VISUAL MAPPING: A TOOL FOR DESIGN, DEVELOPMENT AND COMMUNICATION IN THE DEVELOPMENT OF IT-RICH LEARNING ENVIRONMENTS

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Abstract

Visual representations have long been advocated by educators as cognitive tools to enhance student learning. However, visual mapping of concepts and ideas are also part of the design and development tools of graphic and interface designers (drawings and sketches), media producers (story boards), and programmers (flow charts). In higher education settings, the use of visual representations that show the key conceptual relationships and patterns in a content domain have the potential to become used as cognitive tools to facilitate educational decision-making about the choice of appropriate technologies to support student learning.

In this paper, examples of visual representations, including concept mapping and graphical representations, which have been used successfully in the development of coherent educational environments will be discussed. The focus is the use of visual mapping as a cognitive tool to facilitate communication and understanding between the academically diverse members of the team who develop complex educational environments that incorporate interactive multimedia (IMM), and information and communication technologies (ICTs). This approach recognises the prior knowledge and visual skills that many IMM and ICT developers possess.

Keywords

visual representations, ICT development, interactive multimedia, teams

Introduction

The development of academic courses that incorporate both interactive multimedia (IMM), and Information and Communication Technologies (ICTs) is almost mandatory in some sectors of higher education. Where once the use of such technologies in academia was seen as being more useful for distance education or off-campus programs (particularly computer-mediated communication), these tools are becoming part of the day to day tertiary experience for all students. The incorporation of IMM & ICTs has become a point of institutional focus since these technologies now occupy core components of the educational experience of many students (Kennedy, Webster, Benson, James, & Bailey, 2002).

Developing modern learning environments that utilise IMM & ICTs is a complex task that (ideally) requires a team of people with a range of skills. Typically, a team may comprise a subject matter expert (SME), graphic designer, interface designer, and programmer. There are two other key team members. The first is the educational designer, who has the task of integrating the student learning outcomes articulated by the SME with the use of appropriate technologies, and the second is a project manager to coordinate resources, budgets and time lines for the development process. Each member of the project team brings skills and professional knowledge to the group. However, individual skills alone are not sufficient to create a well designed and implemented technology-supported learning environment. There needs to be a coherence of understanding shared by all team members about the design and development model used, as well as an understanding of the underlying conceptual structure of the content developed by the educational designer and the subject matter expert (SME). All projects involve decisions catalysed by budget and time constraints. A shared understanding of the key educational intentions will alleviate conflict in the design and development phases of a project.

Concept Mapping as One Form of Visual Mapping

Concept mapping has a long history of use in education contexts, but has focused primarily on aspects of student learning. For example, as an instructional tool to improve students' achievement (Horton et al., 1993); addressing students' misconceptions in chemistry (Cullen, 1990); improving students' achievement in biology (Jegede, Alaiyemola, & Okebukola, 1990); the elucidation of students' prior knowledge in the design of hypermedia (Kennedy, 1995), and the design of computer-based cognitive or learning tools (Kennedy, 2001). It is only in the last example where the tool has been used specifically as a design and development tool. Concept mapping is one visual mapping technique that may be used as a cognitive tool in the design and development phases. Concept mapping has the potential to support communication in teams, by helping achieve a congruence of understanding amongst team members of both the conceptual needs of the content domain, and issues of design of IMM & ICT resources that impact on student learning.

Figure 1 illustrates how concept mapping may be used to show key relationships between knowledge, knowledge construction, concept mapping, IMM & ICTs and student learning outcomes. The IMM & ICTs developed as a result of the framework articulated in Figure 1 support a constructivist view of the student learning environment, one that requires students to actively interact with new material in ways which require reflection (McNaught, 1993). It is no longer sufficient to expect students to attempt to understand an argument or explanation in a detached way. The learning environment should encourage students to articulate their knowledge, and reflect on what they have learned. While visual representations constructed by students are effective tools for evaluating and articulating student understanding (de Vries & Kommers, 1993; Kennedy, 1995; Novak, 1990), students may also use such representations in order to better understand key concepts in a domain. For example, students who used concept maps integrated with traditional distance education print materials and asynchronous computer-mediated communication in a course of study in economics had better assessment results than past students in a similar course of study (Kennedy & Reiman, 2002).

It should be noted that developing IMM & ICTs from a constructivist perspective requires early, ongoing and meaningful evaluation of each iteration of the courseware with students, peers and the development team. Visual mapping and formative evaluation of the design and development phases with students, peers and reflections by members of the IMM & ICT developers will alleviate many potential design problems (Barker & Giller, 2002; Hedberg & Alexander, 1994). The iterative approach to constructing complex ICT environments is valuable because the final form of the materials is often very difficult to specify precisely (Kennedy et al., 2002; Moonen & Schoenmaker, 1992).

Visual Mapping as a Cognitive Tool in IMM/ ICT Use in Education

Visual representations of knowledge have been proposed as having the potential to enhance student learning by providing students with multiple representations of knowledge. For example, Mayer (2001) has shown that the learning of science students is enhanced if text is enhanced with animations, or vice versa, rather than the text or the animation alone, while Moreno (2002) has demonstrated similar outcomes in mathematics when students are able to work with graphics, symbols and verbal guidance. McLoughlin & Krzysztof (2001) adopt the view that visualisation in teaching and learning is important because technology-based visual representations have the potential to foster higher order cognition by supporting reasoning, visual articulation of ideas, and engage the learner in dynamic non-linear modes of thinking.

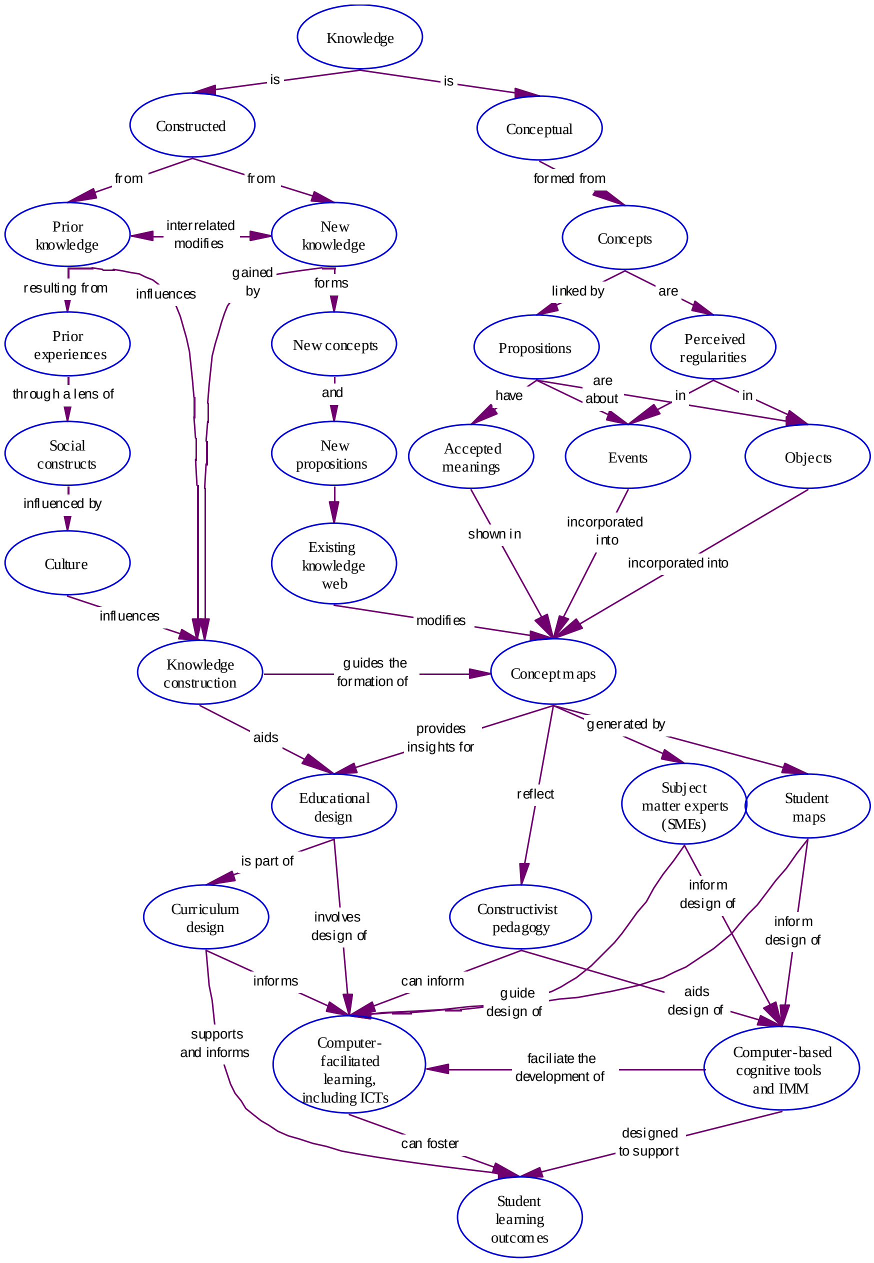

Figure 1: Key relationships between knowledge, knowledge construction, concept mapping and student learning outcomes. (after Kennedy, 2001)

In the two examples provided in this paper, visual mapping is used at a macro level. That is, visual mapping can be a useful tool in the design of curricula and as a focus to aid the decision-making processes in the development phase. The need for all members of the team to have a broad view of the curriculum is essential in IMM & ICT development. The strengths of visual mapping are:

- presenting visual representations of curriculum areas, as an alternative to conventional, more traditional, written course outlines;
- providing a non-linear representation of conceptual knowledge that can incorporate a variety of visual media;
- embedding the pedagogy of learning within the course structure (both implicitly and explicitly);
- linking the student learning outcome statements with the educational framework; and
- facilitating the melding of modes of assessment within the course focus and structure.

Once this broad educational structure has been articulated, there is an additional use to which visual mapping may be put—with other, non-SME members of the development team. The visual maps may also be used to:

- provide academic and non-academic team members with a common design framework that incorporates multiple perspectives;
- explicate the logical connectives between key educational concepts that are to be integrated to form the curriculum;
- show the relationships between IMM and/ or ICTs and key concepts from the content domain; and
- articulate the hierarchical relationships between specific educational needs of the learning environment and the technical implications that arise as a result.

At a micro level visual mapping is also very useful in the design of particular learning activities and tools. These discussions primarily occur between the educational designer and the SME, but on occasion, such discussions also involve other team members (see below). At a micro level, the use of visual mapping can highlight specific student learning needs, including which:

- conceptual areas students had most difficulty with, and
- problem-solving skills they needed to acquire.

The Importance of Communication in Multidisciplinary Teams

Much has already been written about the need to form teams of individuals with a range of skills including educational design, facility and skill with media (video, audio and graphics), graphic/ interface design and programming skills (Canale & Wills, 1993; Hedberg & Harper, 1998; Jones, 1998; Kennedy, 1998; McNaught, Phillips, Rossiter, & Winn, 2000). There is also a potential pedagogical impediment to effective communication and team coherence. The paradigms that people adopt for the development of educational multimedia reflect prior knowledge and experience, the manner in which they were taught, and implicit (or explicit) models of teaching and learning she or he has experienced in their own educational undertakings (Bain & McNaught, 1996). The adage that 'people teach as they were taught' may be extended to 'people design IMM & ICT based upon their experiences (and perceptions) of teaching and learning'.

There is support for different aspects of intelligence that may enhance particular roles in a team, or the careers that individuals may gravitate towards. Gardner (1996) proposed that there were seven separate forms of intelligence, and suggested that learning environments should endeavour to engage the different cognitive styles represented by these intelligences. The seven domains are:

- Linguistic, effective use of language;
- Musical, communicates by written or playing music;
- Logical-mathematical, good pattern recognition, hypothesis testing and solving;
- Spatial, has a strong visual sense of the world, remembers visual details more readily than others;
- Bodily-Kinaesthetic, good hand-eye coordination, skilled user of physical tools;
- Intrapersonal, good metacognitive skills, recognises own motives and emotional perspective; and
- Interpersonal, sensitive to emotional perspectives of others, relates well to others.

In Gardner's view, the graphic and interface designers would have high spatial intelligence, project managers would have high interpersonal intelligence, and programmers would have high logical-mathematical intelligence. Mechanisms to facilitate communication between such diverse professionals are important. An effective team dynamic is fundamental to success in developing learning environments that leverage the full educational potential promised by IMM & ICT, As so many curriculum developments now incorporate IMM & ICT there is a need for all members of the team to have some understanding of the broad educational planning of the course materials. Understanding both the broad educational and technical issues helps facilitate contributions from all team members in the design and development phases, and contributes to delivering IMM and/or ICT-based resources that have the potential to enhance student learning in an acceptable timeframe, and budget. The use of a visual map provides a valuable mechanism to focus discussion.

In software engineering the development of courseware is guided by a number of key stages which attempt to make the software requirements unambiguous, consistent and complete, but in reality most projects do not function in that way (Kennedy, 1998; Pressman, 1997). Each key stage (in some models) is associated with extensive documentation intended to minimise potential errors and maximise quality. Visual mapping limits the text-based documentation by providing an alternative perspective of the content and key student learning needs. The remaining sections of the paper discuss two quite different projects that used visual mapping to improve communication in the development teams. The first is SOLAR, Student Oriented Learning About Radiography, a web-based problem-based learning environment. The second is Anatomedia, a CD-Rom-based anatomy resource.

The SOLAR Project

SOLAR was designed to support student learning by providing an environment that enabled students to gain the practical skills of experienced radiographers. The SOLAR scenarios expose students to a broad range of clinical problems. Students have the opportunity to integrate and acquire radiological knowledge, develop reasoning skills, engage in self assessment via comparison with expert reports, and improve their communication skills.

In Figure 2, the left side and central area of the visual map provided a focus for discussion with the technical members of the team. The need for the images to have a range of levels of fidelity to mimic the difference between a good and a poor radiograph, for the text materials to have the same or similar format to the documents used in hospitals, and the requirement for a range of information to be easily available (e.g., patient care issues) so that student learning could be supported. By articulating the core relationships in the SOLAR environment on a single page, Figure 2 enabled non-expert radiographers (the non-SMEs in the development team) to gain a clear understanding of the key educational issues to be addressed by the technology components (e.g., fidelity of the graphics, structure of specific forms and documents, and online communication). Figure 2 provided a framework to support discussions between team members from different academic disciplines, alleviating confusion and misunderstandings.

Figure 2 was also used to indicate a range of possible scenarios for experienced radiographers (who were asked to contribute realistic and meaningful scenarios) to develop for students. In a sense, Figure 2 (with accompanying written documentation and suitable examples) became the template from which the practicing radiographers could construct each scenario. The right side and central areas of the map provided the focus for initial conversations with the writers. Developing scenarios was often a matter of indicating what could be done or supported by the computer environment, and also the educational perspective that was underpinning the whole project. In many situations, using a computer in the way intended by SOLAR was new to the practicing radiographers and the template (Figure 2) became central to their writing and acquisition of resources (e.g., X-rays, sample radiographer reports, expert diagnosis).

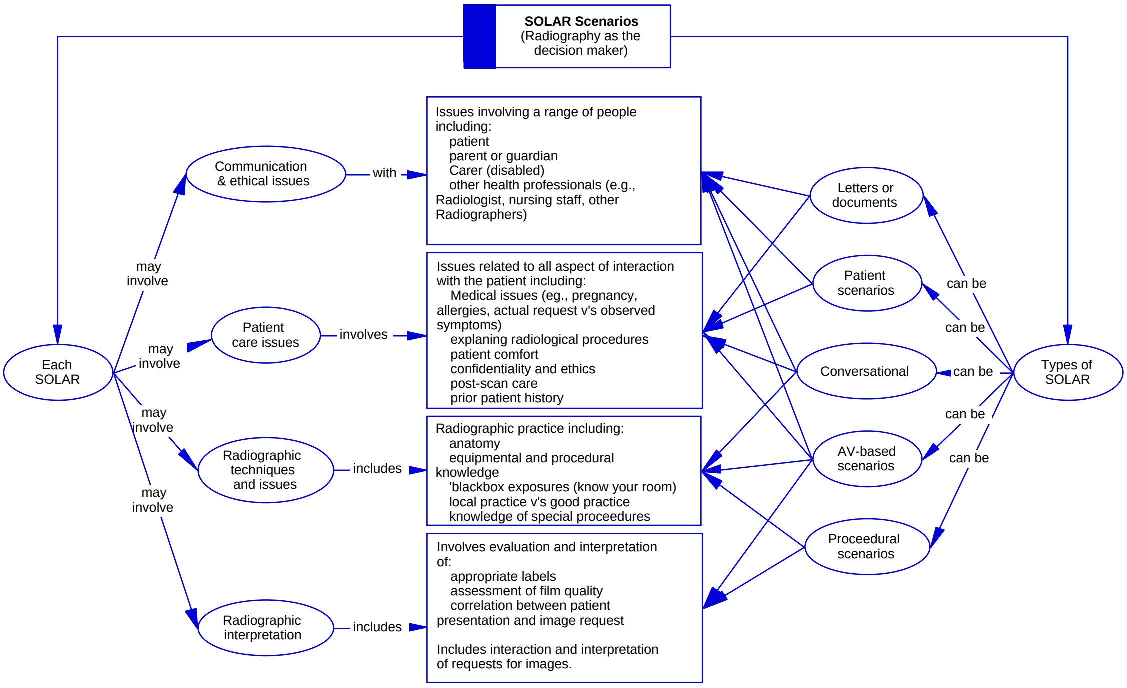

Figure 2: SOLAR: Student Oriented Learning About Radiography

Anatomedia: A Clinical Approach to Learning Anatomy

The second example is the project Anatomedia (see http://www.anatomedia.com). This innovative resource (CD-Rom) for the teaching of anatomy was initially developed for undergraduate medical students at The University of Melbourne. The educational rationale of Anatomedia arose out of initial developments (primarily print-based) aimed at encouraging an understanding of anatomical principles that could be utilised in future clinical contexts. Although students found the original resources highly successful, their value was limited by the primarily descriptive teaching materials then available (print-based). Students intending to adopt a deep approach to learning were restricted by the medium of text. The question was then asked—how could the innovations be supported (assuming that the popular approach was to continue)?

Students recommended that the learning materials be designed around the course rather than the reverse (Driver & Eizenberg, 1989). The first phase involved the development of an innovative text book design (Eizenberg, 1988, 1991). The structure of this text was based upon research that investigated the principle factors in a textbook that encouraged students to adopt a deep approach to learning (Driver & Eizenberg, 1995).

The critical design factors in the content and organisation of the textbook, linking anatomical details with the clinical perspective was extended and enhanced in the development of the Anatomedia CD-Rom. This has been done by the use of:

- high quality images (e.g., radiographs, detailed dissection images from real human bodies, and graphics with coloured overlays highlighting key anatomical details);
- integration of clinical questions and answers;
- the facility for the student to examine anatomical concepts from multiple perspectives using multiple pathways; and
- integration of the Anatomedia CD-Rom into the new problem-based learning environment (Kennedy, Kennedy, & Eizenberg, 2001).

The need to strongly support students to integrate the knowledge from multiple perspectives and a range of clinical contexts is critical if students are to function successfully as professional doctors with real patients (Bowden & Marton, 1998, p. 129).

However, moving from a mature educational medium (print) to IMM was not straightforward. One of the key issues was how the interface could be designed in such a complex academic domain. Questions arose, such as how to:

- incorporate the traditional teaching approaches to anatomy in medicine (Systemic or Regional) into the new materials;
- continue and extend the innovations shown to effective in the printed materials (e.g., incorporation of clinical questions and procedures); and
- incorporate multiple perspectives, images, clinical questions, dissection without creating an overly complex environment for students to navigate?

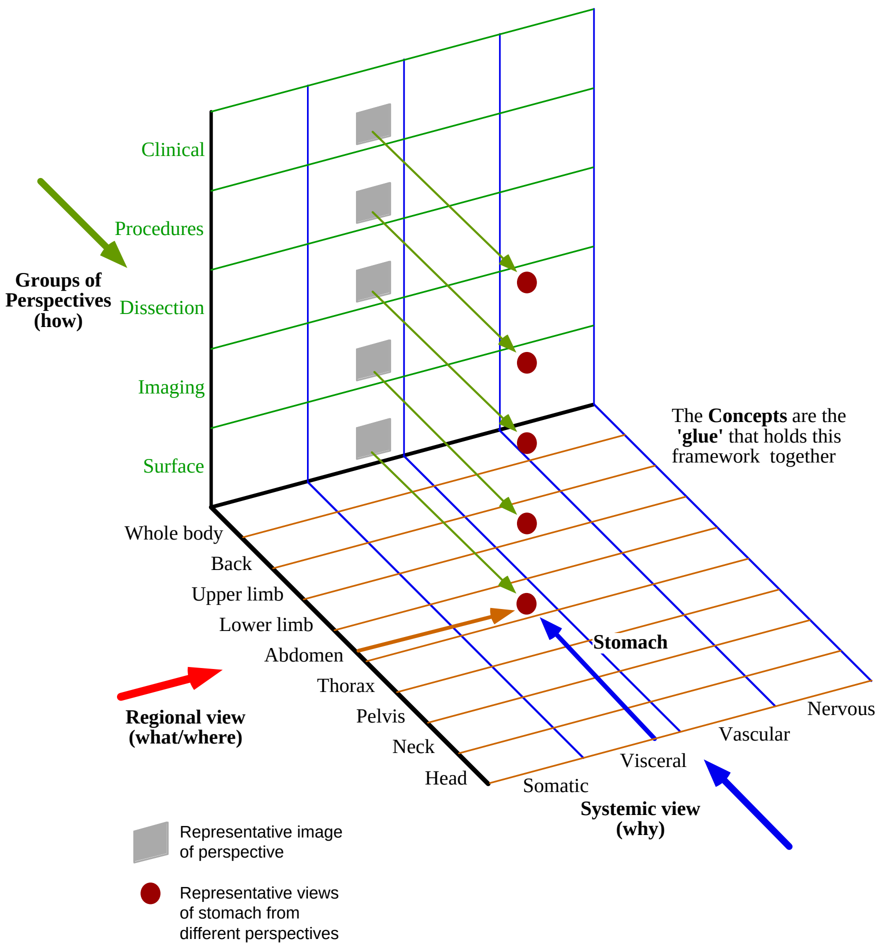

Figure 3: Initial graphical representation of Anatomedia CD-Rom

One element that contributed to solving these difficulties was the development of a graphical representation of the content. In Figure 3, the first iteration is shown. It was realised at this time by members of the development team (most of whom were not medical doctors), that while every component of the CD-Rom resources could be mapped into a specific location in three dimensions, it was not a viable model for interface design. Students would rapidly get lost in the complexity of any multimedia environment based upon this model.

In Figure 3, the SMEs were able to visualise the complexity of their undertaking, and gain an insight into the problems faced by the interface and graphic designers. Figure 3 also enabled the designers to explore and suggest alternatives in a common framework, one now shared by the development team.

In Figure 4, the four perspectives finally adopted by the design team are shown. The evolvement of Figure 4 from Figure 3 was, in part, the realisation that the original strength of the innovative clinical approach to the teaching and learning of anatomy was the integration of the clinical questions and procedures, and that the human body could be constructed (imaging) or deconstructed (dissection). The clinical aspects became the 'glue' that held the four perspectives together. The final interface design now reflects the four perspectives.

The evaluation of Anatomedia with students, tutors and medical educators has been extensively reported elsewhere, and shown to be a highly effective resource in the problem-based learning medical curriculum (Kennedy, Eizenberg, & Kennedy, 2000; Kennedy et al., 2001).

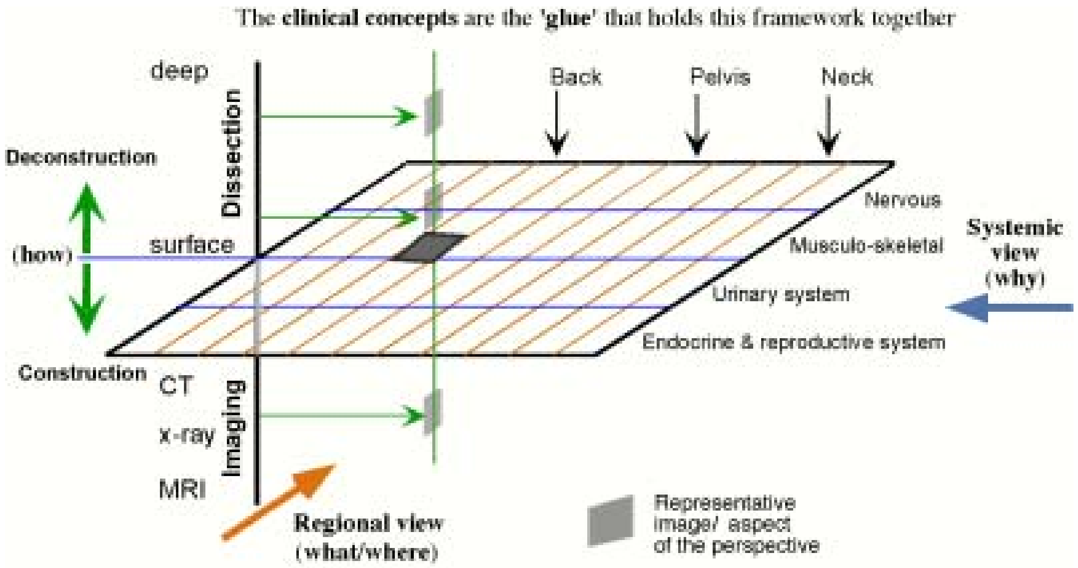

Figure 4: The four perspective view of Anatomedia

Summary

The implications for teams of individuals who have the task of integrating technology into teaching and learning environments suggest that different roles may be filled with individuals who have diverse skills, and whose strengths lie in a various types of intelligence as suggested by Gardner. Using visual representations of the content domain of a subject has the potential for:

- creating a common framework for all members of a courseware development team;
- utilising the intellectual strengths or predispositions of key members of team involved specifically in creating the IMM & ICTs; and
- summarising both key educational concepts and technical requirements for a particular set of course materials.

This discussion has indicated there exist further directions for research in which the assertions are examined in more detail.

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