Motion Picture Science: A Fully Integrated Fine Arts/STEM Degree Program

Victoria M. Scholl, Megan M. Iafrati, David L. Long, Joseph J. Pow
Rochester Institute of Technology, vms3476, mmi7593, dllppr, jjppci@rit.edu

Abstract - **Technology has advanced in such a way that there is now a need within the motion picture industry, as well as in society in general, for professionals trained with a comprehensive knowledge of Science, Technology, Engineering, and Mathematics (STEM) as well as the traditional Arts. In the School of Film and Animation (SOFA) at Rochester Institute of Technology (RIT) a novel undergraduate program has been developed to cultivate students into professionals with the skill sets necessary to fill this niche. This undergraduate program is Motion Picture Science (MPS), a degree developed to give students relevant tools to take into synergistic STEM and Arts careers in the modern motion picture industry. Pioneered in 2007, Motion Picture Science has consistently boasted increasing enrollment and successful graduates who earn meaningful employment in the fields of their choosing. The program has also provided some valuable insight into the social dynamics of an undergraduate regimen where students representing a comprehensive mix of artistic and scientific personalities work together; a multi-disciplinary reality fully consistent with contemporary filmmaking.**

Index Terms - Motion Picture Science, multidisciplinary, undergraduate education, STEM education.

BACKGROUND AND MOTIVATION

In education, the worlds of engineering and fine art have historically been separated on a fundamental level, both pedagogically and institutionally. But in practice, these two worlds have run in parallel all throughout history. Further with the last century's advancements in technology, the line between them has almost entirely blurred, especially in the motion picture industry. Animation has evolved from being hand drawn, frame-by-frame, to being computer generated and automated on a large scale. Vector graphics and other mathematical devices are utilized in order to bring an artist's ideas to fruition. Plays, originally performed exclusively on a confined stage by live actors and supported with live orchestras, have evolved to complex film sets with camera crews and supporting technology. The captured footage is edited, enhanced with post-produced audio and special effects, color-corrected with advanced software, and exported to its final state to be watched on a variety of screens and devices by people all over the world.

Today, a majority of Americans entertain themselves with ubiquitous TV shows, movies, and video games as opposed to attending some form of live entertainment. Further, they are increasingly accessing this content on-demand and across multiple platforms at home and on-the-go. As technology has advanced, so too have the possibilities in the world of art, an idea that has been embraced in most professional practices but is less well addressed in education. Motion picture professionals are expected to have a certain technical proficiency as well as an understanding of artistic principles but there is often a divide between those two subjects within education. This rift has prevented artists and engineers from collaborating to the greatest extent possible in formative experiences during secondary and post-secondary learning, leading to a widespread lack of understanding of the entire process of filmmaking and imaging in general. In the modern entertainment industry, this deficiency demands attention.

The genesis of the modern motion picture industry correlates quite appropriately with the incredible innovations in science and engineering of the late 19th century. Early inventors and engineers such as Nipkow, Baird, Edison and the Lumiere brothers devised methods by which to capture and store live performances for audiences to enjoy at later times and in far distant locales. In their labs were born prototype televisions, video broadcast systems, film cameras and projectors. In the very beginning, demonstrations of these systems lacked artistic creativity, instead relying on the broadcast of 'actualities.' These were simple scenes from everyday life meant to show off the technology and share social experiences across long distances. But it was not long before performing artists saw power in these early systems to share creative works across time, distance and culture. The artistic roles of screenwriter, director, cinematographer, actor, costumer and editor were born as distinct from their counterparts on the live stage. Content was delivered directly to the people rather than the people making pilgrimage to the cultural centers where the great art of the day was concentrated.

For the next 100 years, technical innovation continued to be fueled by artistic vision. The introduction of commercial color imaging by Herb Kalmus and Technicolor in the 1920s provided a new palette for directors and set-designers to paint with. 1939's *The Wizard of Oz* actually made the technology of color an artistic plot point to differentiate the neutral reality of Kansas form the colorful dream of Oz. 1927's *The Jazz Singer* evidenced the first

successful use of sound on film, permitting grander scores and sound design than possible with older live orchestras or vitaphone disks (early record players). In the mid 20th century, Ray Harryhausen and others pioneered practical visual effects to put on screen what could not exist in a live performance. These early stop-motion animation techniques transcended quickly to computer-generated imagery in films like *Future World* (1976), *Tron* (1982) and *The Young Sherlock Holmes* (1985). Animation and live-action performance were indelibly linked with these new technologies. 1995's *Toy Story* showed how an artist could work entirely in the virtual digital realm to generate a compelling film.

Avatar, an epic film released in 2009, is a perfect example of the modern-day collaboration between art and technology in motion pictures. Winning three of nine Academy Award nominations, specifically for Best Cinematography, Best Visual Effects and Best Art Direction, this film makes it clear to modern audiences that the union of left and right-brained mentalities offers desirable results. In addition to stunning virtual landscapes and a beautiful soundtrack, an innovative motion-capture stage was used to digitally record the facial expressions of the actors. Supplemented by novel "Light Stage" technology for capturing geometry and material properties of an actor's face, these photorealistic characters driven by cutting-edge technologies assisted in creating the incredible work of art that *Avatar* presents [1]. By utilizing such technologically advanced tools, it was possible for the cast and crew to make director James Cameron's artistic vision a reality.

The motivation behind Rochester Institute of Technology's (RIT) Motion Picture Science program (MPS) is to address the deficiencies of traditional arts and technology education in not recognizing the full scope of the multidisciplinary landscape in the film and entertainment industries. MPS is a program of study that integrates the artistic aspects of film with a heavily technical understanding behind the hardware and software that makes modern filmmaking and other forms of imaging possible. In the examples provided from the industry's past, artistic vision was the driving force behind many of the technical innovations. That example also supports the purpose of MPS: producing a workforce that has experience creating works of art as well as possessing the technical skills to develop the tools to make their artistic visions possible. Undergraduates enrolled in this innovative new program at RIT are involved in and exposed to the artistic side of the film world, but potentially have a career grounded in science and engineering. This is a valuable merge between technology and the fine arts resulting from collaboration between educators and industry professionals.

It should be noted that film is not the only area where emerging trends in integrated arts and sciences education are showing value. The growing interest in merging the STEM and Art fields has led to the development of numerous STEM + Art initiatives, often referenced as "STEAM" [2]. According to numerous education journals, the incorporation of creativity and imagination has been shown to have positive impacts on students' critical thinking and ideation [3], skills absolutely necessary, too, for innovation in science and engineering. A review of current literature on STEAM initiatives reveals most programs involve co-opting Art exercises into an existing STEM program or vice versa, often in the K-12 classroom, outreach camps, and a few undergraduate programs. Mixing of learning modalities shows evidence of improving retention and problem-solving skills. Similarly, invention and innovation in technological pursuits are inherently creative processes in the brain, better unlocked when the two pedagogies are juxtaposed. There are also, though, examples where practical connections are being made in fields traditionally not thought of as STEAM. Some example undergraduate programs in this category involve the integration of environmental sustainability and engineering into the fields of design [4,5].

Although implementation and success for these mixed curricula is increasing in popularity, the modern film industry is an example of where art and technology are not combined purely for pedagogy; rather they are naturally inseparable. Unfortunately, the structure of most institutional undergraduate programs separates STEM and Art degrees into differentiated colleges such as Fine Arts and Engineering or Science. MPS is the first of its kind – seamlessly integrating the fine art of film and fundamental engineering skills from the field of imaging science.

MOTION PICTURE SCIENCE

I. CURRICULUM

Initiated in 2007, this Bachelor of Science (BS) degree program entails a unique and multidisciplinary curriculum that is key to its success. The degree combines courses in imaging physics, computer vision, optics and color science with others in motion picture engineering and applied system design to acclimate students to current technologies and practices in the motion picture market. But it also incorporates coursework in screenwriting, film production, editing and color-correction. It is at its core a combination of the Bachelor of Fine Arts (BFA) Film and Animation and the BS Imaging Science degrees found at RIT, and students will typically find themselves integrated into both of these communities.

Starting in their first year, students are exposed to and educated in both ends of the STEM/Art spectrum. The degree requires not only the foundational project-based calculus and calculus-based physics sequences taken by all engineering majors at RIT, but also courses in traditional filmmaking and animation. This is done deliberately to expose technology-minded students to the artistic side of the business. They are tasked with these creative projects in classes taken alongside students earning BFA degrees in the School of Film and Animation. There is intentionally no segregation in these efforts. As creatives and technicians work side-by-side in the industry, so to do the students earning BFA and BS degrees produce works in a

collaborative environment every year of the undergraduate sequence. When looking into the landscape of job descriptions in the modern film industry, the combination of creative and technical skills is inherently crucial. Modern systems and processes make it impossible for any artist to be naïve to the complexities and capabilities of production and post-production tools.

The art- and/or STEM-related courses required for MPS students are listed in Table I for the first and second years and Table II for the third and fourth years, organized by their relevance to either or both of these fields. Figure 1 illustrates the number of classes taken in each discipline by year level. Notice that in the first two years of the degree, the students mainly take courses that are deeply rooted in either the art or STEM world, to develop foundational skills in both disciplines. In the last two years of the program, a majority of their courses are highly specialized to integrate both art and STEM concepts and information and to develop critical thinking skills. This prepares the students to use their foundational knowledge from both worlds in the field of their choosing upon graduation.

To further tailor their skills and experiences towards their individual interests, students are encouraged to take electives of upper level courses in any related disciplines. Students who enter the MPS degree with a stronger interest in artistic careers where technology plays a supporting role tend to specialize in advanced topics in cinematography, visual effects, animation and post-production.

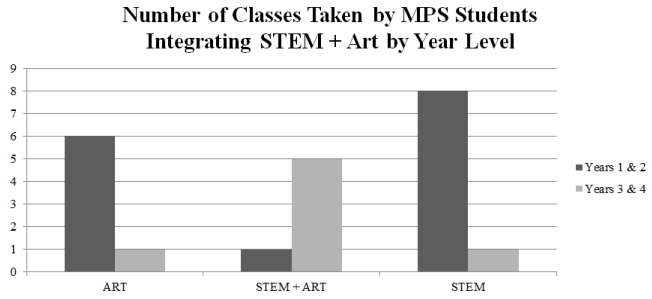

FIGURE 1
A PLOT OF THE NUMBER OF STEM-BASED, ART-BASED OR INTEGRATED STEM AND ART-BASED COURSES BY YEAR LEVEL

Students who foresee careers in technology and engineering to support the artistic community specialize in electives in electrical and microelectronic engineering, computer science and imaging science among others. Even with the natural collaboration of the arts and sciences in contemporary careers in film, many students find the actual career paths available to them to occupy particular points on a spectrum of mixed expertise between the two options. Thus it is not uncommon to find an MPS student who is interested in being an on-set digital imaging technician for a film's cinematography department working at RIT alongside another who hopes to design the actual imaging sensors and cameras for use in the next wave of cinema.

II. The Student Experience

Needless to say, students face challenges when being enrolled in a program that is multidisciplinary. In addition to experiencing the academic rigor of both STEM and Art classes, the social dynamics vary greatly due to the typical personalities and mindsets of people that gravitate towards each of these fields. This leads to extensive social opportunities for some students or potential cultural clashes and isolation for others. Since the MPS students split their time between two cultures, the film world of the traditional RIT BFA students and the scientific community of the RIT BS Imaging Science students, this can lead in some cases to a social disconnect. Some students initially have trouble identifying with one or both communities, feeling excluded by peers immersed more fully in just one of the two. College is already a new environment for students, a new world to find where they fit in. The disassociation that naturally comes with trying to combine students who would typically be found in either the art or science communities exclusively into one major can be a real challenge at a personal level.

As example in 2007 at the MPS program's initiation, both the Imaging Science and Film students had facilities devoted to work and leisure activities associated with their degree programs. These personal spaces are critical to a sense of belonging. At that time, though, there was no dedicated space for MPS students in either of the main buildings where they have class outside of that shared with the two legacy programs.

TABLE I
REQUIRED STEM AND/OR ART RELATED COURSES FOR MOTION PICTURE SCIENCE STUDENTS

	Years 1 & 2	
Art	STEM + Art	STEM
Film Production I,II	Film/Video Materials & Technology	Project-Based Calculus I, II
Film Survey	Basic Sound Recording	Freshman Imaging Project
Animation Survey		Calculus-Based Physics I, II
Production Processes		Radiometry
		Vision & Psychophysics
		Linear Math & Fourier Methods

TABLE II
REQUIRED STEM AND/OR ART RELATED COURSES FOR MOTION PICTURE SCIENCE STUDENTS

	Years 3 & 4	
Art	STEM + Art	STEM
Introduction to Computer Animation	Color Science Image Capture & Production Technology Digital Image Processing & Computer Vision Digital Post-Production Technology Film Projection and Digital Cinema	Geometric Optics

Recognizing these shortcomings, numerous actions have been taken to better accommodate the students in this growing program. A dedicated space was established for MPS students to socialize and collaborate. The common space for Imaging Science students is now fully accessible to MPS students as well, as are RIT Center for Imaging Science funded micro grants (previously available only to Imaging Science students to pursue research projects). The MPS program chairs have been developing a sense of culture and community among the MPS students themselves through frequent program meetings and annual travel opportunities to motion picture technology-related conferences and facilities. Increased enrollment in the program, illustrated in Figure 2, has also led to a greater sense of community among the students and faculty. The program has gained the necessary population to host its own community and the consistent rise in enrollment is an indicator of increased interest from prospective students, which translates to program success. With all of these improvements, MPS students now have social experiences and networking opportunities comparable to other programs at RIT.

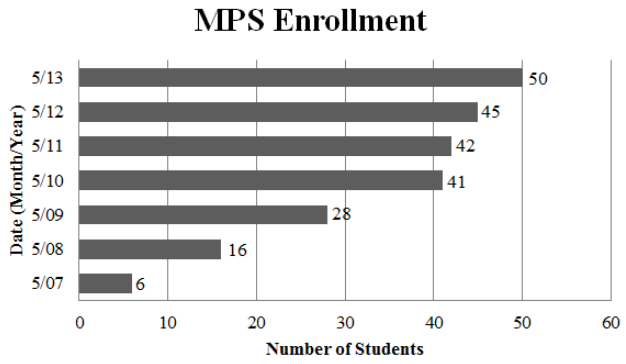

FIGURE 2
A PLOT OF THE NUMBER OF STUDENTS ENROLLED IN THE MPS MAJOR ASSESSED IN MAY OF EACH YEAR SINCE THE PROGRAM BEGAN IN 2007

Despite potentially rocky social beginnings for MPS students who are stuck between the two realms, there are undoubtedly scenarios in which their unique combination of skills and knowledge give them a sense of value and confidence. A majority of the Imaging Science students lack filming and editing experience, while the MPS students learn to use various types of cameras and professional editing programs such as the Final Cut Pro and Adobe Premiere suites during their first year film classes. This gives MPS students a broader perspective on imaging technologies, as they understand the filmmaker's methods and processes. In the artistic world, film students and faculty appreciate the technical interest and capabilities of MPS students. Obviously there are benefits to the integration of STEM and Art in the academic setting, but there are also challenges. These challenges are continuously addressed by faculty to refine the program and update the curriculum while also holding true to the needs of industry.

III. MPS Students After Graduation

Being a relatively new program, MPS has had four graduating classes and boasts a 96% placement into motion-picture or imaging fields with most positions based in New York City and Los Angeles. The most popular companies where MPS students have been placed are:

- Apple
- Arri
- Deluxe Laboratories
- Dolby
- Exelis
- IMAX
- NBC Universal
- HBO
- Sony Pictures Entertainment
- Technicolor
- UTC Aerospace Systems

Within the denoted companies, MPS graduate can pursue a range of careers that fall in various places on the STEM/Art spectrum. Some produce films while others engineer solutions for government contracted imaging projects. The top career titles that MPS students pursue after graduation are [6]:

- Post-Production Engineer
- Imaging Scientist
- Color Scientist
- Software Engineer
- Special Effects Technician
- Technical Cinematographer
- Sound Designer

To understand the various careers that graduates of the program have pursued and how they would classify their jobs, a survey was distributed to the alumni. The responses depicted the natural diversity amongst MPS participants, falling on all different positions of the STEM/Art spectrum. One alumnus works on classified government-contracted projects doing image quality analysis and algorithm development whereas another alumnus works as a color correction assistant to keep the color of films consistent through the entire post-production workflow. A different alumnus at NBC edits, does quality control, and delivers the resulting video to the various distributors of their programming. The career possibilities are truly broad for MPS graduates.

The distributed survey also inquired about the students' experiences in their careers after MPS, in order to try and assess if the graduates of the program felt adequately prepared to enter the industries of their choosing. Despite having diverse positions throughout the Motion Picture and Engineering industries, the positive responses are overwhelming. Many students began their education at RIT in other majors, but found themselves lacking passion and interest. Of those students, the BFA Film and Animation program was often appealing but lacked the promise of stable and regular employment, as is typical for film school graduates in the motion picture industry. Others were interested in computer science, engineering, or similar technical programs, but felt that a lack of art in their life would leave them unhappy. According to one student,

"I came into RIT as an electrical engineering student, however, found that was not my passion nor something I enjoyed, so I looked for a different major at RIT. I found MPS, which had a really interesting blend of art and technology. This was something I felt I could be better at... I never knew color science or imaging science was a real thing. Although some of it was stuff I was not interested in nor had a knack for, it definitely expanded my knowledge in these areas... I was stuck between wanting to do something engineering related but not wanting to abandon my love of arts. Originally I was thinking about double majoring in computer science and fine arts!! I know now that would have been a total disaster."

MPS has proven to be a perfect fit for such students whose interests span the artistic and technical fields, because it enables the students to pursue any job in either field. Two-thirds of the graduates who responded to the survey described their resulting skills as equally artistic and technical, while the remaining third considered their skills to be predominantly technical. Although every graduate leaves the program with different strengths from their peers, a majority noted that their diverse skills were essential to helping them stand apart from other applicants during the job search. When asked if MPS prepared students for their careers after graduating, the overarching response was,

"Absolutely." "Without MPS I would not be able to do my job - it prepared me with a combination of imaging science, color science, and hands-on experience with film/video technology. I still use the textbooks that we used during RIT classes, and I consistently use knowledge and techniques from courses and labs we did."

Overall, MPS graduates have left the program with a diverse set of skills that have prepared them for their job of choice in the motion picture and imaging industries. Further, they have enjoyed learning about how to be successful filmmakers as well as professionals who understand how the technology and systems necessary for modern motion pictures work.

CONCLUSIONS

Towards the future, MPS continues to grow and evolve. Some attention is still given to photochemical film-based workflows but less so as the industry adopts more digital practices. Added to the course offerings are experiences in computational photography, digital image processing, digital sensor design, computer graphics and digital color management. Computer generated imagery is replacing live actors and sets in increasingly complex film and television productions and coursework in computational algorithms and advanced imaging science are essential. MPS also continues to impact the workflows for student film production in the BFA program at RIT by contributing expertise in more modern professional practices. The digital video world is experiencing an explosion of capabilities and features that MPS students are uniquely able to harness and apply to the visions of filmmakers at RIT. Skill sets required by employers demand this constant re-assessment of what is taught, but the juxtaposition of technology and creativity remains the long-term key.

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AUTHOR INFORMATION

Victoria Scholl, Student, School of Film and Animation/ Chester F. Carlson Center for Imaging Science, Rochester Institute of Technology, Rochester, NY.

Megan Iafrati, Student, Chester F. Carlson Center for Imaging Science, Rochester Institute of Technology, Rochester, NY.

David Long, Associate Professor, B.S. Motion Picture Science Program Chair, School of Film and Animation, Rochester Institute of Technology, Rochester, NY.

Joseph Pow, Associate Director, Chester F. Carlson Center for Imaging Science, Rochester Institute of Technology, Rochester, NY.