

An Analysis on the Role of Computer Graphics and Animation in Zimbabwean Film Industry

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Abstract

The film industry has been shifting and advancing in such a manner that even actors can now be substituted with robots or animated cartoons to represent human beings in films. Artificial sceneries are now becoming difficult to distinguish from real places. Computer graphics and animation have greatly affected the operations of film production globally and proven to be an inevitable source that create and enhance realistic images and sound in films that resembles a real environment. Because of its flexibility, most audiences are now interested in scientific films, and similar genres which highly use computer graphics and animation. The introduction of computer has also increased demand for many digitalized and online platforms for such films. This study focuses on the existence of computer graphics and use of animation in Zimbabwean film and television production. The paper will trace the development of computer graphics and animation, and its future prospects. Presently, the Zimbabwean film industry has been less appealing to most Zimbabwean audience leaving the industry less competitive.

Keywords

Computer graphics, animation, technology, film, Zimbabwe

1. Introduction

Due to the rapid changes in technology, filmmaking has also changed a lot. Today, computer graphics (CG) is considered as the most important computerized communication tool, which film directors can rely on to communicate their dream effectively. CG and animation have now become a part of most cinema projects and gained lots of popularity worldwide with successful films such as Avatar, Kungu Fu Panda, Lion King, Black Panther, Avengers, etc. The use of latest technology like 3D animation and graphics has been able to draw a huge number of audiences, from children to senior citizen, to the theatres. It becomes important to explore if Zimbabwean filmmakers have been able to employ CG and animation in their film productions or not.

1.1 Background of the Study

The definitions of CG and animation are indistinct as they can be interpreted as anything using typography or imagery. Computer graphics (CG) is defined as a representation of image which is generated by computers with specialized graphic hardware and software (Kerlow, 2003). The art of creating moving visual images with a 2D or advanced 3D computer graphics is called animation or CGI (Computer-generated imagery). According to Salmon (2016), CGI application creates scenes and adds special effects in films and television that are not possible using camera. Graphics use images such as pictures, diagrams and similar visual representations (Salmon, 2016), and animations use a series

of graphics that change over time (Crawford, 2003). They further explained that specialized graphic hardware and software are used in computers to create computer graphics. Most filmmakers use 2D computer graphics which are easy to use, fast at rendering and require low bandwidth (Adamson, 2001). CGI and animation are the current fundamental aspect in editing a modern film. They both have become a very powerful tool which attracts a viewer's attention as they present complex ideas beyond a person's imagination, and thus they have proved to be fascinating and entertaining to all ages of audiences. In Zimbabwe, CGI has been employed mostly in informative advertisements and in some feature films like "Flame" where some scenes were manipulated with explosions, gun shots and other animated illusions.

CG and animation in Hollywood is believed to have emerged with Lumiere brothers, the creators of 'Cinematograph' - a small machine which could be used as a camera. They introduced 'mise – en scene' and created special effects that audience could easily relate to, for instance they could reproduce a place that actually exist. According to Salmon (2016), another method of creating a CG imagery for illusion of movement is to display an image on the computer screen, which is then quickly replaced by a new image that is similar to the previous image. According to Zagreb (2009), graphics is a means of visualizing ideas that the camera footage cannot. The CG-animated visuals include 2D or 3D cartoon, scenery or moving characters depending on the creativity of the filmmaker.

During 1980s, CG and animation were mainly used in commercial adverts, educational television programs (Mutsinze, 2016). Since 1992, Zimbabweans started to equip and update software to produce animated visuals. Chaz Maviyane-Davies was one of the first Zimbabwean CG designer to use Commodore Amiga and Macintosh as a critical design tool which could draw more accurately than other methods. By 1991, companies like Danes Design were already winning awards for their work. However, most filmmakers in Zimbabwe still lack knowledge on CG due to the lack of tertiary educational facilities that offer such skills. Presently, Nafuna is the only official existing CG and animation institutions in Zimbabwe, which was established in 2012 by Nqobizitha Mlilo. The institution has been providing most of the digital design and animation services (Mutsinze, 2016). There is also an organisation called Joint African Animation Group (JAAG), which was established by Solomon Maramba and Malvern Danda. The organisation has about 80 members on social media and has been holding awareness campaigns to promote animation to be recognized as an industry.

1.2 Statement of the Problem

The advent of technology brought so many changes in the production of a film. Zimbabwe, as a developing country, has not been able to afford to purchase some of the equipment and software required to be competitive with other film industries. CG and animation has emerged as the most significant production process which is used in film making. This evolution of production has affected the audience preference of films as most viewers are now accustomed to films on satellite and online televisions with computer-generated imagery. The lack of use of advanced CG and animation in Zimbabwean film production has caused most audiences to shift from the national broadcasting television (ZBC TV) to satellite TV (such as DSTV, Kwese tv) for films and entertainment. The Zimbabwe film industry has become less lucrative for investment and has lost young audiences who prefer animated content offered on VOD and DSTV platforms.

1.3 Objective of the Study

The purpose of this study is to explore the extent to which CG and animation is being employed to produce films in Zimbabwe. The paper investigates the usage and impact of CG and animation in the modernization of filmmaking in Zimbabwe. The paper also forecasts the future of film production in Zimbabwe on the basis of the current challenges that filmmakers in the industry are encountering.

2. Literature Review

This study will focus on the visual nature of CG and animation - a new production process that edifies and manipulates the footage captured by the camera. How CG and animation complements a camera to create events and characters used as a footage? Theories like Visual Realism by Rowley (2005) are useful in understanding the role of CG and in controlling or enhancing realism. According to DelGaudio (1997), there is no pre-existing reality as animation film exists based on the artist's imagination and the re-enactment creation which replaces the camera to capture the real

events. Many filmmakers believe that real-life documentaries distort realism through editing even without the involvement of CG. It can be concluded that there is no realism in films as some scenes are reconstructed. However, it is necessary to use CG to create footage that one cannot capture in real life, for instance CG was needed to create a true historical footage of sinking of Titanic ship in the film Titanic needed to be regenerated because of the absence of real footage. Hence, CG reconstructs past events and create imagination into something called augmented reality (Chastine and Zhu, 2008) using tools such as Maya, 3DS Max (Autodesk, 2010). This study uses realism theory to assert the existence of use of CG in Zimbabwean films. According to Rowley (2005), there are six types of realism as stated in the table 1 below.

Table 1. Types of realism

Types	Details
Visual Realism	It assess the extent to which the animated environment and characters are understood by the audience compared to the ones from the actual physical world. Software like Maya, a 3D modeling software (Autodesk, 2010) provide advanced rendering techniques for filmmakers to create realistic objects and landscapes with vivid texture and lighting. This software is easy to use even for filmmakers who do not know how to draw.
Aural Realism	It is almost similar to the visual realism. It is the enhancement of convincing sounds using CG, for instance the sound of birds can be recorded.
Realism of Motion	It contrasts with characters moves and motion. It is a series of illusions from static images, and natural laws of physics are used in production in order to convince the audiences that the objects are real. It includes the computer generated characters (animation) and objects created accords and sensors with real human actors. This increases a sense of realism in motion.
Narrative and Character Realism	It attempts to make fictitious events seem real. It uses soft ware that convince audiences that what they are watching is real. Filmmakers can now control what they feel they might need in their production without boundaries in their imaginations to visualize what's in their thought. Now filmmakers have the power to manipulate the skin of an actor or produce animated characters, realistic environment to achieve more realistic results. According to Mutsinze (2016), Zimbabwe have used elements of CGI in films like Neria (1992) for car explosions reflecting the use of narrative.
Social Realism	It creates a diverse and complex world of animation which represents the world or makes audience believe that the event indeed took place in this real world which is fictitiously designed. This conviction is based on what objects or environment the society itself can relate too.
Psychological Realism	It shows the emotions of animated characters. This type of realism is significant as characters in film are a conviction to audiences that the animated characters are as emotional as human characters. The use of original or hand animated three-dimensional world techniques and other technique, such as rotoscoping, is largely employed in animated film Moana (2016).

2.1 The History of CG and Animation

In primordial era, people used to draw and paint into caves with tools, such as bones, as a way of visually expressing their ideas and experiences. The advancement in technology continued to evolve, and today we have graphic designers and animators who use computers to design. Through software, algorithms, mathematical formulae and coding, computers have become a special aid that generate visuals. Image processing software have also been a useful special effects in film industry, architectural design and engineering to produce 3D models and objects. Animation is believed to have emerged from the theory of thaumatrope (a Greek word which means wonder turner) that create an illusion of movement designed by Paul Roget in 1828. It was later developed in 1843 by William Horner, a British mathematician, who introduced zoetrope ('wheel of life') which produces an illusion of movement from static pictures.

The technological development in cinema brought so many changes in animation. The most significant development was the introduction of sound in animation by Walt Disney (McLaughlin, 2001) for producing films like Steamboat Willie in 1928 and a popular animation character Mickey Mouse (Wright, 2005). This marked the establishment of "golden years" for animation (Bendazzi, 1994; McLaughlin, 2001). This development created a demand for more animated films, and even animated television series such as Sofia the First and formation of big companies, especially

in North America, that employed a large group of people and technicians who were responsible in the creation and development of animated films. The commercialization of CGI largely resulted in abundance of science fiction (SF) movies and visual effects (VFX) from 1970s.

Films like Terminator I, were created when the CGI was still on its early stage and most of the materials were constructed out of real rubber and silicon using robotics, but it was very costly and time consuming. The poor technologies gave an unrealistic look of terminators and limited the creators' creativity. However, the use of CGI reduced the use of construction materials bringing more realistic actors in Terminator III. According to Jones and Oliff (2007), the new advanced software are so delicate to the extent that it is very difficult to acknowledge the unreality in objects and events created.

Animation usually is helpful when there is more narration material than footage, for instance, crime-related documentary can be animated through a 'flythrough', a CG-generated building might be shown for crime site while the narration is running. Visual effects are needed in the case of the absence of footage to portray what could not be captured by a camera for filmmaking as some of the things may not physically exist, for instance a scenery of another planet which is not the Earth. 3D animated CG reconstruction are aiding tools that can portray such scenery in films (Jones and Oliff, 2007).

2.2 The Role and Significance of CG and Animation in Film and Television

Paul Wells view animation as an omnipresent pictorial form, the most significant creative development of the 21st century. The existence of computers resulted in the creation of CG and animation in filmmaking, more global distribution channels were also established. As a result, film have been turned into one of the cultural competition medium among different countries. The invention of filmmaking has always been based on the creativeness of artist, innovative ideas, constant change in technology and the hunger to be competitive (Hesmondhalgh, 2002). The animation industry has proven to be very profitable, sustaining wider animation markets for studios like DreamWorks and Disney in the global film market. CGI and animation have created new partnerships between countries, and Canada is a perfect example for collaborating animation with more than 20 countries for co-productions (Raugust, 2004). These co-productions have resulted in (i) fresh creativity from other countries, (ii) growth of Canadian film industry, (iii) shared cost of production, and (iv) opening of new marketing distribution channels in countries that they have partnered with.

It has been established for a very long time that CG and animation products were basically cartoons which were meant to entertain children (Mortimer, 2004). He noted that there is a learning process that occurs when a child is watching a cartoon and this largely affects the child's behavior. Hence, cartoons influence how the child interact with their counterparts and perceive the world. However, Crawford (2003) mentioned that cartoons can bring an illusion to children under the age of 7 who still have a difficulty in distinguishing the difference between reality and fantasy as some children will turn out to be aggressive because of violent animated films they watch.

The fact that it has received just a few academic attention from scholars like Paul Wells with publications that include Art and Animation (1997) and Animation and America (2001) shows that the subject have been under researched. However, the evolution in technology has made animation to the masses and today it is one of the fastest growing industries. The use of cheap software and fast rendering of CGI animation has brought the emergence of satellite and online TV which has increased the popularity and demand of animated films that in the past were considered as films for children, however recently the content and editing software has been constantly advancing to create realistic animation series like The Simpsons for adult audiences. The use of CGI and animation has enabled productions to diversify and generate products, such as video games like Fifa, which is highly popular among adults too (Raugust, 2004).

Kerlow (2003) noted that there has been intensive competition among the television broadcasters, all with the intention of dominating the market. The advancement in 3D computer animation technology has resulted in quality films. Software such as 3D studioMax have been employed to films like Jurassic Park in 1993 - the movie mixed real actors to interact with dinosaurs through CGI (Acuna, 2014). They all contain plenty of special graphics effects and 3D animation. This technology has improved the editing efficiency, thus enabling filmmakers to create moving effects for landscapes and objects through the application of animation. CG and animation have proven to be one of the best technological development in filmmaking. There is a lot that filmmakers would fail to articulate as some of the content

may not exist in the real world or might be inaccessible, for instance when creating an object, colour brightness and the shape must at least be in compliance with the audience's aesthetic psychology for acceptability. CG and animation has become highly popular among filmmakers to explore creativity and imagination that cannot be captured by a camera.

One of the first film to be influenced by the use of CGI is 'Titanic', which fascinated a lot of people as it was based on a historical event and the footage had to be reconstructed. Some of the evident usage of CGI include the ocean and sinking of ship with thousands of people. CGI always present new opportunities in film industry, for instance the destruction scene of New York City shown in the film 'The day after tomorrow' (2004). This was only possible from the photographers who had to capture over 50,000 photos of New York in order to produce a real 3D model of a city and apply a digital wave to destroy the town in the movie. The successful development of CGI and animation has resulted in movies like "Avatar" by James Cameron, which was scripted decades ago and was later successfully developed as per the writer's imagination such as flying dragons, human-like creatures with detailed facial expressions and some of real human attitude called Avatars. This movie introduced different kinds of new techniques, for instance a rain forest, waterfalls and plants created a realistic feeling among audience (Florida, 2002).

Furthermore, the establishment of local CG and animation education facilities are essential to produce local graphic designers and animators in order to reduce the employment of expensive professionals from overseas. Such educational facilities will help: (i) to significantly improve the efficiency of the film production processes, (ii) filmmakers benefit artistically when designing, (ii) to gain communication and management skill techniques that will allow a person liaise with other technical crew, work under pressure for long hours and unlimit one's creativity (Wright, 2005). Trained graphic designers will always consistently invent something indigenous, and go beyond an average person's imagination to produce intuitive visions in order to remain competitive and put their skills in use. Wright (2005) encouraged that there is a great need to constantly develop new software for film and television for the continuity of entertainment.

3. Research Methodology

The paper basically presents the results from the pilot study conducted among Zimbabwean film stakeholders about their use of CG and animation in their films, and their understanding on related subjects like visual effects and 3D modelling. The research used qualitative approach to gather required information, using both primary and secondary sources. Primary source included questionnaires with both open and closed ended questions on the use of CG and animation in Zimbabwean film and television industry. The targeted sample were filmmakers in Harare, students from Midlands State University who are studying film, and CG artists and animators in Zimbabwe. About 20 individuals (4 filmmakers and 16 students) were identified for the pilot study, but only 16 of them returned the completed questionnaires. The survey questionnaires were sent and received via email. Secondary sources included conference papers, journal articles, national reports, online sources, etc. The study used films produced from 2010 till-date to illustrate the successful use of CG and animation by Zimbabwean filmmakers.

4. Findings and Discussion

4.1 Data Presentation and Analysis

CG and animation have proven to be a very powerful tool in film production which have attracted huge number of global audience. According to Mutsinze (2016), the local film and television in Zimbabwe has lost a large number of audience who rather prefer to use digital and online platforms such as DSTV and Youtube. Hence, Zimbabwean film industry needs to include CG and animation if they want to be internationally competitive. An estimated 36.7% of Zimbabwean filmmakers use CG and animation (Mutsinze, 2016).

The results from the survey showed that most of Zimbabwean filmmakers are aware of the importance of CG and animation, and also understand its necessity in modern film production process. However, most audiences seemed to lack the importance of CG and animation in films, except they concluded that animation is for those who are interested in producing cartoons. It was observed that most of the respondents (about 69%) prefer watching films on DSTV and other online platforms (Figure 1) because of ease of access and enhanced digital contents. Even, some filmmakers acknowledged that their films lack digital content which needs to be quickly rectified.

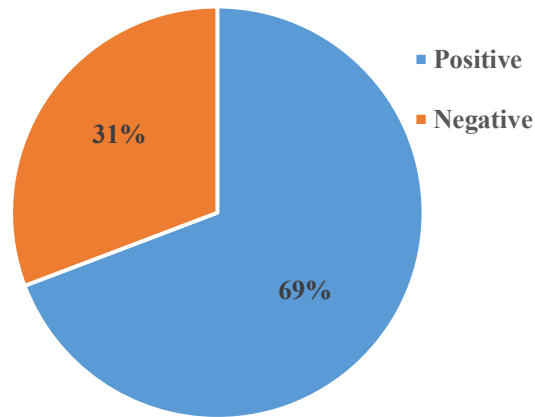


Figure 1. Respondents' preference to DSTV and online platforms

When asked about the impact of using CG and animation in films and television, more than half of the respondents (about 56%) acknowledged that it would have positive impact (Figure 2). These respondents mentioned that CG nowadays is very essential as it has become one of the major component of filmmaking process that is used to artistically express and visualize a script in a more advanced way. They expressed that animation can improve the quality of film production in Zimbabwe and cut production cost by at least 60%. However, the advent of these technological system has been a little bit expensive for filmmakers to use in the current economic crisis in the country, hence purchasing broadband to make a film is currently out of context. Therefore, most filmmakers and other television programs broadcasted on national television have decided to use alternative cheaper software (e.g. adobe software) to enhance some visual and sound. About 25% respondents thought that CD and animation have negative impact towards children. They believed that children's behavior are highly influenced by animated films that they watch.

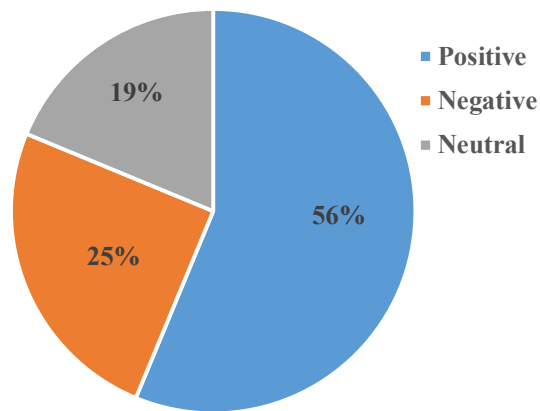


Figure 2. Impact of CG and animation

4.2 Challenges Faced by Existing Animators in Zimbabwe

There is lack of appreciation of CG and animation in Zimbabwe as most filmmakers are not aware of the advantages of CG in enhancing the quality of films (Povo magazine, 2012). As a result, the talent of animators is not exploited to the fullest in the film industry, and hence it cannot be recognized at international level. Lack of support from both the Zimbabwean audience and the national broadcasting service has been one of the greatest challenge that the filmmakers have been encountering (Povo magazine, 2012). The current economic environment can neither permit animators to produce a complete animation film as broadband in Zimbabwe are expensive nor allow audiences to go to cinemas frequently to watch films. The industry also lack competent professional animators who are trained in CG and animation. Marimba recommended that filmmakers should be equipped with CG skills to modernize the production of films in Zimbabwe for better quality production.

The Zimbabwean animators are facing various challenges (Mutsinze 2016), some of which are indicated in table 2 below.

Table 2. Challenges being faced by Zimbabwean animators

Area	Challenges
Absence of investors	Inadequate money to buy necessary equipment and software.
Lack of training facilities	Most tertiary institutions do not offer animation courses.
Lack of human resources	Most of the trained animators and graphic designers have migrated to other counties.
Bad economy	The country has been going through some economic hardship and it has been difficult for animators to buy equipment.
Poor domestic market	The local market is stagnant. Zimbabwe has not managed to exploit the advantages of CG and animation. Local advertisers and filmmakers lack the knowledge of this new way of producing a visual content. Most Zimbabwean audience who are interested in animation films watch them online or on satellite television.
Lack of international marketing relationship	Currently, there are no signs of any international partnership for exchanging skills, exhibition that might benefit the Zimbabwean animators.

It was observed that CG and animation has been largely employed in Zimbabwean advertisements for persuasiveness. The intention of most commercial advertisers' is to attract as many customers to purchase their products. Hence, they can afford to employ a graphic designer to add value to their products and services. However, most Zimbabwean filmmakers cannot afford to employ graphic designers.

5. Conclusion and Recommendations

This paper investigated the existence and use CG and animation in Zimbabwean film industry. In Zimbabwe, CG and animation has been largely employed by advertisers than filmmakers as most filmmakers cannot afford software to modernise their film production. Most filmmakers acknowledge that it is the major reason behind the loss of interest in Zimbabwean films as they are not digitally enhanced compared to films offered on digital and online platforms. Availability of funding is the main barrier for the growth of the film industry as they are not able to produce animated films due to the lack of the equipment, skills and other facilities. There is no doubt that the advent of CGI and animations only has exceeding benefits and in the future most of the footage will be based on modern technologies and software. Science and technological advancement must be adopted in cinema for its effective communication and entertainment. When more creative applications of CG and animations are incorporated in films, the impact is huge because the success of films nowadays depend upon young audiences, as more youngsters are attracted towards enhanced visual effects and animation in films. The use of visual effects, CG and animation in cinema definitely changes the mindset of the younger generations towards scientific advancements. This study suggests incorporation of CG and animations work in films, which will strengthen the communication and entertainment aspects of films. Therefore, the study outlines following recommendations for Zimbabwean film industry to maximize CGI and animation to for competition advantage.

5.1 Recommendations

Zimbabwe lacks CG and animation in most of their films, and most animated films are imported. The following recommendations will be useful for the film industry in Zimbabwe.

- i. Zimbabwe should conduct CG workshops to spread the knowledge among local filmmakers about the importance of special effects to enhance their films and be competitive in the globalized open market.
- ii. Tertiary institutions should include CG and animation disciplines just like any other discipline. If possible, it is recommended to add animation from primary level in order to motivate children who have passion in art and drawing.
- iii. There should be a research initiative that shall include experts from CG and animators, academics and practitioners to develop new methods and advanced software to sustain the film industry in the future.
- iv. International partnerships should be formed for exchange of skills and to acquaint themselves with various festivals that will help them improve their films.

- v. A detailed pilot project should be evaluated, materialized and presented to the government so that the initiative will be funded. This might be the beginning of a well-established, sustainable organization for CG and animation in Zimbabwe.

References

- Acuna, K., How 4 Minutes of CGI Dinosaurs in 'Jurassic Park' Took a Year to Make, 2014, Available <http://www.businessinsider.com/how-cgi-works-in-jurassic-park-2014-7>, April 14, 2018.
- Adamson, J., *Tex Avery: King of Cartoons 1975*, New York: Da Capo, 2001.
- Autodesk, 3DS, Available: autodesk.com, 2010.
- Bendazzi, G., *Cartoons: One Hundred Years of Cinema Animation*, Bloomington: Indiana University Press, 1994.
- Chastine, J. and Zhu, Y., The Cost of Supporting References in Collaborative Augmented Reality, In *Proceedings of Graphics Interface 2008 (GI '08)*, Windsor, ON, Canada, Canadian Human-Computer Communications Society, 2008.
- Crawford, A., The Digital Turn: Animation in the Age of Information Technologies, Prime Time Animation: Television Animation and American Culture, eds. Stabile, C. and Harrison, M., New York, 110-130, 2003.
- DelGaudio, S., If Truth be Told, Can 'Toons Tell It? Documentary and Animation, *Film History*, 9 (2), 189-199, 1997.
- Florida, R., *The Rise of The Creative Class: and How It's Transforming Work, Leisure, Community and Everyday Life*, New York: Basic Books, 2002.
- Hesmondhalgh, D., *The Cultural Industries*. London: Sage Publications, 2002.
- Jones, A., and Oliff, J., *Thinking Animation: Bridging the gap between 2D and CG*, Boston, MA: Tompson Course Technology TTP, 2007.
- Kerlow, V. I., *The Art of 3D Computer Animation and Effects*, London: Sons, 2003.
- McLaughlin, D., A Rather Incomplete but still Fascinating History of Animation, *The History of Animation*, University of California, LA, 2001.
- Mortimer, R., Kids TV Brands need to go Global to Compete., *Brand Strategy*, 186, 12-13, 2004.
- Mutsinze, Q., An Investigation in the Growth and Use of Computer Graphics and Animation in Zimbabwe: Present and Future Prospects, 2016.
- Povo Magazine, The Birth of Animation in Zimbabwe, Interview of Nqobizitha Milio, 2012.
- Raugust, K., *The Animation Business Handbook*, New York: St. Martin's Press, 2004.
- Rowley, S., Life Reproduced in Drawings: Realism in Animation, *Animation Journal*, 2005.
- Salmon, V. L., *Computer generated images (CGI)*, Salem Press, 2016.
- Wright, J.A., *Animation Writing and Development: From Script Development to Pitch*, Burlington: Focal Press, 2005.
- Zagreb, A Retrospective Programme of Zagreb School of Animation. Zagreb: Zagreb World Festival of Animation, 2009.

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