base.
- **Assistant:** a tool with its own screen that can be used in two different modes, Author and User. This allows the instructor to prepare and organize, using the tool's palette, the sequences for the Unimedia materials to be used in lessons (Author mode), which will then be readily available for easy use in class (User mode).

Figure 6. Assistant screen and the tools palette.

III. Application to Engineering Thermodynamics

The definition of a computer didactic model for Engineering Thermodynamics includes the use of traditional teaching methods adapted to new technologies by means of a combination of courseware materials, developed according to constructivist principles. Such an approach leads to a wholly computerized, interactive, teaching-learning, open environment. The courseware materials developed to combine with the corresponding methodologies are as follows.

- **Unimedia Materials**: multimedia-type presentations including images, animations, video etc. They are prepared with some presentation tool such or are more elaborate created with an authoring tool such as Director. These software tools are sometimes combined with commercial programs, specific tools for the subject matter, and other resources, to change the traditional lecture of the expositive type (blackboard and chalk) to a much richer one referring to didactic possibilities including student active participation and implication. Programs have been developed for the fifteen main lessons of the subject matter, and for some general solving problem samples as well.

Multimedia Units: intended for student self-learning. They feature corresponding interactivity and correspond to the different themes of the course, or to specific concepts with special cognitive difficulty. More than 300 Mbytes of material have been constructed covering most of the concepts.

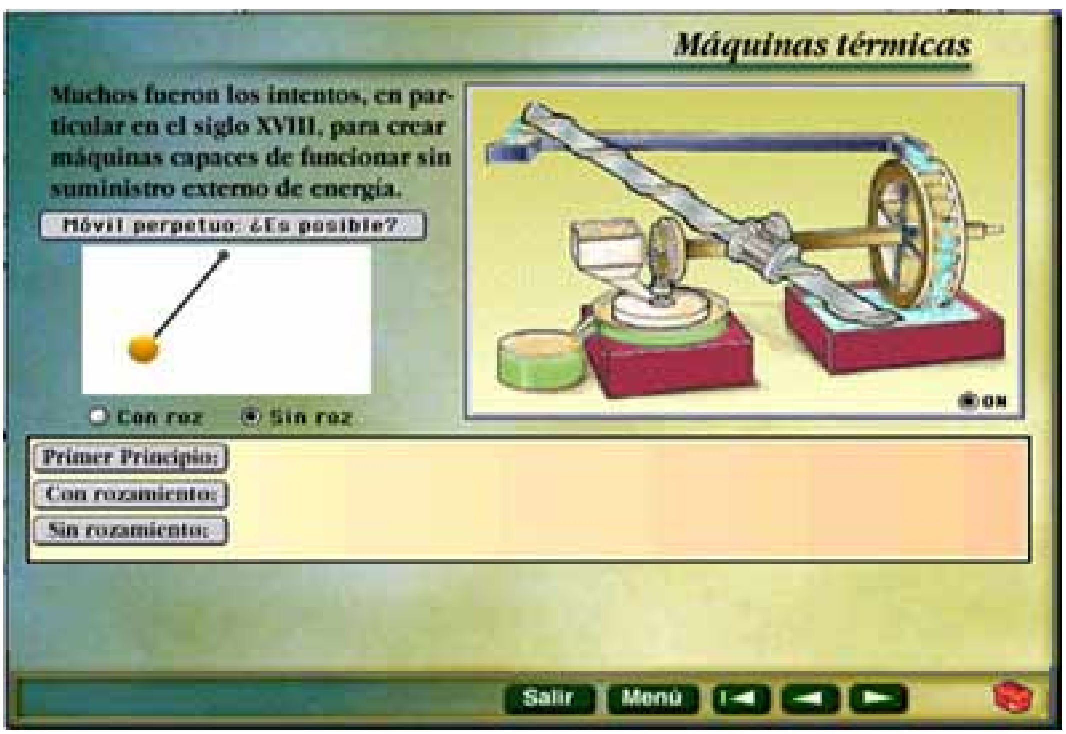

Fig.7. - Multimedia material for self-learning with GAME

- **Specific tools:** three purpose-specific didactic programs that have been developed for the subject matter.

  - **Thermograph:** a very helpful and easy-to-use program, developed with JAVA, especially appropriate for the applied study of most of the main concepts relevant to Engineering Thermodynamics (transversal concepts) using graphical analysis, which is a very important aspect of this subject matter[14].
  - **ARIES:** a JAVA program that allows the resolution of problems referred to thermal installations.

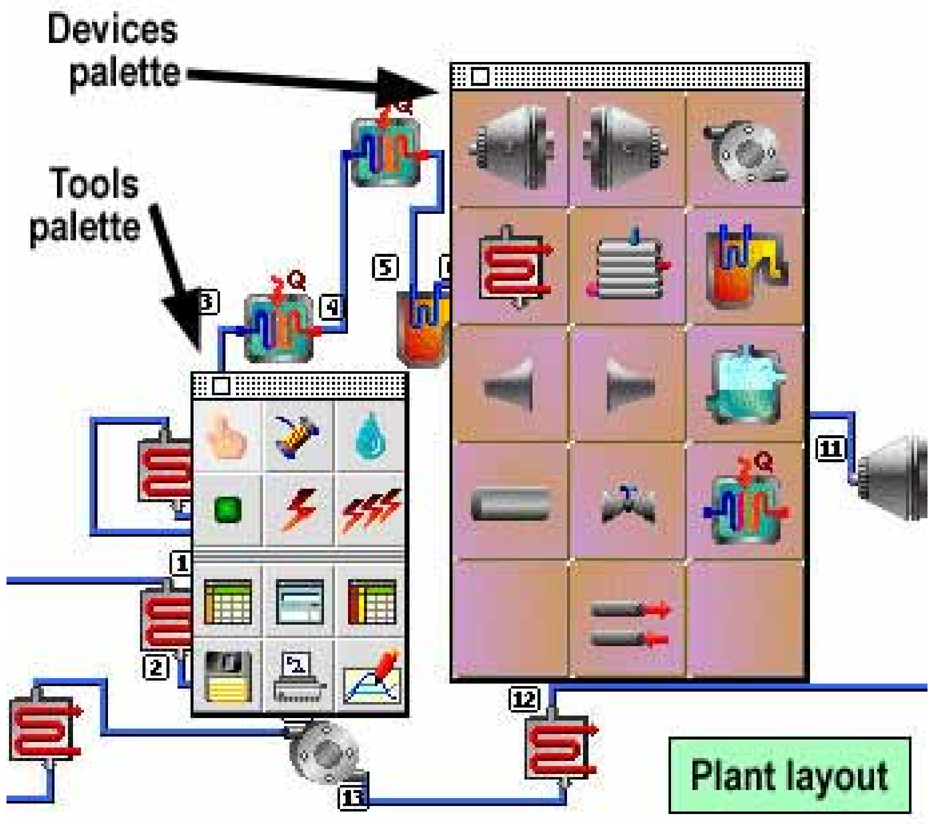

Fig. 8. - Aries screen with some of the components to work with.

  - **PropSust:** developed with C++. PropSust specifically calculates thermodynamics properties, including a graphical analysis, and likewise it can be used for the resolution of general thermodynamics problems.

- **Simulation programs:** programs for virtual laboratory practices consisting of a set of five simulation programs to work with those concepts that are not encountered in theoretical lectures, or those of special difficulty or with no corresponding experimental equipment available. The latter situations include the analysis of errors, comparison of calculation models for thermodynamics properties, irreversibility, entropy change processes, etc

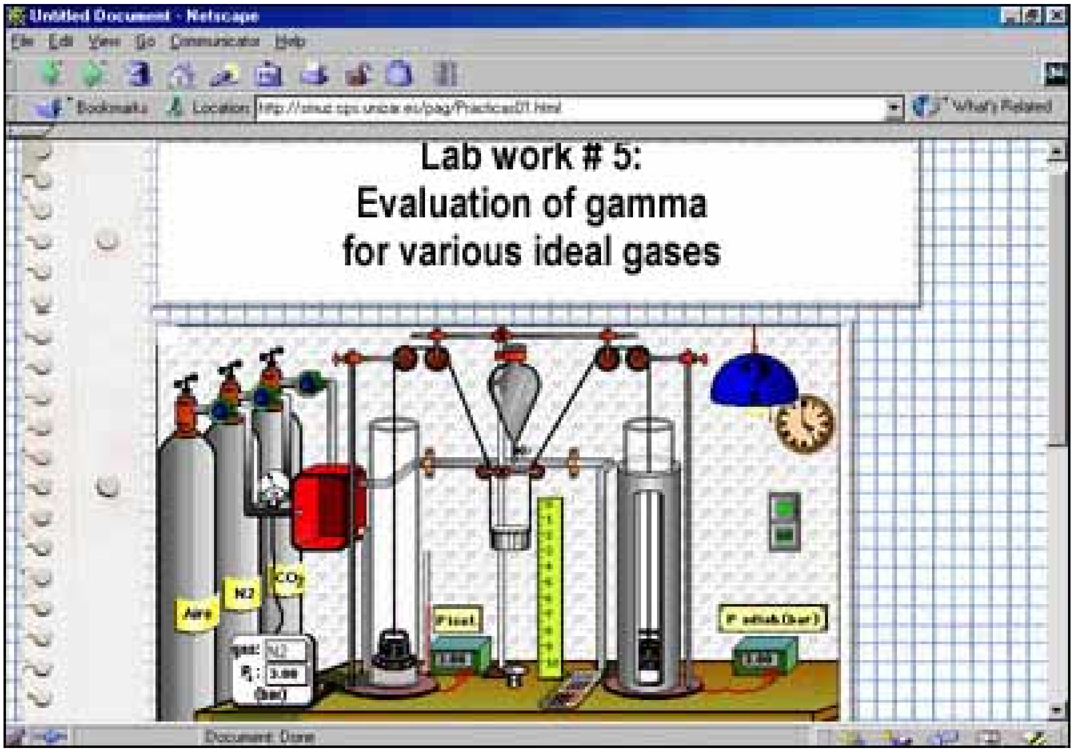

Fig. 9. - Simulation lab screen in a Web configuration

- **Hipertextual content of the subject matter:** material that corresponds to the electronic book included in *Gestor*, derived from the basic textbook of the subject. It constitutes the basis for the functioning of the entire self-learning package, and supports the connections system. The final process of implementing the **auxiliary materials** (problems, questions, exams, simulations, etc.) is partially done for a number of lessons, and is being completed at this moment.

- **Collaborative work:** a set of materials related to real thermal installations (power plants, cogeneration, refrigeration plants, etc.) that are available from the web. Students can select one of the installations and get the corresponding material to work with it in small groups, to solve the problem progressively, as the course proceeds, the questions posed corresponding to the concepts being studied in class.

  This type of methodology is meant to reinforce the level of student motivation, as they have to work with real data and apply what they are studying to a real installation. In addition, working on a peer basis raises the level of discussions, which is the best way to get a meaningful learning.

- **Evaluation:** the programs were developed to allow the student self-evaluation. Besides, the instructor to revise the student progress can use them. This applies specifically to multimedia material where a test creator was made to construct different types of tests.

IV. Conclusions

In the traditional methodology the student has little chance for developing a conceptual map of the whole matter, so the difficulty of gaining a 'global perspective' of the matter which is essential for its understanding, is obvious.

Hypermedia and multimedia systems present advantages and disadvantages for students and instructors. Theoretical arguments contend that hypertext is a system, which offers an absence of direction, allowing its users to compile their own experience of the contents as a whole. However, it is also true that viewing the text with a computer is limited to the current screen, and preceding or earlier passages are obscured. Scrolling back and forth to locate an earlier sentence or paragraph creates for many people a form of cognitive motion sickness[15].

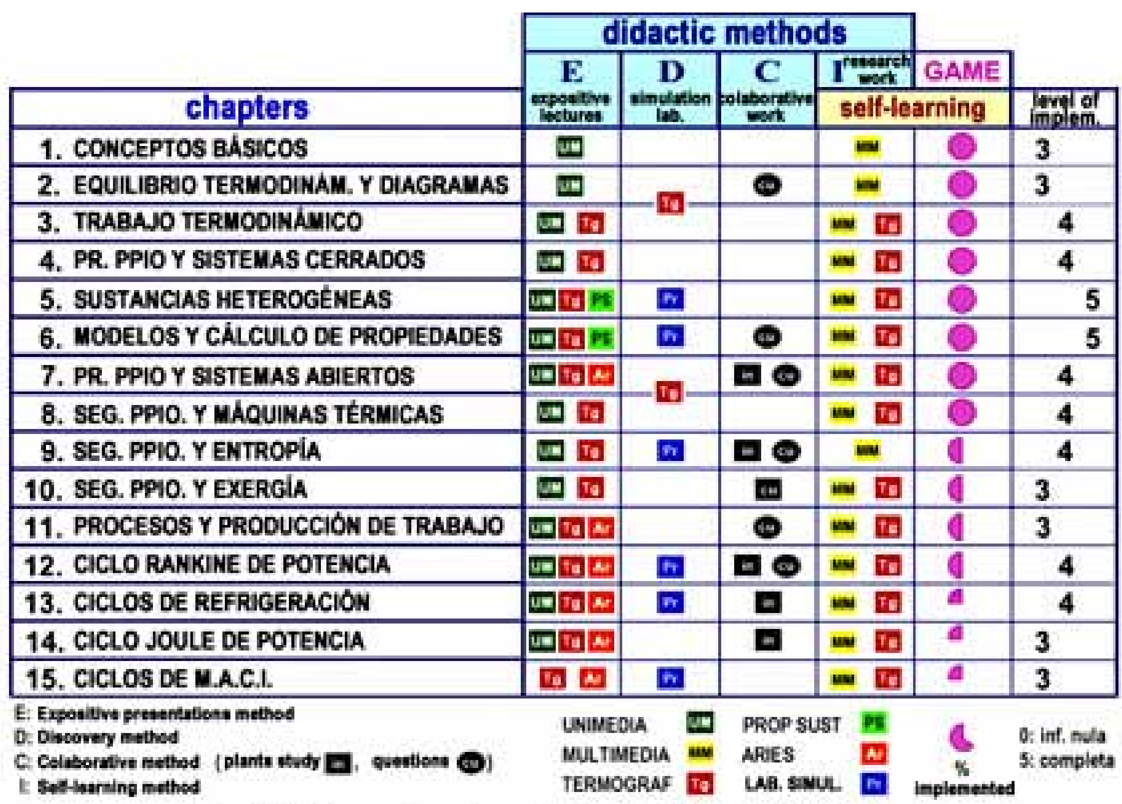

Fig. 10.- Types of implemented materials and distribution

In addition, navigational and information retrieval difficulties deal with the fact that in general, the student must decide on where to go next within an information structure without having a clear a priori target in mind.

We think that an organization as that of GAME environment can reduce significantly most of these limitations, improving lecture class and self-learning work with a clear optimization on the spent time. The courseware that we have designed and built with GAME, includes a complete multimedia course with about 300 Mbytes of Director files concerning different Thermodynamic topics, an hypermedia system which assist the cognitive mapping of concepts to proceed in non-linear fashion, a set of simulation programs for virtual laboratory work and three specific tools: Thermograph, that allows the analysis of Thermodynamics concepts by drawing processes or cycles and editing them on the screen, and ARIES and PropSust for the resolution of problems. Figure 10 shows the reached level of development for the different type of materials and the way they are been used combined with the different methodologies along the course.

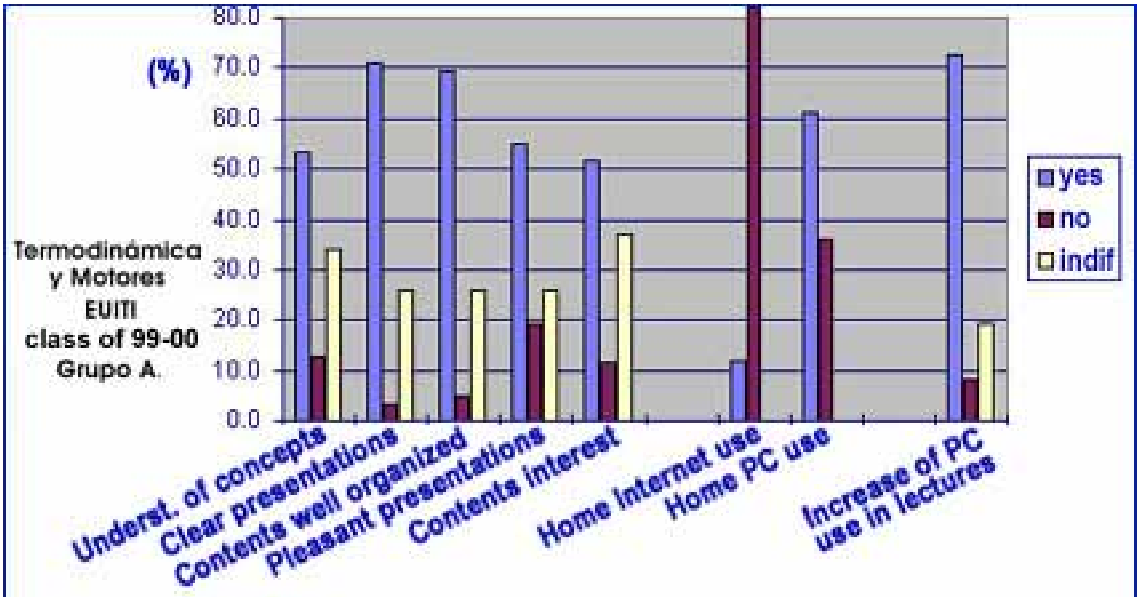

Fig. 11.- The Unimedia class compared with the traditional lecture class

Most of the materials have been ready to be used by the students very recently. As GAME facilitates de design and realization of experiences in order to study the effectiveness of the materials working with the whole system, further research will be conducted in order to optimize their use.

A qualitative evaluation of the of developed Unimedia materials effectiveness used for the expositive class has been carried out among the students during the years 98-99 and 99-00. Figure 11 shows a partial result of the student's opinion related to its comparison versus traditional lectures. The graph reveals a clear difference in the student's perception of their quality and their preferences.

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