Ruben Gonzalez, Greg Cranitch, and Jun Jo

Academic Directions of Multimedia Education

Ask for a definition of "multimedia," and you'll likely never hear the same description twice. So, how do we go about teaching it?

While the term "multimedia" is often the subject of contention, there is no disputing its novelty and the rapid escalation of its evolution. It was only eight years ago that digital video on computers first emerged. Since then, MPEG-1, MPEG-2, and MPEG-4 have been ratified, and MPEG-7 is already under consideration.

One significant characteristic of multimedia is that it is a vehicle for the convergence of the traditionally separate technologies of computing, entertainment, and telecommunications. To this is added a rich diversity of application areas wanting to exploit this new technological medium including education, commerce, advertising, and medicine, to name a few. This conjunction of technologies and applications creates a very fertile ground for innovation and creation of new multimedia forms. Vocationally, there is high mobility of practitioners in the field and there are very few well-defined career paths. In this rapidly evolving environment, it is imperative that practitioners are highly adaptable and multiskilled.

In this context a number of universities have recently introduced undergraduate multimedia degrees. This has presented some interesting challenges to those involved in designing these courses. Under the garb of multimedia there is certainly industry demand for graduates, but defining "multimedia" has proved to be a difficult task. This burdens academics with the problem of achieving consensus on a curriculum for multimedia. This is not so much due to the wide scope of multidisciplinary applications of multimedia (much like word processing) but because the term "multimedia" has metamorphized into something akin to the mythological, multiheaded Hydra where its meaning is often determined by some immediate context in isolation from its source. Implicit in this debate about the definition of multimedia is the question of which discipline can claim ownership, with all that entails. Is it possible that multimedia is not part of an existing discipline but a new one? Some have argued that multimedia is like the emergence of computer science 30 years ago. CS, however, evolved from a conjunction of the fundamentally related disciplines of electrical engineering, mathematics, and other sciences. The similar academic and research cultures associated with these disciplines provided a strong sense of cohesion and direction to their progeny. Unfortunately, this is not the case with multimedia as a number of the disciplines that lay claim to it have traditionally antagonistic cultures. Attempts to synthesize a definition of multimedia and, hence, an undergraduate course as simply a conglomeration of the multitudinous diverse views

of multimedia can only be unsuccessful in the long term. The lack of cohesion and identity in the context of cross faculty implementations would limit the quality and depth of knowledge that could be imparted.

Contrary to some opinions, multimedia is more than just a collection of sound, images, video and animations. It is a vital, dynamic field offering new challenges, interesting problems, exciting results, and imaginative applications. The challenge is whether the unique essence of multimedia can be distilled into an essential discipline. It is worthwhile reflecting that Vannevar Bush proposed such a new profession of what he called "trailblazers" exclusively to create and manage non-sequential multimedia systems [1]. This new, highly skilled profession was not to be involved in content creation but in creating structured information spaces from existing content. We are rather removed from this vision if we are still mainly focusing on the raw materials of multimedia and not the architectures of the information spaces that can be created with those materials. Admittedly, one can only assume that Bush foresaw this as a discipline that required specialist training.

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Multimedia Education

Traditionally, a major goal of universities has been to equip students with an intellectual culture that enables them to adapt to changing work environments for the duration of their careers. This is achieved by instilling in students more than just knowledge of facts or tool skills (especially in an environment where tools become obsolete in less than two years). Students need the mental apparatus required for them to self-learn new skills, and more importantly, understand and be able to deploy new technologies in their fields as they arise. A university course should strive to achieve this in order to provide long-term benefits for the students themselves and society as a whole.

As important as preparing graduates for careers in multimedia, the other principal goal of undergraduate studies is to provide a path into higher degree studies and supply potential researchers in the field. This requires that students have a profound understanding of the principles and theoretical constructs underlying multimedia systems. The first researchers in multimedia were electrical engineers, followed by researchers in IT, and then from education and psychology. Clearly, most of the current research in multimedia requires a solid background in one of these disciplines.

Ultimately, academics need to decide what is to be expected from their graduates. These expectations will determine the constraints, directions, and standards that identify the course. This presents the first major hurdle in developing a curriculum for multimedia and can be restated as a rather contentious question: What is multimedia? Is multimedia solely multimodal information, that is, mainly concerned with the process of its creation or authoring? If the answer is "yes," then multimedia is relegated to being predominantly just another creative arts genre, and most definitively not a computing discipline. In other words, is multimedia the message or the medium, or a combination of both?

That multimedia presents a new paradigm in information handling and delivery, with intrinsic support for profound interaction, is indisputable. This interactivity cannot be isolated from the medium for it is the very medium itself—the digital computer—which mediates its provision. While in some respects the multimedia revolution is akin to the dawn of television, in others it is radically different. Television is a multimodal broadcast technology primarily for experiencing events displaced in space and time that could equally be experienced without the technology by being present in person at the event. In television, the message and the medium are traditionally independent of each other (except in the event of special effects). In contrast, multimedia cannot be experienced without the technology because it is the technology that creates the experience. Multimedia is not just another genre; it is a fusion of both the medium and the message to conceive interactive, multimodal information spaces effectively in the form of an artificial environment. These constantly evolving environments are created by a combination of computer processing and interface hardware, software programs and at least two or more digital modalities of data. The fact remains that many multimedia systems such as hospital

information systems will never contain *authored* content. An education in multimedia should empower students to be proficient in creating these artificial, interactive, multimodal environments and not just content authoring using certain software packages.

The very nature of these environments is highly fluid and under constant evolution. These may be distributed or centralized systems involving either synchronous or asynchronous communication. They may involve shared workspaces and computer assisted-collaborative work. They may be fully immersive or handheld, low-bandwidth wireless systems. They may have stringent security requirements or utilize intelligent software agents. They may utilize visual, acoustic, or haptic interfaces. Hence, if multimedia is to be considered an emerging new specialist discipline, it must, while borrowing heavily from other disciplines, focus on integrating certain elements from these to create application-specific, artificial, interactive, multimodal environments on any platform. This entails much more than just being skilled in the use of authoring packages, it requires a profound understand of the underlying host systems and technologies.

Table 1. Multimedia career opportunities.

Level	Authoring	Application	System
Email	Content creation by using authoring tools	Creation of multimedia software applications by using programming tools	Creation and running of entire multimedia systems by bringing together all components
Typical example	Multimedia educational/ training materials	Multimedia authoring tools	Information systems such as in hospitals
	Online books/ publications	Hypermedia viewers/ browsers	Entertainment systems (games)
	Multimedia advertising/ business materials	Multimedia data editors	Business systems, information kiosks, and so forth.
	Creating 3D animation and movie special effects	Multimedia database management systems	Communication system computer-mediated collaborative work

Careers and Vocational Training

To envision the multimedia industry as restricted to content authoring is like mistaking the scope of an iceberg by only considering the portion above water. Multimedia encompasses much more than that, but these activities are often under the guise of traditional vocations. Those developing interactive television, multiplayer video games, online film libraries, or hospital information systems are just as much involved in the multimedia industry as graphic designers are. Indeed, the majority of the people working in multimedia have technical, not artistic, backgrounds. For a person with appropriate training, the scope of possible careers in multimedia is wide-ranging.

Multimedia practice tends to exhibit three main focal points; the *authoring*, *application*, or *systems* levels (See Table 1). Training undergraduates to function at the authoring level requires much more than just training in the use of the tools. While workers need to know how to use their tools well, good workers need to understand the nature of the raw material they are working with, especially when it is rapidly evolving. This is a significant issue with multimedia. Digital video up to and including the MPEG-2 standard has simply been a precomposited unstructured bit stream. With MPEG-4, digital video is defined as a structured set of unrendered objects to be composited and rendered at runtime. The nature of multimedia data will continue to evolve with data models and representations becoming more abstract, and the interactions with and operations that may be performed on the data become increasingly varied and powerful. The implication of this is not just the rapid obsolescence of tools but also that the methods of working with the data and the design objectives will also change. If students have only been tool skilled without an understanding of the underlying principles of multimedia data representations [2] many will have difficulties in adapting to new tools and will not be able to exploit the full capabilities of the new systems.

Apart from data, the presentation environments for the data are also evolving. This is due to the use of specialized platforms for hosting multimedia such as set-top boxes for interactive television and band-limited, low-power mobile systems. Graduates in multimedia should be able to deal with these emerging environments. The type of content in multimedia systems is also evolving. Graduates must not be limited to only creating aesthetically pleasing graphic designs, they must be able to handle content in multimedia databases or dynamic or intelligent

agents in virtual environments. Aside from changing environments, tools, and data, effective content authoring may require knowledge in the more traditional areas of human factors, educational psychology, advertising principles, video production, graphics, and sound design, to name a few fields.

Most multimedia authoring efforts are highly dependent on very technically skilled professionals. The main reason for this is that graphic designers in general do not have the necessary background and skills to quickly adapt to new technology and tools without retraining. Additionally, the tools used for the high end work (or lack thereof) had to be developed in-house, consumer tools often being insufficient. For example, broadcast TV does not use the standard VCR-level video and users must know how to handle substantially more complex equipment and have a more fundamental understanding of video than as some polarized fields on a magnetic videotape.

Multimedia is about creating artificial environments that implement rich, interactive, multimodal information spaces, arising through a fusion of computer hardware, software, and multimodal data.

If a multimedia degree course is only going to provide graduates with the skills to create content, then it is subscribing to the concept that multimedia is just another arts genre and therefore not part of a technology-based discipline. Multimedia authoring involves more than just creating new content; it also involves integrating existing content into a multimedia system. This often requires the development of database interfaces within the authoring environment to enable users to access stored data. This database access may need to support multiple query or browsing interfaces and provide advanced reporting functionality such as intelligent filtering of query results. The content may also consist of software simulations of financial, scientific, or engineering systems for educational, entertainment, or business purposes. Integrating this existing content into a multimedia system requires additional software development skills.

In essence, any information space is characterized by three dimensions: its logical structure, its content, and its representation or layout and rendition of the content. In any multimedia information space, due to the complexity of the content and its representations the role of the logical structure is predominant to a large degree in determining the success of the system. Therefore, it is widely accepted that the main problem in multimedia is not the creation of new content, but the design of the information space so that the content is easy to access and present to reduce cognitive overload and facilitate osmosis of the information. This involves deterministically designing the linkages, information structures, and state transitions to ensure that the architectural integrity of the information space is not compromised.

The application level involves the creation of multimedia software applications. This covers everything from applets to authoring tools, multimedia presentation engines, or multimedia database management systems. To function at the application level, graduates need to have a solid foundation in object-oriented software design, programming, human-computer interaction, multimedia information management, and distributed systems. Graduates must also have a strong understanding of computer graphics, multimedia data compression algorithms, and data formats. They need to know how to perform low-level manipulation of multimedia data and how to interface to a range of multimedia hardware and other software systems.

A notable example of this class of multimedia practice was the development of *Jurassic Park* in 1993. The movie utilized an unprecedented level of computer-generated special effects and 3D animation. A number of the tools used by the animators had to be developed internally by Industrial Light and Magic as they were not commercially available to enable them to create the effects they desired [4, 8]. The animators required a high level of technical proficiency to quickly learn and effectively utilize largely unproven tools, and the engineers developing the tools needed to understand both the highly specialized requirements of the anima-

tors and how to achieve effective solutions. While this was a highly ambitious undertaking that stretched the boundaries of both artistic and engineering endeavors, we are left wondering what role graduates in multimedia would have been qualified to take had they been involved in this project.

While authoring only involves creating content for a given environment, and the application level focuses on creating the software components of the environments, the system level focuses on creating the environments themselves. This level epitomizes multimedia in its fullest sense and involves the integration of processing platforms with input and output devices, data networks, software applications, and unrestricted multimodal data to synthesize specialized, effective multimedia systems. This is not mainly concerned with hardware or software design but being able to effectively exploit existing offerings to arrive at quality solutions to novel problems. It involves being able to apply multimedia in new ways and under different scenarios, possibly acting as consultants within the industry. They must be able to compromise the often competing quality requirements imposed by the media content, information space architecture, control software, and delivery platform. Therefore, graduates will need to have expertise in all the principles of all of the basic technologies that comprise a multimedia system.

Table 2. Multimedia research areas.

Type 1	Info. Management	Info. Processing	Data Compression	Communication Systems
	Content-based retrieval	Expert systems	Audio Coding	Multimedia service provision
	Hypermedia systems	Recognition	Video Coding	Mobile multimedia systems
	Resource discovery	Understanding	Image Coding	Distributed services
Type 2	**Education and Training**	**Psychology**	**Management**	**Data Visualization**
	Instructional design	Cognition	Decision support	Data sonification
	Distance education		System simulation	Use of haptic interfaces

Multimedia Research

Multimedia research can be segregated into two main categories: research into multimedia systems (*Type 1*) and research that applies multimedia to classical endeavors (*Type 2*). Multimedia systems research is technological in nature and involves investigating multimedia data models, system architectures, information management, and compression and processing of multimedia data. Type 2 research mainly focuses on assessing the impact of multimedia on other enterprises, as in assessing the impact of multimedia on education and decision support systems. The majority of multimedia research is traditionally of the first category. Table 2 classifies some of the existing research.

Type 1 research does not involve any authoring skills, but requires system- and possibly application-level skills. Like all research it demands a good understanding of the principles and technologies that conjunctly define multimedia. These include telecommunications, database systems, information theory, signal processing, and computer systems, among others.

Type 2 research involves few application-level skills, it's mainly concerned with authoring and possibly some limited system-level skills. The theoretical understanding required is that particular to the specific field to which the application of multimedia is being investigated. Little to no understanding of the theoretical principles underlying multimedia systems is required. As there are virtually an infinite number of application areas, it is difficult to provide students with a comprehensive preparation to perform this type of research outside the target discipline.

In either case, each area requires an understanding of one or more formal theoretical frameworks and strong analytical skills in the context of those disciplinary frameworks. It is within these disciplines that most of the active multimedia research occurs. Without a suitable introduction to these formal theories, students would not be equipped with the mental apparatus to undertake research and would find it difficult to proceed with more advanced studies in multimedia.

Curriculum Design

We have considered the skills and knowledge that may be expected from a potential multimedia degree graduate. We have also seen that multimedia can only exist as a fusion of technologies, hardware, software and multimodal data to form artificial environments. Hence, a degree in multimedia should equip students with proficiency in creating these interac-

tive multimodal information spaces. To do this students must be provided with in-depth knowledge of both standalone and distributed multimedia computing systems including the various interaction mechanisms. This also requires some expertise in software development and the preparation of multimodal data. We should notice here that the preparation of the data constitutes about a quartert of the components of multimedia. Indeed, a multimedia curriculum may be considered unbalanced if it is concerned with content creation to a greater proportion.

Irrespective of which career options graduates may choose, while they should be skilled in the deployment of multimedia data on computer, as a university degree holder, each graduate will be expected to play a role more than just as a screen or sound designer. Graduates should have the capability of managing an entire system development/production process. They have to know how to develop the initial requirements, perform system analysis, and design and manage entire projects through the implementation, testing, and final commissioning of the multimedia system/product. For this, good communication and analysis skills are needed as well as a suitable understanding of team and project management and diverse quality control issues.

Many of the arguments about programming being an art or science, about killing programmer creativity or developing maintainable systems are as relevant to multimedia development today as they were in the last two decades of the computing industry. Unfortunately, there is no document titled "Multimedia Curricula 1998" similar to "Computing Curricula 1991" [7]. These curricula provided a range of courses in computing being hosted in different discipline groups—arts, science, and business. However, all have a common core body of knowledge. The 1991 report provides several guiding principles for a computing curriculum that similarly apply to multimedia and can be extended to formulate a similar set of possible curricula for multimedia.

The curriculum must focus on ways to provide students with situations where they can gain the desired knowledge, expertise, and experience. This means that students need more than just learning how to use the latest authoring software. While one can study for a degree in journalism, there is no such thing as a Bachelor of Word Processing (as pointed out by P. Eklund). The curriculum needs to have unifying themes and goals. This will ensure that students gain a deeper understanding of the fundamentals behind the glamor of multimedia. The various subjects need to be designed to reinforce concepts presented in earlier subjects. This will enable students to identify recurring themes in their studies. Laboratories, fieldwork, and experimentation provide alternatives to lectures while the new media provide ample opportunities for innovation in the courses.

Many multimedia products are developed using authoring or scripting languages. These languages aim to hide the low-level details from the developer. This can often lull the developer into a false sense of security. Issues that are of concern to traditional software developers, such as concurrency, network traffic, and disk performance are often ignored. These authoring packages function as a set of automata, several of which can be active at the same time. This is a concurrent programming problem with the potential for deadlock or mutual exclusion as two or more finite state machines try to take control of the same resource. Problems also occur when multimedia systems are distributed over a network [6]. Issues relating to compression, latency, jitter, bandwidth, and operating system characteristics become important [3, 5]. It is clear that even content creators need to have a precise understanding of the technology they will use for the delivery of multimedia data.

Conclusion

Multimedia is a diverse and rapidly evolving discipline. Much of the activity central to multimedia does not takes place under the umbrella of multimedia, but goes by the name of more traditional vocations. Training graduates to be proficient in developing multimedia systems and assuring the long-term value of this training requires clear discernment regarding the real nature of the multimedia phenomenon and understanding what sets multimedia apart from more classical endeavors.

Multimedia is not mainly about content authoring; many multimedia systems contain no authored content. Multimedia is about creating artificial environments that implement rich, interactive, multimodal information spaces, arising through a fusion of computer hardware, software, and multimodal data. An education in multimedia should empower students to be proficient in creating these environments, irrespective of the target application, legacy data, host platform, or framework. To do this, students must be provided with in-depth knowledge of multimedia computing and communication systems in addition to expertise in software and multimodal data processing technologies.

This article has discussed a range of significant issues in the context of the development and implementation of Australia's first undergraduate multimedia degree course at Griffith University. Designed

to stimulate discussion about the academic directions of multimedia undergraduate education, this article has presented a vista of multimedia practice and research in multimedia. It has also assessed the likely intellectual tools required by graduates to ensure the long-term viability of their learning during the undergraduate degree.

Attempting to develop an undergraduate degree in multimedia presents many challenges. Should a degree course in multimedia seek to prepare graduates at each of the three main vocational levels? What curriculum is best suited to ensure students are equipped with the mental apparatus required to adapt to the rapidly evolving nature of multimedia systems for the duration of their careers? How much emphasis should be given to tool skilling—subject to rapid obsolescence—in contrast to formally learning the principles and theory behind multimedia systems? While our current degree offering is now in its third year, we are still struggling with many of these questions. C

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Ruben Gonzalez (R.Gonzalez@gu.edu.au) lectures in IT and multimedia at Griffith University, Gold Coast Campus, Australia, where he also leads a multimedia information and communication technology research team.

Greg Cranitch (G.Cranitch@gu.edu.au) is the head of the School of Information Technology at Griffith University on the Gold Coast, Australia.

Jun H. Jo (j.jo@gu.edu.au) is a lecturer in the School of Information Technology, at Griffith University on the Gold Coast, Australia, teaching multimedia authoring and interactive multimedia.