A three-dimensional map to help exploration and understanding of a building

Visibility of the process of knowledge construction through traces

Sandro Varano[1], J.C. Bignon[2] and G. Halin[2]
MAP CRAI UMR n°694/CNRS/CULTURE
[1]*Ecole Nationale Supérieure d'Architecture de Strasbourg*
8, Boulevard du Président Wilson
67000 Strasbourg
France
varano@crai.archi.fr
[2] *Ecole Nationale Supérieure d'Architecture de Nancy*
2, rue Bastien Lepage
BP 40435
54001 Nancy
France
bignon@crai.archi.fr ; halin@crai.map.archi.fr

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Abstract: Through the use of existing digital tools, the research work consists of proposing a new 3D navigation mode based on systemic, practical and graphic assumptions.
During the exploration of the Vianden Castle, we outline a graphic representation system as an aid to representation and memorization of archaeological and architectural knowledge.
For this, we recompose some concepts related to video games, we materialize the "mental map" described by Patricia Marks Greenfield and we take into account the cognitive capacities of the learner.

1. INTRODUCTION

The virtual reconstruction of heritage monuments is an emergent task in the archaeological and architectural framework. Several stages characterize this reconstruction: on the one hand, we find and retain a form that can be

exploited scientifically (acquisition of data, three-dimensional modelling and virtual images), while on the other hand, we recreate a world to communicate with the public. Visualization and transmission of the information represent the last stage in the restitution of the heritage.

To conceive an efficient learning system able to improve the acquirement of knowledge, we have defined side-objectives, such as MOTIVATING – REPRESENTING – MEMORIZING. The focus here is to help the learner by encouraging his/her visualization and representation of information and increasing its memorization.

Since the beginning of the first electronic games, numerous studies have been made in relation to their impact on the player's psyche. Some theorists consider video games as an instrument liberating the mind and facilitating imagination and creation.

According to Jacques Perriault, games are really instructive: they teach discovering game rules. This involves a learning process (Perriault, 1998).

The aim of the article is firstly to give an account of certain multimedia works relating to the communication of cultural heritage. From an experimental point of view, we suggest investigating the characteristics of video games to identify those which may be used for the conception of an instructive and communicative system. In this way, the experiments conducted by Patricia Marks Greenfield and Jacques Perriault to put together computers and learning, are an original contribution to which we will refer to develop our proposal. The reconstruction project for the Vianden Castle (Luxembourg), having a pedagogical aim, is a support to this work.

2. NAVIGATION SYSTEMS FOR ARCHAEOLOGY OR ARCHITECTURE

2.1 Navigating in information

Navigation systems on Internet or on CD-ROM generally propose hypertext to visit different themes. Exploration between various documents is possible through dynamic links, defining interactivity of multimedia.

The work of reconstruction, *Paris, a Roman city*[1] is one example illustrating the plurality of access to the same information. The user can choose a word or an image (2D or 3D) to access similar data, because different signs can have the same meaning. The CD-ROM *Paths of Opera*[2]

[1] *Paris, a Roman city*. Url: http://www.paris.culture.fr/en/
[2] *Parcours d'Opéra*. Url: http://www.aria.archi.fr/Opera/index.html

improves the notion of interactivity with interactive filmed paths or rotations of 3D objects by successive clicks, respecting the pace of the user.

We begin to take into consideration the educational profile of the learner. The principle of the hypertext is advantageous, insofar as it provides a multitude of paths. But the risk for the user is getting lost.

All the stylistic devices activating the screen display incite the user to move the mouse to find sensitive areas. Then, successive clicks determine a path branching out into several others. The path depends on the choices of the user, but also on the interface. If no mechanism provides a general view of the constructed path, the user will attempt by himself this operation, which might require a considerable mental effort. "In front of a learning software, the user has the difficult task of gathering information and transforming it into knowledge. If he has to spend a great part of his cognitive energy accessing the contents of the product, it is as if he needed to turn pages of a book each weighing several kilos[3]" (Kellner, 2007).

To avoid a "cognitive overload" (Jacquinot, 1996), a real system of knowledge transmission and acquisition must be able to help the learner in his task, by first facilitating access to the information and secondly by acquiring it. The example of the CD-ROM *Fortified Castles*[4], designed in 1999 by Nicolas Faucherre, was already a good reference: a "multimedia notebook" helped the learner in his movements, with the possibility of coming back or annotating personal remarks.

Hypertext encourages us to think about the organization of the information, because it's on that that depends the coherency of the path created by the learner.

2.2 Presentation modalities of information

The various modalities of presentation allowed by the multimedia can consider information of different kinds. The experiments conducted by Jean-Michel Boucheix demonstrated the benefits of multimodality: "The results of this work with professionals who are moderately literate show the advantage of new technologies, provided that the cognitive abilities of learners are respected. […] The multimodality (oral, sounds, images, animations) can reduce the cognitive load related to the treatment of writing

[3] "Face à un logiciel d'apprentissage, l'utilisateur a la lourde tâche d'accéder à de l'information et de la transformer en savoir. S'il doit dépenser une grande partie de son énergie cognitive à accéder au contenu même du produit, c'est comme s'il devait tourner des pages d'un livre pesant chacune plusieurs kilos".

[4] *Les Châteaux Forts*, by Faucherre Nicolas, Syrinx, 1999.

during understanding, and can aid the construction of dynamic cognitive representations[5]" (Boucheix, 2001).

In a specialized domain such as archaeology and architecture, plans, excavation profiles, sections, elevations, perspectives, maps, etc, are used in abundance and easily decipherable by specialists. The virtual visit in the *Janus's Temple to Autun*[6], gives us access, during real-time movement, to the various documents. These drawings show the objects in terms of their functions and not from the standpoint of perception. Most of the web sites and CD-ROMs use the superposition and break down principle, by varying transparency, lines, colours, and by adding sounds. The danger for the user is to have to manage too much information, thus causing once again a "cognitive overload" (Jacquinot, 1996).

What is important in our relation with information is the perceived message. Serge Tisseron sees the image as a territory to explore, where the learner attempts to find meaning: "we must thus be in the image and transform it into meanings territory[7]" (Tisseron, 1997).

3. VIDEO GAMES AS LEARNING SYSTEM

Since the 1980's, researchers have attempted to analyze the relationship between video games and education, while questioning the knowledge they transmit in an informal and unconscious way.

Among them, Patricia Marks Greenfield wonders what the effects are that video games have on the way of thinking and perceiving things. In this sense, video games would shape the cognitive process, which has a universal aspect, arriving at the expression "cognitive socialization" (Greenfield, 1987). Apart from the fact that they encourage the command of complex systems and develop research skills through induction, video games strengthen the capacity to interpret flat and static images in three dimensions, as well as improve the necessary abilities to transform, manipulate and mentally connect dynamic and changing images. The mechanism consisting of mentally connecting successive different screens enables Patricia Marks Greenfield to introduce the notion of the "mental map" (Greenfield, 1994) of the player. This ability is reinforced by

[5] "Les résultats de ce travail auprès de professionnels faiblement lettrés attestent de l'intérêt des nouvelles technologies, à certaines conditions, qui tiennent compte des contraintes cognitives des apprenants. […] La multimodalité (oral, sons, images, animations) peut alléger la charge cognitive liée au traitement de l'écrit pendant la compréhension, et favoriser la construction de représentations cognitive dynamiques".

[6] *Le Temple de Janus à Autun*. Url: http://www.temple-de-janus.net

[7] "Il faut donc entrer dans l'image et la transformer pour pouvoir la constituer progressivement en territoire de signification".

television and cinema that do not show the entire space at once, but bits at a time. The user then makes a spatial assembly that consists of mentally gathering all the bits to rebuild space.

Jacques Perriault is also interested in knowledge acquisition and construction by computerized games. His observations partly concern, acquired or reinforced skills. Concerning space representation, three skills were studied: spatial perception – mental rotation - spatial visualization. Concerning iconic representation, playing improves control of an iconic code. It is important for him to locate these ludic practices compared to the constructivist hypothesis: active knowledge is only created by the person himself (Perriault, 1994).

4. PROPOSAL HYPOTHESIS

Based on the idea that video games are intrinsically educational, several sub-hypotheses can be formulated.

4.1 Exploring in real time

Assisting in acquiring of knowledge is undertaken using spatio-temporal paths (to move freely in a virtual environment, inspect, choose, act, return, etc) of a strategic nature. The establishment of a narrative context leads the learner to a total and intuitive understanding of the Vianden Castle.

We can add a number of particularities concerning the motivation of the user: giving him a desire to explore a world, finding clues, meeting obstacles, and following rules. It's the principle of exploration games, where the player discovers the story by solving riddles. Vincent Mespoulet and Anne Scholaert show the educational value of the CD-ROM *Crusader: Adventure Out of Time*[8], by combining plot and historical content and by placing the clue in the heuristic process (Mespoulet and Scholaert, 1999).

Christian Vandendorpe notices similarities in the cognitive mechanisms while reading a story or playing a video game: "it seems that *Riven*[9] can be considered as a pseudo-text, because its reading requires activities of concatenation, recall and selection. This reading uses skills of observation, deduction, abduction and problem-solving [...] The word "reading" is used

[8] *Crusader: Adventure Out of Time*, Wanadoo Edition, 1999.
[9] *Riven: The Sequel to Myst*, Cyan Worlds Inc, Broderbund Inc, 1997.

here in the sense of connecting data collected by sight and submitting them to interpretation[10]" (Vandendorpe, 1998).

If we consider the Vianden Castle as a pseudo-text, we can then interpret the three kinds of cognitive operations:

- Concatenation, the operation of sequencing of spaces,
- Recall, linking the signs and clues,
- Selection, where the solving of the riddle involves a synthesis in the reading.

4.2 Materializing the learner's mental map

We refer to the notion of "mental map" described above, while reinterpreting it. Our approach consists of materialising these maps by using several ludic mechanisms.

The learner materialize an idea or a mental image during the exploration: this is a screenshot projecting a particular point of view. It becomes presentation and representation support of the information (drawings, text, images, sounds, etc) rendering perceptible a passage point of the path.

The learner's mental map is formed by successive additions of the mental images materialized during the exploration.

This becomes a real three-dimensional map encouraging the user to adopt a ludic attitude:

- The map is used as a guidance and locating tool,
- it allows the user to represent and organize ideas,
- it assist the memorization process of knowledge.

Such materialization thus maintains a process of knowledge construction resembling a creative activity.

4.3 Visibility of the process of knowledge construction through traces

We have seen that the understanding of the castle involves two parallel activities: a reading activity during the exploration and a creative activity during the construction of the three-dimensional map.

Throughout the creation of this map, the learner outlines his path. For that, he must be able to detect relevant elements in the castle, and use a three-dimensional map to make useful conclusions and debrief his path and

[10] "Il apparaît que *Riven* peut être considéré comme un pseudo-texte, car sa lecture exige des activités de concaténation, de rappel et de sélection. Sur un plan transversal, cette lecture met plus précisément en jeu des habilités d'observation, de déduction, d'abduction et de résolution de problème. […] Le mot « lecture » est ici employé au sens de mise en relation de données recueillies par la vue et soumises à interprétation".

his deductions: locate, sketch, formulate a hypothesis, give prominence to points of view, correct, etc.

During “concatenation” and “recall”, visual or sonorous information is reproduced on bi-dimensional pages. 3D connections are possible on pages or between them. The 3D links can report waypoints in the castle for example, or link clues. During “selection”, the learner identifies the various elements that could solve the riddle. The map is under the visual control of the user, and can be appropriated according to his pace and his own interests.

Sensitive areas allow round trips between the three-dimensional map and the Vianden Castle. A rapid movement system is thus established to come back to the path. This feedback system allows him the revision or the correction of information. The learner has several points of view: internal focus (subjective view during the exploration of the castle), zero focus (during the reading or creation of the map).

4.4 Example with the Vianden Castle

The Vianden Castle was constructed between the 11th and 14th centuries on the foundations of a Roman “castellum” and a Carolingian refuge. It is one of the largest feudal residences of the romanesque and gothic periods in Europe.

Several aspects of the Vianden Castle are considered for its restitution (temporal, spatial, object, character, etc). Each aspect corresponds to a level (Figure 1). Each level has several entry points to begin a quest. The quests offer various riddles to be solved (R1.1: riddle 1 of quest 1, R1.2: riddle 2 of quest 1, etc) and the learner chooses the order of the clues.

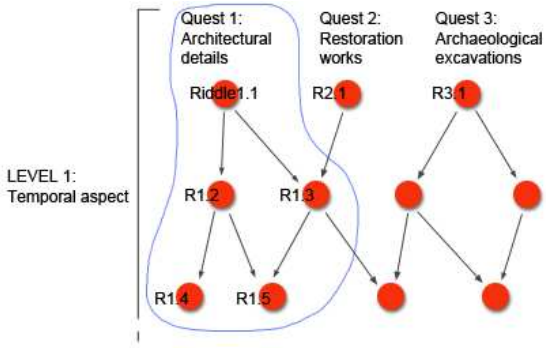

Figure 1. Principle of the hierarchy of level-quest-riddle

For this example, we illustrate briefly riddle 1 of quest 1 (architectural details) in level 1 (temporal aspect).

One of the particularities of the castle concerning its evolution is on the surface and in the walls. Indeed, the walls have a number of visible clues which sometimes appear as insignificant details. These details can be clues to determine the various architectural styles through periods.

We can define riddle R1.1 in this way:

- To identify the periods through the walls between the Large Palace and the Chapel.

4.4.1 Operations based on "concatenation"

An initial task of location is necessary: five screenshots allow the location of spaces between the Large Palace and the Chapel (Figure 2):

- The Arms Hall
- The Knight's study
- The Byzantine Gallery

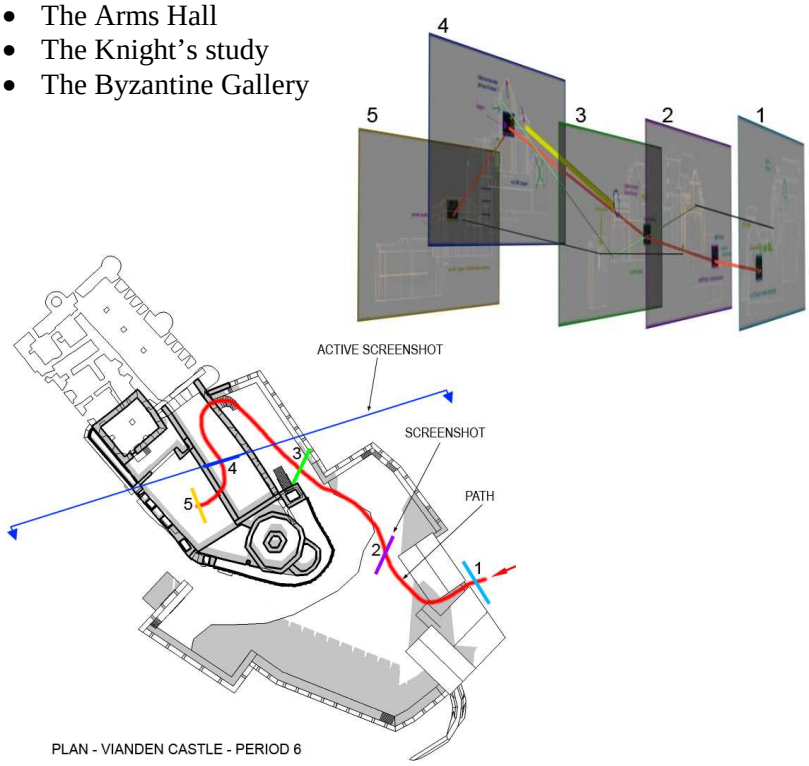

Figure 2. The path and the screenshot-assembling to create a 3D map

During the real time movement, various documents are displayed (by clicking on sensitive areas) and stored on screenshots.

4.4.2 Operations based on “recall”

The previous information is combined with the subsequent clues from the outside and inside walls. The screenshot number 4 gathers and connects multimodal information, found in the database or on Internet (Figure 3).

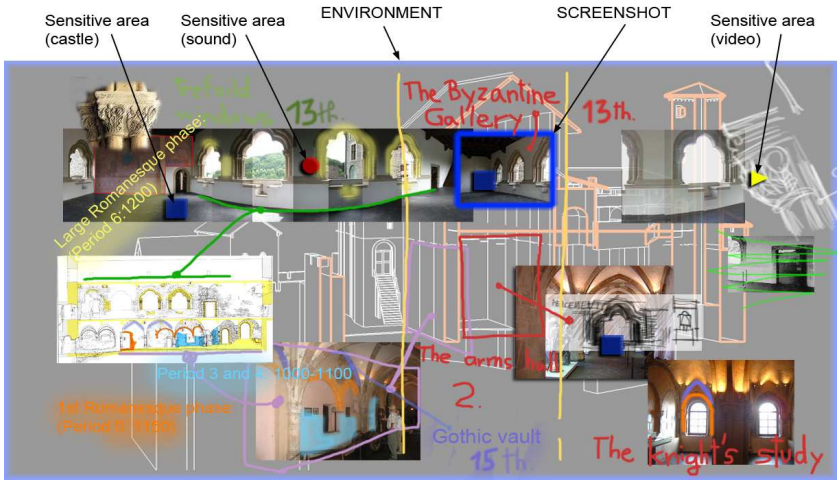

Figure 3. Screenshot number 4

The links between pages 3 and 4 establish the guidelines of the research work of the learner. The free play of associations by similarity allows the formulation of the metaphor and interpretation (Figure 4).

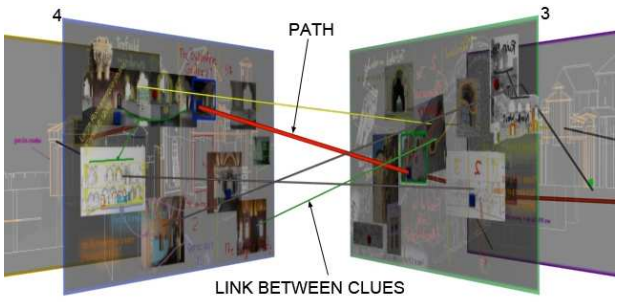

Figure 4. Links between screenshot 3 and 4

4.4.3 Operations based on “selection”

The learner updates his path through the reading of the 3D map. He identifies and tries to understand the links. The theory established leads to the solving of the riddle. The different periods are identified on the walls between the Large Palace and the Chapel:

- Period 4 (approximately 1100)
- Period 5 (first Romanesque phase, 1150)
- Period 6 (the Large Romanesque phase, 1200)
- Period 7 (the Gothic phase, 1250)
- Restoration works (approximately 1900)

The three-dimensional map preserves the traces and the risks of the path. The learner can begin a new quest or a new map.

5. CONCLUSION AND FUTURWORK

In trying to restore archaeological and architectural heritage, we have presented a graphic representation system as an aid to memorization.

We were interested in the cognitive aspects which are implemented in the exploration of a building and in the generation of traces. The dynamic aspect of the process of knowledge construction is represented by a three-dimensional map preserving the learner’s path in the Vianden Castle.

The map becomes a travel journal, identical to the stories illustrated in the travels of explorers, themselves in the pursuit of knowledge. The map is not the exact image of the castle, but rather the learner’s representation or perception. The important thing for the user and for his individual fantasy, is to make sense of what he perceives.

It would be interesting, on the one hand, to specify a model by defining the properties of information (as knot) and links (as arcs), on the other hand, to define an experimental protocol in order to know if this map really participates in knowledge memorization.

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