Disciplining Multimedia

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The word multimedia conjures up many emotions and responses—it often refers to anything that uses visual and acoustic data. As a result, some may brush multimedia off as just a marketing slogan. However, many universities have recently introduced degree courses in multimedia. This article attempts to define the scope and basis for a multimedia discipline.

Recently, a flurry of educational institutions has rushed to develop undergraduate degree courses in multimedia. While faculties of arts or humanities have often hosted these courses, in a number of other cases such as at Griffith University, these have been offered within an information technology/science framework. In my experience, this led to a considerable amount of internal discussion among the course designers regarding academic directions and what curricula to teach. While not completely unrelated to the traditional rivalry between the arts and sciences, this discussion arose because of multimedia's diverse and nebulous nature. The core question is whether multimedia can ever mature into becoming a discipline or if it's condemned to indefinite multidisciplinaryity?

Although myself and others agree in general with Reisman's observations,¹ we believe that multimedia has a future as a discipline and not just as an extension of existing disciplines into the digital realm. Hence, this article aims to look at the basis for multimedia to become a proper discipline. I explore these issues from a decidedly technological stance with the view of arriving at an understanding of what academic directions must be followed if multimedia is ever to emerge as a cohesive discipline. To this end I'll attempt to define multimedia (yet again!). I'll also analyze the likely requirements for proficiency in designing, implementing, and maintaining multimedia systems and discuss what a multimedia discipline should entail. In this article, I'm less concerned with the evolution of multimedia technology and practices than I am with the more fundamental question of multimedia as a discipline, which will in the long term directly affect these other aspects. I don't discuss strategies or curricula for integrating multimedia elements into existing disciplines.

Hence, since the goal of this article is to discuss and encourage reflection about disciplining multimedia, some may find it controversial.

What is multimedia?

Defining multimedia has proven a serious problem for many, probably because as the *Macquarie Concise Dictionary* (2nd edition, 1993) tells us, the word "multimedia" is an adjective and hence, without a subject is devoid of any denotation. The common colloquial use of the term as a noun complicates the task of arriving at a proper understanding of what multimedia encompasses. Another problem with defining multimedia results from its dynamism as a technological, social, and economic phenomenon. As an adjective, multimedia is an attribute of something, so you need to survey the entire domain of multimedia things (Table 1) to understand what multimedia generally means. Specifically, multimedia is an attribute of a system related to multiple data modalities and interactivity.

The original definition of multimedia was in the context of a computer system with the capacity to deliver visual and audio information to a user interactively. It certainly doesn't refer to a multimodal data set or to passive delivery of multimodal data such as with television. We'll return to this example of television later. There is, however, an earlier instance of multimedia long before the days of digital computers and long before the term multimedia was even coined. In 1945, Vannevar Bush, the father of hypermedia (a superset of multimedia) proposed the first multimedia machine, which he called the Memex. This was an extensive online, graphical system for storing, browsing, and annotating both text and picture information nonsequentially.² In all of these cases, multimedia refers to interactive, multimodal, information management systems. Today, such systems support content-based and intelligent retrieval of nontextual data through multimodal query interfaces.

Even before the days of personal computers, mainframe systems such as the IBM 1500 Instructional System³ and Plato from Control Data Corporation were to some extent multimedia capable. However, in reality computer games were the first consumer applications of personal computers capable of interactively displaying images and playing sound simultaneously, starting with Atari's release of Pong in 1972. Moreover, they remain the largest application in terms of gross revenue. A driving force in the consumer market for multimedia computers is their game-playing

Table 1. Domains of multimedia systems and example applications.

Domains	Example applications
Information management	Hypermedia, multimedia-capable databases, content-based retrieval
Entertainment	Computer games, digital video, and audio (MP3)
Telecommunication	Videoconferencing, shared workspaces, virtual communities
Information publishing/delivery	Online training, electronic books, and streaming media

potential. Today, many computer games not only use advanced graphic and audio synthesis, but also deploy sufficient video footage to qualify as interactive movies. Any working definition of multimedia must embrace the area of computer games and other entertainment systems.

In the case of online multiplayer games, real-time distributed control and network transport is required to permit hundreds of players from all over the world to simultaneously interact in the game-world space. This reveals another long-established patron of multimedia, namely telecommunications, especially in the sense of multimedia services such as videoconferencing and computer-mediated communication. Without Integrated Services Digital Networks (ISDNs), the concept of interactive television and other such advanced multimedia applications would never arise. The explosive growth of the Internet shows the impact of telecommunications in this area. The realm of multimedia also includes digital communication network services. Today, networks and multimedia services interrelate intrinsically.

Another postulant for multimedia is the area of electronic information delivery services and publications such as electronic books. Information delivery services include media streaming and subscription services to noncontinuous media publications. The publication areas include the business, educational, and entertainment sectors. In this context multimedia provides flexible information and is often associated with instructional design and authoring skills. However, restricting the multimedia industry to a certain, limited authoring genre seriously underestimates its scope. To a large extent, proponents of multimedia from this sector regard it as purely the multimodal information content they create. Hence, in this view multimedia is considered to be the message only⁴ (often of only one particular type) to the exclusion of the medium.

What isn't multimedia?

I won't dispute that multimedia presents a new paradigm in interactive information handling and

delivery. This interactivity can't be isolated from the medium because it is the medium—it involves the digital computer, which mediates its provision. In some respects the multimedia revolution resembles the dawn of television; in others, it's radically different. Television is a multimodal broadcast technology predominantly for experiencing events displaced in space and time that could be experienced without the technology by attending the event in person. Hence, in television the message and the medium are traditionally independent of each other (except for special effects). In contrast, multimedia can't be experienced without the technology because the technology creates the experience. Multimedia isn't just the message, but is a function of the medium.

Many multimedia systems, such as hospital information systems, will never contain authored content. Yet these still provide interactive access to multimodal information. The origin or purpose of the content neither detracts from nor commends a system being a multimedia system. Just presenting a different text or picture in no way modifies a multimedia system. The functions and definition of a word processor remain invariant regardless of whether it's used to edit or view a short story, a technical publication, or a personal letter. Likewise, the definition and function of a multimedia system remains independent of the information contained or the storage format. In short, multimedia is independent of the type or origin of the content.

The actual content identifies the specific application area of the multimedia system. We can classify the various application domains, but they don't increase our understanding of multimedia. The general nature of the application makes little difference to the nature of the multimedia system as a whole and provides few distinguishing features about it. Hence, multimedia is also independent of the application area.

Distilling multimedia

What distinguishes all these multimedia application areas?

- Their operational environments, and
- the architecture of the information spaces they deploy.

The operational environment is a function of the host delivery platform and the physical interfaces. For example, a multimedia system may be a stand-alone or a networked client-server system. Networked systems can be centralized or distributed, over a wired or wireless medium. The information space is a function of the data's structure. This includes the logical structure, the time structure defined by any state or dynamic behavior as determined by scripts or autonomous software agents, and the spatial structure such as its 2D layout or 3D placement. Hence, its information space and its operational environment characterize multimedia.

From the delivery platform viewpoint, multimedia is largely independent of specific delivery platforms or system architectures. Valid platforms for multimedia include set-top boxes for interactive high-definition television (HDTV) and low-power, low-bandwidth, wireless, palm-size computers. Because you're not restricted to CRT displays with a mouse pointer, you can explore fully immersive 3D virtual environments using visual, acoustic, and haptic interfaces. Multimedia systems of this nature are increasingly deployed in medical, scientific, training, and entertainment systems. These alternate architectures host a wide range of applications such as multimedia groupware, video-on-demand (VoD) services, electronic shopping systems, interactive television, surrogate travel, and virtual reality systems.

An important consideration in trying to define multimedia is that it must be analyzed within its correct context in the framework of the evolving technology that creates it. While not ignoring the transitory social and economic phenomena that also evolves in response to the changing underlying technology, we must concede that technology drives the field. For multimedia to mature into a discipline, we must isolate its unique, unchanging principles. The transient idiosyncrasies of multimedia's current form and deployment don't help us in this endeavor. Those who consider multimedia to predominantly consist of the message to the exclusion of the medium relegate multimedia to being just another creative arts genre and hence, not really anything new—certainly not a new discipline.

Multimedia includes many advanced and var-

ied technologies. Although it doesn't depend on the specific delivery platform or presentation software, content, or message, multimedia does rely on the medium and is characterized by its information space and operational environment. Hence, a useful working definition is that multimedia is an interactive, multimodal information space in an artificial environment conceived by fusing both the medium and the message. These environments constantly evolve, created by a combination of computer processing and interface hardware, software programs, and structured digital data of multiple modalities. Thus, any multimedia discipline must focus on the design of information spaces, their architectures, and the specific technology required to create the operating environment.

Requirement analysis

Now that we understand the scope of multimedia, we next need to analyze the requirements to design, implement, and maintain these special information environments. Elsewhere, I've discussed three main categories of current multimedia professional practice.⁵ These categories encompass the systems development, application software development, and audio-visual content development phases. How do each of these roles relate to developing complete multimedia systems?

Multimedia developers will have to deploy multimedia systems across a broad range of delivery platforms (hardware and software). These platforms may use a variety of advanced user interface technologies for speech, haptic, or advanced visual-based systems. The delivery platform may be a large, distributed system or a low-performance, mobile device. These considerations will naturally affect the nature of the content the system delivers because the channel will unavoidably constrain the message.

Developers must understand the constraints imposed by a delivery medium and how they affect the interaction and presentation of information, and provide methods to work around them. The constraints include things such as capacity or bandwidth, synchronization, latency, delay jitter, and audio-visual rendering limitations. For example, it's currently impossible to deliver full-color, high-resolution, full-rate uncompressed video over a narrow-band wireless channel to a handheld mobile computer. Developing multimedia systems requires broad technical skills and delivery platform independence.

Teaching developers how to use specific soft-

ware tools will not suffice. Multimedia data forms are rapidly evolving from precomposed, unstructured bit streams to structured sets of unrendered objects to be composited and rendered at runtime (as is evident in the coding paradigm shift from MPEG-1 to MPEG-4⁶). The nature of multimedia data will continue to evolve, with data models and representations becoming more abstract and featuring increased support for high-level interaction and manipulation.⁷ The presentation environments for the data are also evolving into specialized host platforms such as set-top boxes for interactive HDTV and band-limited, low-power mobile systems. As a result, we should expect developers to cope with evolving data forms and emerging host environments. Additionally, they should be able to integrate existing structured content from multimedia databases or handle dynamic, intelligent agents in virtual environments and not restrict themselves to creating only aesthetically pleasing audio-visual presentations.

Creating effective multimedia systems requires the systematic design of structured deterministic information environments. It includes more than just compositing a set of images and video clips. Multimedia developers should not be so much concerned with artistic license, but with designing functional information spaces that reduce cognitive overload. To do this, they must understand and manage the three principal components of information spaces—the logical structure, the content, and the layout of the content.

Because of the complexity of the content and its representation in any multimedia information space, its logical structure primarily determines the system's success. Hence, the main problem in multimedia is designing the information space so that users can access the content easily. In addition, the content must be presented in a manner that reduces cognitive overload and facilitates understanding of the information. This involves deterministically designing the links, information structures, and state transitions to ensure that the information space's architectural integrity isn't compromised.

Navigation is a significant problem common to poorly structured multimedia systems with non-sequential access mechanisms. This leads to increased user disorientation within an information space as its size and complexity increases. One solution to this problem is to embed information management functions within multimedia systems,⁸ which requires expertise in multimedia information management technology.

Developing multimedia systems requires understanding the main application areas. However, possessing strong systems analysis, design, and project management skills is more important. It's of little use to create impressive multimedia presentations if they don't successfully accomplish their purpose. Even if proper specifications are produced, a poor understanding of the technology or lack of system design skills or effective project management will lead to good-looking but useless multimedia systems. Developers can easily get carried away with creating pretty pictures and neglect the more important system issues.

Building multimedia information systems and information spaces also requires expertise in programming. A multimedia system often needs to provide form processing (possibly over the Web using the Common Gateway Interface, or CGI) or may need to deploy some autonomous software agent or applet. At the very least, using the advanced features of many multimedia software environments often requires scripting languages to access them. Additionally, it may be necessary to interface to a range of existing software and hardware systems, or write special software extension plug-in modules to perform custom functions. Other requirements include a good understanding of data representation formats, how to manipulate multimedia data, and how to address multimodal human computer interaction issues.

Just working with the data content, creating multimedia software, or connecting various hardware components together doesn't suffice. While possibly specializing in one of these areas, multimedia system developers should have generalist system-level skills capable of creating entire multimedia environments. This involves integrating processing platforms with input and output devices, data networks, software applications, and data to synthesize specialized, effective multimedia systems. It involves applying multimedia in new ways and under different scenarios. If a multimedia discipline doesn't empower you to function at this level, then it isn't a discipline.

Discipline of multimedia

Unfortunately, a number of the multimedia degree courses currently offered were designed using a bottom-up rather than a top-down strategy. Some institutions did this so that they could be the first to offer such courses, since this strategy promises a quick outcome with reduced initial effort. This method typically starts with interfaculty course

Table 2. Horizontal development roles.

Role Demarcation	Development Role
System creation	Creating entire specialized multimedia systems system. Overall design and integration of data, software, and hardware components.
Application creation	Creating required software components and gateways to other software applications and integration of existing data.
Content creation	Creating information spaces within existing software frameworks and creating gateways from these spaces to existing content in other information systems. Includes content creation and reworking of existing data.

components (subjects) that are already in place. Faculty construct the course by integrating all the suspected useful components. The dilemma is that the outcome may not meet the requirements because the original components were inappropriate. This bottom-up approach is also appealing in the case of multimedia—the field is so poorly defined that this strategy makes course designers feel they can develop an improved understanding as they go along and still achieve something without having a full understanding to begin with. While convergence to a solution is faster, a successful outcome depends on many intangibles such as experience and insight. Hence, this popular strategy can almost be considered antidisciplinary, leading to at best poorly structured courses.

Many existing undergraduate degree programs in multimedia were formed by combining science and technology courses with arts and humanities courses. As noted, this approach isn't cohesive because of the lack of focus—graduating students have only a shallow grasp of these various disciplines. While multimedia is interdisciplinary, could it also be multidisciplinary? If so, to what extent? Most of these difficult issues can be avoided by providing minor study programs in creative arts for technology students and information technology courses for arts students.⁹ These solutions, however, don't lead to the creation of a multimedia discipline.

The ACM Special Interest Group in Multimedia (SIGMM) Education Committee (MMEC) has been working since 1995 to formulate guidelines for syllabus design for a variety of courses.¹⁰ The diversity that MMEC seeks to reflect unfortunately doesn't advance multimedia as discipline. Although MMEC has attempted to formulate guidelines for multimedia education, it focused on extending to existing disciplines, which negates

the concept of multimedia as a specific discipline. One of the reasons for this approach is the lack of teaching staff with appropriate interdisciplinary knowledge. However, current degree courses in multimedia seem to imply that such a multimedia discipline exists or at least is hoped to exist.

Many multimedia degree courses target teaching students how to use a range of applications or authoring tools.¹¹ From my experience, most students expect this manual training from multimedia degree courses. Yet this directly conflicts with the mission of higher education to provide mental training and mimics the mission of trade schools. This “tool skilling” approach could never form the basis of a discipline.

A multimedia discipline may align itself either horizontally or vertically. The vertical alignment views multimedia systems holistically (not according to specific development tasks) and considers the tasks as subordinate to the overall system deployment. This approach treats each task in the development process equally. It focuses on generalist development skills across all multimedia domains and system issues specific to each domain.

The horizontal alignment projects the components of multimedia system development horizontally within specific application areas. The focus is on specific roles within the overall multimedia system design and development process. Specific technology issues related to different application domains are considered subordinate. Hence the horizontal approach tends to produce graduates with more precisely demarcated vocational roles (see Table 2).

The horizontal approach tends to produce more specialized and constrained graduates who must work in teams to produce complete multimedia systems. This is a weakness because each of the three vocational areas overlaps directly with existing disciplines—graphic design (content creation), computer science (application creation), and computer engineering (systems creation). These roles have evolved due to the lack of graduates with interdisciplinary skills. While these current vocational roles may only be a transitory phenomenon, we shouldn't disregard them.

The vertical approach has greater commercial attraction, since it produces graduates with generalist skills capable of single-handedly deploying (or managing the deployment of) all aspects of entire multimedia systems with specific application focuses. The application requirements—not the developer's abilities—impose the only constraints on the development of multimedia sys-

Table 3 Horizontal and vertical divisions in multimedia systems development.

	Information System	Communication System	Entertainment System	Business System	Education System
System	Distributed enterprise database	Computer-supported collaborative work	Network multiplayer game	E-commerce	Online publishing
Application	Database access gateway	Shared workspaces/video conferencing	3D game engine	Online store	Electronic training system
Content	Photographs	Live video	Virtual world	Pictures	Text and pictures

tems. Since there exists a range of diverse application domains, each having specific system requirements, these may be addressed as specialization areas within the discipline. These application domains can be broadly classified as pertaining to

- **Multimedia information systems:** databases, information kiosks, hypertexts, electronic books, and multimedia expert systems
- **Multimedia communication systems:** computer-supported collaborative work, videoconferencing, streaming media, and multimedia teleservices
- **Multimedia entertainment systems:** 3D computer games, multiplayer network games, infotainment, and interactive audio-visual productions
- **Multimedia business systems:** immersive electronic commerce, marketing, multimedia presentations, video brochures, virtual shopping, and so on
- **Multimedia educational systems:** electronic books, flexible teaching materials, simulation systems, automatic testing, distance learning, and so on

Table 3 shows the relationship between the vertical and horizontal alignments in each of these application domains. For each domain, I identified the components at each horizontal level for a specific example application. For example, the horizontal alignment can only produce developers capable of handling content across all domains, but not capable of undertaking any application or system-level roles. The vertical alignment allows developers to perform at all horizontally identified roles, but with specializations specific to certain application domains.

Ideally, those disciplined in multimedia should

be equipped to operate in any or all of the vocational roles to develop application-specific multimedia systems and be unconstrained by host platforms, software frameworks, application domain, and nature of the content. Ultimately, regardless of what alignment a multimedia discipline wishes to pursue, graduates must have a range of skills dealing with each of the main components of a multimedia system. These components fall into four main categories:

- The physical delivery medium, including the computing platform, interface hardware, system configuration, and its distributed or networked aspects, if any.
- The software environment, including the operating system, software gateways, presentation/rendering engines, software applications, and other software agents.
- The data content, including not only the information and its manner of presentation, but the compression and multimedia information technology and processing techniques.
- The logical, spatial, and temporal architecture of the information space.

An educational program to train people in a multimedia discipline should impart a good understanding of how these four elements interact and the constraints that can be imposed in a multimedia system. Most importantly, students with strong system analysis and design skills must be able to create systems with good designs in each of these areas and effectively fulfill all the design goals. Finally, the unique principal feature of multimedia that identifies it from other systems is its reliance on well-designed multimodal information architectures and nontextual data access and processing methods. Hence, these two aspects

represent the foundation of the emerging multimedia discipline.

Conclusions

Multimedia isn't dead—it's barely nascent. Unfortunately, the confusion about multimedia's nature has lead some to think that multimedia is really nothing new. In this view the term multimedia—while embracing computer graphics—describes the foray of other disciplines into the digital realm. This is reflected in a number of the multimedia degree course offerings available, where the discipline taught is effectively that of audio-visual arts with an emphasis on computer software tool skilling. Is this all multimedia has to offer? Can a true multimedia discipline ever arise? I believe that it can as long as multimedia develops from within a scientific discipline. I ardently disagree with the view that multimedia is only the message, that is, multimodal data of some form or another.

Many courses in multimedia today focus mainly on content creation and provide little knowledge of system- or application-level issues or of multimedia systems that don't employ authored content. While certainly a market exists for content creators, these can't be considered disciplined in multimedia. Those disciplined in multimedia should have some mastery over the system- and application-level areas as well. Here I've noted the main weaknesses in a horizontally aligned discipline; hence, I favor a vertically aligned discipline. For proper balance, roughly equal emphasis should be given to the content, software, and system creation areas.

This article has investigated the basis for the rise of a discipline in multimedia. I've tried to investigate what multimedia is by surveying its various dimensions. A piecemeal approach to multimedia education most likely won't lead to a cohesive discipline. While it may also be disputed whether the proposed systematic approach will lead to a multimedia discipline, one will never arise if we treat multimedia as just the deployment of computer-based tools in the practice of existing disciplines. MM

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