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Filmmaking courses for scientists help promote richer alternatives to chronological narratives

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ABSTRACT

Scientists have the tendency to communicate their scientific accounts using linearly structured narratives (Introduction, Methods, Results and Discussion; IMRAD). Likewise, the linear narrative is dominant – due to force of habit – when scientists prepare films about their research. Yet, this does not necessarily have to be the case for the new generation of scientists-as-filmmakers, who is trained to appreciate and apply alternative narrative structures. We evaluated the narrative structures of scientists from Swiss universities and research centres. Before the filmmaking courses, 94.1% of participants would use the linear narrative structure in their films, while the remaining participants would use one of the other alternative narrative types. However, after participating in the filmmaking courses, the number of potential users of the linear narrative fell almost 11-fold, and this type of narrative became the least popular. By contrast, after the courses the before-climax-backwards narrative experienced a 79-fold increase in potential use. The parallel, frame and end-backwards narratives had seven-, six- and four-fold increases, respectively. The filmmaking courses also dramatically increased the number of types of narratives that participants would consider using. Filmmaking courses for scientists help scientists-as-filmmakers make a clean break from linear narrative structures in favour of other more varied structures.

KEYWORDS

Chronological narrative; non-chronological narrative; linear narrative; alternative narrative; end-backwards narrative; before-climax-backwards narrative; frame narrative; parallel narrative; Switzerland

Introduction

Science films are an excellent tool for communicating science to peers and the general public (Career Feature 2018; CUNY TV PBS 2016; National Academy of Sciences 2008). In recent decades, the demand for science films has increased hugely. However, this expanding demand cannot be entirely satisfied by professional filmmakers. Thus, universities and scientific institutes are now encouraging their scientists and students to produce their own films by setting up accredited filmmaking courses as part of their science communication programmes. This has given birth to a new generation of scientists-as-filmmakers, that is, ‘scientists that assimilate filmmaking as part of their academic preparation, albeit not in a professional way’ (Angelone 2019). Besides, learning filmmaking has a direct application for science films and can also help improve oral and written scientific communications (Dahlstrom 2014; Jones and Crow 2017; Martinez-Conde and Macknik 2017). Nevertheless, it is not
clear how these courses will affect the films produced by the next generation of scientists-as-filmmakers, e.g. the narrative structures of the documentary films.

Although ‘narrative’ and ‘story’ are often used as synonyms in informal contexts, these two concepts are somewhat different in meaning. A story refers to the content, that is, the events (actions) and existences (settings and characters) that are being related, while narrative is more concerned about the how this content – via points of view, narrative voices and plots – is presented to readers/audience (Chatman 1980). Two temporal sequences combine in every narrative: (i) chronological time in which events unfold (story time) and (ii) narrative time, that is, the time it takes for events to be told (Genette 1983). A narrative is ‘narrated’, while events in a story ‘happen’ (Kim et al. 2018). Jean-Luc Godard summed up the differences between story and narrative as follows: ‘A story should have a beginning, a middle and an end, but not necessarily in that order’ (Sterritt 1999). The ‘not necessarily in that order’ is the narrative.

A non-linear narrative is a storytelling device that does not portray the events of a story in chronological order; this may mean a reverse order, going back and forth between past and future events, or even switching between one parallel plot and another (Kim et al. 2018). In the non-linear narrative the relationship between events does not follow the original cause–effect sequence, the purpose of which may be to heighten the mystery and tension. A narrative can withhold information, which is revealed at a later point. Another possibility is to start in the middle of the story or even at the end, and then travel back to the same point in order to capture the audience’s attention immediately without any need for detailed descriptions (Aarseth 2012; Chatman 1980). Patterns of non-linear narratives and their effects on audiences, as well as how audiences perceive such story lines, have been well studied in many media contexts (Genette 1983; Propp 2010). Appreciating and applying non-linear narratives is not necessarily an intuitive task due to the often complex temporal disruptions in event sequences and the non-explicit recording of the temporal order of the story (Kim et al. 2018).

Scientists tend to communicate their scientific stories using linearly (chronologically) structured narratives based on the classical main sections of scientific manuscripts: Introduction, Methods, Results and Discussion (IMRAD) (Sollaci and Pereira 2004). Indeed, even the sub-sections are usually chronologically presented (e.g. in Methods fieldwork comes before laboratory work) and, given the nature of scientific publications and presentations, it is understandable that this tendency is closely adhered to in films. Consequently, it comes as no surprise that linear narratives are dominant – due to force of habit – when scientists make films and that the alternative types of narratives that film as a media offers are rarely taken into account.

The aim of this paper is to understand and predict how filmmaking courses will affect the narrative structures used in future documentary films produced by the new generation of scientists-as-filmmakers.

**Methods**

**Filmmaking courses’ organisers, trainers, and participants**

There is a general consensus in Swiss universities and scientific institutes that scientific outreach programmes are needed, mainly to bridge the gap between science and society (Leshner 2003). Hence Swiss universities and scientific institutes established and funded numerous outreach programmes, among them filmmaking courses (Angelone 2019).

Authors of this paper were responsible of establishing the curricula and teaching these courses. Changing narrative structures was one of the designated desired outcomes of these filmmaking courses, through teaching participants alternative narrative structures.

Our study included 102 scientists (mainly PhD and post-doctoral students) from nine Swiss universities and research centres: seven universities (Zurich, Geneva, Lausanne, Fribourg, Neuchatel, Basel and ETH Zurich) and two research centres (Swiss Federal Institute for Forest, Snow & Landscape Research WSL, and Swiss Federal Institute of Aquatic Science & Technology EAWAG). The organisers
worked together on common programmes in the preparation of some of filmmaking courses and, for example, Life Science Zurich (which includes Zurich University and ETH Zurich) worked in close collaboration with the Conférence des Universités de Suisse Occidentale (which includes the universities of Geneva, Lausanne, Bern, Fribourg and Neuchatel). The participants, of whom 73 were women and 29 men, had different scientific backgrounds.

Course description

Our study analysed a wide variety of the filmmaking courses taught in Swiss universities and research centres in 2015–2018.

1 Storytelling and storyboarding science: these are two–four-day courses. The main aim of these theoretically oriented courses is to teach scientists how to borrow narrative attributes and techniques of storytelling from filmmakers and apply them in their communications (i.e. in their abstracts, presentations and scientific papers). Scientists also learn how to watch and analyse films from a technical standpoint, and how to convey the ideas behind scientific narratives to professional filmmakers. Attending film festivals (e.g. the Locarno Film Festival and Global Science Film Festival) sometimes forms part of these courses and allows participants to analyse screened films and have professional discussions with filmmakers (e.g. Science Film Academy 2017).

2 Filmmaking for scientists: these are more technically oriented courses, where scientists learn how to prepare their own films. During two–five-day courses, participants are taught mainly how to work with camera, lighting and sound equipment. They are also taught the basic of storytelling, script, storyboarding and editing techniques. Producing short films by the end of the courses is usually an essential part of these courses, especially the longer ones. Produced films are usually directly related to the scientific research of the participants (e.g. Life Science Zurich, Zurich University and ETH Zurich 2015).

3 Science filmmaking marathon: in these usually competitive, four-day courses, scientists and filmmakers work in small groups to produce films. Shortly before these courses, scientists are introduced to basic filmmaking techniques. The resulting films are not necessary related to the scientific research of the participants but are scientific in content in a general sense. At the end of the marathon, the resulting films are usually screened to the public and a special jury (e.g. Swiss Academy of Sciences SCNAT 2017).

For more details see Table 1.

Non-linear narrative structures

The participants in all courses were taught to recognise and apply four alternative narrative structures that we believe are appropriate for simple science films:

1. Two in media res structures

In media res means that the film begins in the middle of the storyline rather than at the beginning. Two different in media res structures were taught; namely, starting a story in the middle (before climax–backwards) or even at the end (end–backwards), and then doubling back to the same point. This technique aims to grab the audience’s attention without any detailed introduction by placing the audience immediately right in the heart of the action. A simple example of an end–backwards structure involves introducing the main results and then moving backwards to the IMRAD. A successful before–climax–backwards structure can be achieved by presenting part of the results (not the main results) at the beginning, and by then moving back in time to the IMRAD.

II. Parallel and frame structures
<table>
<thead>
<tr>
<th>Course</th>
<th>Course Content</th>
<th>Duration (days)</th>
<th>Participants</th>
<th>Number of Participants</th>
<th>Credit Points</th>
<th>Date</th>
<th>Organizers and Hosts</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Filmmaking for Scientists</strong></td>
<td>Mainly, how to work with camera, lighting and sound equipment. As well, storytelling, script, storyboarding and editing techniques. Films are related to the participants’ own scientific research.</td>
<td>two–five</td>
<td>PhD students but master’s and post-doctorate students are also considered.</td>
<td>10–15</td>
<td>one–two</td>
<td>2015–2018</td>
<td>Conference des Universités de Suisse Occidentale (Universities of Geneva, Lausanne, Bern, Fribourg and Neuchatel), Life Science Zurich (ETH and Zurich University) and Zurich-Basel Plant Science Center (ETH, Zurich University and Basel University)</td>
<td>e.g. Life Science Zurich University and ETH Zurich (2015).</td>
</tr>
<tr>
<td><strong>Science Filmmaking Marathon</strong></td>
<td>The basics of filmmaking techniques (storytelling, script, storyboarding and editing techniques, cameras and lighting and sound equipment)</td>
<td>four</td>
<td>PhD students but master’s and post-doctorate students, and researchers are also considered. Filmmakers also participate in this workshop.</td>
<td>25–40</td>
<td>two</td>
<td>2017</td>
<td>Swiss Academy of Sciences, Life Science Zurich (ETH and Zurich University), Conference des Universités de Suisse Occidentale (Universities of Geneva, Lausanne, Bern, Fribourg and Neuchatel), Swiss Federal Institute for Forest, Snow &amp; Landscape Research (WSL), Swiss Federal Institute of Aquatic Science &amp; Technology (EAWAG) and Science Film Academy</td>
<td>e.g. Science Film Academy (2017).</td>
</tr>
<tr>
<td><strong>Storytelling and Storyboarding Science</strong></td>
<td>Storytelling, script and storyboarding techniques. How to communicate with professional filmmakers. How to borrow narrative attributes and techniques of storytelling from filmmakers. Attending film festivals to watch and analyse screened films, and to talk with filmmakers about their stories and storyboards.</td>
<td>two–four</td>
<td>Very wide range: undergraduate, master’s, PhD and post-doctorate students; associate researchers and lecturers</td>
<td>10–50</td>
<td>one–two</td>
<td>2017–2018</td>
<td>Swiss Academy of Sciences, Didactica (ETH and Zurich University), Department of Evolutionary Biology and Environmental Studies (Zurich University), Locarno Film Festival and Global Science Film Festival</td>
<td>e.g. Swiss Academy of Sciences SCNAT (2017).</td>
</tr>
</tbody>
</table>
Parallel and frame stories use narrative structures that rely heavily on the role of the narrator to convey layers of meaning. A parallel structure refers to two distinctly different, yet closely related storylines that occur simultaneously. Similarly, a frame structure – also known as an embedded narrative – consists of many smaller stories within the context or timeframe of a larger story. Each of the narratives within the timeframe can usually stand individually but have more meaning when analysed alongside the larger overall story. Simple examples of the parallel structure include the simultaneous presentation of two distinctly different yet closely related storylines (e.g. fieldwork and laboratory work), even if they took place at different moments in time. In the case of frame, different studies can be presented within the context of a larger one (e.g. different chapters within the context of a PhD thesis or different research focuses within the context of a single research group).

To avoid possible bias in the design and analyses of our study:

- The same person taught all courses.
- Even when filmmaking courses had different aims (learning theoretical or practical parts of filmmaking, producing films and/or borrowing narrative attributes and techniques of storytelling from filmmakers), duration (two–five days) and target audiences, the same didactical materials were used to teach participants how to recognise and apply narrative structures to film.

**Questionnaire**

Before the filmmaking courses began, the technical descriptions of different narrative structures (before climax-backwards, end-backwards, parallel and frame) were unfamiliar to participants. Even if participants did recognise certain narrative structures, they were unable to give them a name, and hence it was not possible to run the questionnaire at the beginning of the courses. To solve this problem, participants were asked at the beginning of the courses to think and write down all details (story, storyboard and the structure of the plot) about the films that they would like to make in the future. After having decided upon the details of the films (including the narrative structure, even if they were unaware of this technical terms) that they would like to film, participants were taught the four above-mentioned alternative narrative structures. Then, participants responded to a questionnaire about the narrative structures that they would have used before beginning the filmmaking courses and the ones that they would use after attending the courses. Each participant could choose more than one narrative structure (see the template of the questionnaire in Table S1).

**Statistical analyses**

To compare between the frequencies of the chosen narrative structures before and after the courses, a frequency analysis $\chi^2$ (Pearson’s Chi-squared test X-squared) was used. Fisher’s Exact Test for Count Data was employed to compare the frequencies of the chosen narrative structures for female and male participants, and to compare the results obtained from the different courses (filmmaking for scientist, storytelling and storyboarding science, and science filmmaking marathon). Non-parametric statistical tests (Wilcoxon signed rank test with continuity correction and Spearman’s rank correlation coefficient) were applied to compare the number of types of narratives that would have been used before and after the filmmaking courses. All analyses were carried out using R Package V.2.15.1 (R Development Core Team 2008) (Figures 1–3).

**Results**

Participants’ preferred narrative structures changed after attending the filmmaking courses (Pearson’s Chi-squared test X-squared = 154.5, df = 4, p-value <.001). Before the filmmaking courses,
94.1% of participants said they would use the linear narrative structure in their films and only a very few said they would use one of the alternative narratives, namely, end-backwards (6.9%), parallel (6.9%), frame (7.8%) and before-climax-backwards (1%). However, after the filmmaking courses, the number of the possible users of the linear narrative fell almost eleven-fold (only 8.8% of the scientists said they would use it) and this narrative became the least popular. By contrast, after the courses 77.5% of participants said they would use the before-climax-backwards narrative, a seventy-nine-fold increase, while 47.1% would use the parallel narrative (about a seven-fold increase). In all, after the course 46.1% of participants said they would use the frame narrative (six-fold increase). The end-backwards narrative increased four-fold, and would be used by 28.4% of the participants.

The filmmaking courses not only affected the choices of the narrative structures (a move from linear to alternative) but also increased the number of types of narratives that participants said they would consider using (Wilcoxon signed rank test with continuity correction V = 77.5, p-value < .001; Spearman’s rank correlation coefficient 0.42, p-value < .001). Before the courses, the majority of participants (84.3%) said they would use only one narrative structure and only 14.7% and 1% said they would use two or three different structures, respectively. However, after attending the courses, the number of participants who said they would use only one narrative structure fell to 44.6%, while the number of participants who would use two or three structures increased to 20.8% and 19.8%, respectively. Indeed, 12.9% and 2%, respectively, of participants said they might even use as many as four or five different narrative structures. There were no differences in the obtained results between the different courses (filmmaking for scientist, storytelling and storyboarding science, and science filmmaking marathon).

In all, 72% of the scientists who attended the filmmaking courses were female; there were no statistical differences between female and male scientists regarding their choices of the documentary
Figure 2. Narrative structures chosen by female and male scientists before (A) and after (B) the filmmaking courses.
modes they would use either before (Fisher’s Exact Test for Count Data, $p$-value = .264) or after (Fisher’s Exact Test for Count Data, $p$-value = .1787) the filmmaking courses.

**Conclusion & discussion**

When they have no filmmaking background, the linear narrative structure is the dominant intuitive choice for scientists. This mode possesses the same traits and conventions as those used in scientific narratives (e.g. scientific papers and presentations) (Olson 2015). The dominance of this structure can be attributed to the lack of knowledge of the possibilities that alternative narrative structures offer. Only a very few scientists said they would opt for a different type of narrative structure (even if they did not know the technical names of these alternatives). The differences between the alternative structures should have been intuitively obvious in the films they watched. The decision to use alternative narrative structures (before attending the courses) could be due to the type of scientific research participants were working on; however, our questionnaire did not include details about the purpose of the films or the targeted audience. For the same reason, due to this lack of knowledge, the number of preferred narrative structures was limited.

After attending the filmmaking courses the preferred narrative structure changed dramatically from lineal to alternative. Indeed, only a very few participants continued to prefer the lineal narrative. Most of the participants chose the *before-climax-backwards*. A large number of participants also opted for the two *in media res frame* or *parallel* structures. The *end-backwards* was also more often considered than before the filmmaking courses but was clearly less favoured than the other structures.
The shift from linear to alternative structures and the increase in the number of preferred structures could be attributed to participants’ beliefs that they would tell better stories using the new structures, or simply could be due to the participants’ curiosity regarding the narrative structures described during the course.

More female than male scientists participated in the filmmaking courses. Gender bias in science and art is an on-going debate and some authors argue that art education is female-stereotyped (Dalton 2001; Wikberg 2013).

Our results could be affected by the nature of the scientific background of the participant scientists and/or their targeted audiences. Neither factor was taken into account in our study.

There were no differences in the obtained results between courses, which was to be expected since the same didactical materials explaining the narrative structures were used in all the filmmaking courses. Less extensive courses are often just as effective as longer ones if the aim is only to learn how to recognise and apply alternative narrative structures; however, this was not the only aim of these science filmmaking courses.

We believe in the replicability of this study, since the studied narrative structures could be universally used in science films. Notwithstanding, the results could be affected by the experiences and training methods of the teacher and the chosen didactical materials.

This study highlights the importance of the filmmaking courses that universities and scientific institutes worldwide offer their students and scientists as a means of encouraging them to produce their own films. These courses should teach alternative narrative structures for scientific stories to the new generation of scientists-as-filmmakers and offer creative alternatives to linear narrative structures, thereby enriching the range of techniques used for portraying scientific insights.

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**Disclosure statement**

No potential conflict of interest was reported by the authors.

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