Producing and Communicating Scientific Topics for New Media: How Interactive vs. Linear Science and Technology Communication Videos Affect the Attentiveness of Audiences

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Abstract--**Science is a truly important part of human life. Scientific and technological concepts should be familiar to the public rather than abstract or seemingly irrelevant. To adequately communicate scientific information, the mass media need to provide appropriate information and channels so the community can acquire new information, and thus bring the generation of new innovations. In addition, new media have become quite essential and convenient for a new generation. The purpose of this study is to investigate methods of communicating scientific topics via new media to reduce costs and offer convenient channels for the audience, and compare the communication effects of interactive vs. linear popular science videos. In this application paper, the researchers produced two popular science videos, one interactive and one with a linear narrative regarding invasive species and environmental protection; the purpose was to investigate which narrative style was more effective in educating the audience regarding this issue. The researchers produced the popular science videos and launched an experiment with 50 persons. Both videos' stories are identical and both use animation. Based on the literature review and our experiment, this study found interactive videos to be more effective in drawing the audience's attention, piquing their interest and enhancing their understanding. For online interactive popular science videos, if the producer can find an adequate hyper-narrative type to arrange some "nodes" to allow viewers to answer questions or decide how the story will continue, more interest and engagement can occur. Those who watched an interactive version of a popular science video can obtain an average scientific knowledge score of 12.32 which is considerably higher than those viewers watching the linear version.**

I. RESEARCH PURPOSE

Science has a very important role in the development of modern societies, Wandersee and Roach [1] believe that science is the application process and the construction of knowledge regarding a phenomenon of nature. It's the basis for national developments, social progress, and an important indicator of overall competitiveness of a country. Therefore it relies on education to improve people's scientific literacy. Using media to convey scientific knowledge to the community is one of the best ways with diverse channels and platforms to pass science information and knowledge, and thus enhance the public's knowledge of science literacy.

Most people use their eyes and ears to experience their environment and to learn. Lee [2] indicated that mostly human beings receive 70% of their learning visually while hearing accounts for another 20% of learning. Therefore, if we use visual and audio media to help with education or science education, these can help learners to remember what they have learned and retain that knowledge for longer time.

Therefore, using videos or graphic images would be easier for an audience to understand scientific concepts. Many experts also suggested that using animations are helpful for audience to receive and realize complicated scientific knowledge. Park & Gittelman [3] investigated the effects of two computer-based instructional strategies -- visual display and feedback type -- in the acquisition of electronic troubleshooting skills. Firstly, they wanted to know if using animation would be helpful for learning skills. The first hypothesis tested was that animated visual displays would be more effective than static visual displays if animation was selectively used to support the specific learning requirements of a given task. Their research results supported this hypothesis by confirming that college students employing animated visual displays needed significantly fewer trials than those using static visuals. Secondly, they assumed that the effectiveness of intentionally mediated feedback (knowledge of results or explanatory information) would be minimal if natural feedback -- the system's automatic functional reaction to external inputs -- was available and the subject had the basic knowledge needed to understand the system functions. Their research also supported this hypothesis. Therefore, this study indicated that visual displays and feedback should be applied selectively based on the specific learning requirements of a given task and both of them would be helpful and more efficient for a learning procedure.

As Kukawadia mentioned in his TED video regarding science and storytelling, "Science is awesome, but science needs to do a better job of communicating that awesomeness to non-scientists. We're sitting on the frontiers of human knowledge, and yet we cannot get others as excited about this issue that we're very, very passionate about…. I realized that the way we can communicate science more effectively is to cast off the typical way we view science for academic purposes and consider it as part of a whole." [4] Based on the development of the internet, digital media and Web 2.0 technologies, the usage of diverse new media has become a trend for both mass media owners and their audiences. Many persons can post science communication contents online, e.g., via Youtube or other platforms, and seek to enlarge their audience while providing their viewers with content that is free. Encouraging non-scientists to get involved and excited about these scientific issues and helping to make scientific knowledge and discovery understood by greater numbers of people is of equal importance to the actual academic achievements of scientific research.

Some articles indicated the effectiveness of interactive videos, for example, for marketing products; Scott [5] said that video ads are forms of interactive media advertisements. Videos may appear automatically when a consumer visits a particular site, or consumers may have the options to view videos, to select the storytelling at their disposal. Scheidies also notes in his article regarding ways to make Youtube video interactive, that having some options or buttons arranged on Youtube videos would provide the video interactive elements and yield more traffic for Youtube videos. The ability to make choices, while video viewers are watching videos, can increase their interests and involvement with the contents [6].

Therefore, the purpose of this study is to discover improved methods for communicating scientific topics via new media such as Youtube videos, reduce costs and offer convenient channels for the audience, and compare the communication effects of interactive vs. linear popular science videos. Listed below are three main research questions for this study:

1. How should a scientist tell a scientific story using interactive videos? How can one make a scientific story more effective during the film production process?
2. What are ways to add and create interactive elements on scientific videos? How can one use lower costs to make these videos and can get more clicks online?
3. In comparing the communication effects of interactive vs. linear popular science videos: which is most effective in communicating? Which can make audiences remember more and learn more scientific knowledge? Which can change audiences' attitudes?

II. LITERATURE REVIEW

Science communication generally refers to mass or public communication presenting science-related topics to non-scientists or common people. This often involves ways to disseminate scientific research results from scientists in labs to the general public in society; it also seeks methods to accelerate public understanding of scientific knowledge. The purpose of science communication is typically aimed toward generating support for scientific research or influencing policymaking or correcting scientific misinformation [7] [8].

What is the significance of communication in science? As Lievrouw [9] [10] indicated, most researchers have tended to see communication as an intermediary step on the way to some other phenomenon of interest. However, from a communication research perspective, the communication processes themselves are the object of study. The diversity and flexibility of scientists' communication behavior and the complexity of their communication channels, styles, messages and networks have not been assessed as a set of related phenomena. Lievrouw also examines the process of disseminating scientific information to the public, explores the particular steps (see Figure 2-1) and strategies that scientists use in taking research findings to a popular audience.

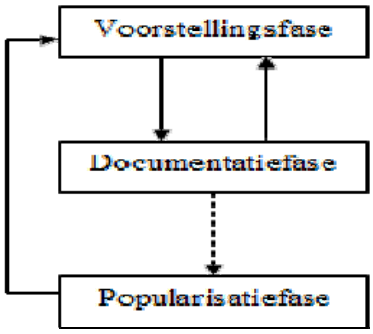

Figure 2-1: The process of disseminating scientific information to the public Lievrouw [11]

Among all media or channels, as Zhang [12] indicated, internet and new media is a combination of different traditional media, such as articles, pictures, images, audio, graphics and animations. It offers a nonlinear approach and a multitude of paths for science learning so that people can learn randomly in this kind of process, become involved in the information deeply, and access mass amounts of information.

Since the rise in numbers of users accessing the internet at broadband speeds and different internet platforms, interactive video has increased online and is used for interactive advertising, marketing, brand image creation or online short drama films. For examples, in 2012, Canadian fashion retailer ssense.com released an interactive music video, featuring Iggy Azalea, Diplo and FKi. All the styles featured in this interactive video could be bought by clicking on the stars wearing them at any time the viewer saw an 'S' tag. The video caused much discussion on fashion blogs and in print. [13] [14]

In 2008, YouTube platform added Video Annotations as an interactive layer of clickable speech bubbles, textboxes and spotlights. Users may add interactive annotations to their videos and through that a new trend of interactive videos arose, including choose-your-own-adventure video series, online video games using YouTube videos, spot-the-difference-game videos, animal-dubbing and more. Also, some company or bloggers started to create interactive advertisements or interactive videos via YouTube's new function to allow the audience have options while they are playing and watching those videos so as to get them more involved and with greater interest during their viewing[15] [16].

How does one create interactive videos? Does hypertext narrative have some particular patterns? According to Syue's literature review [17] and Zhang's study [16], there are several different patterns of hypertext narrative. They include:

1. Sequence:

This is a linear display of information and it's the simplest design for hypertext narrative and it's very similar to the traditional linear text or narrative. However, the audience can choose "forward" or "backward" while they are reading or viewing sequence type hypertext narrative contents. In sum, it's more predictable, lacks the diversity of hypertext narrative and is more like traditional linear narrative (See Figure 2-2).

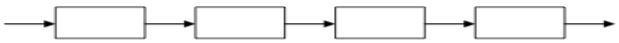

圖 2-3-6、序列式結構形式(Horton, 1990)

Figure 2-2: Hyper narrative type 1: Sequence [16]

2. Sequence with alternatives

This type of hypertext narrative adds some options to the sequence for the audience to allow them able to make some choices so there are some possibilities for multiple tellings of the story during the process(See Figure 2-3). This type allows more diversity in storytelling; as such, this type of hypertext narrative is commonly used for games, short online dramas or interactive advertisements. And by using this type of hypertext narrative to tell stories, the audience can feel more interested and involved while they are interacting with the results of their different decisions.

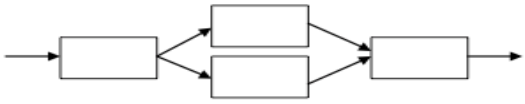

圖 2-3-8、選擇式序列結構形式(Horton, 1990)

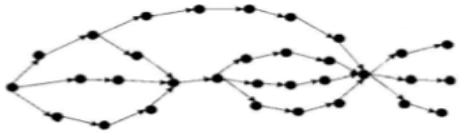

圖 2-3-9、選擇式序列互動模型(Ryan, 2003)

Figure 2-3: Hyper narrative type 2: Sequence with alternatives [16]

3. Sequence with side notes

Sequence with side notes is essentially similar to a linear display of information. It is more like a traditional book with notes or references to allow the audience to jump off from the main sequence to get some notes or references and then jump back to the original sequence (See Figure 2-4).

圖 2-3-11、註解式序列結構形式(Horton, 1990)

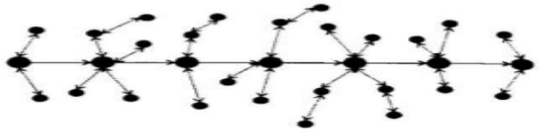

圖 2-3-12、註解式序列互動模型(Ryan, 2003)

Figure 2-4: Hyper narrative type 3: Sequence with side notes [16]

4. Hierarchy

The hierarchy style of hypertext narratives emphasize how to display stories' main points and structures and it has more complete contents and arrangements. The higher level contains main concepts and the lower levels are details and explanations (See Figure 2-5).

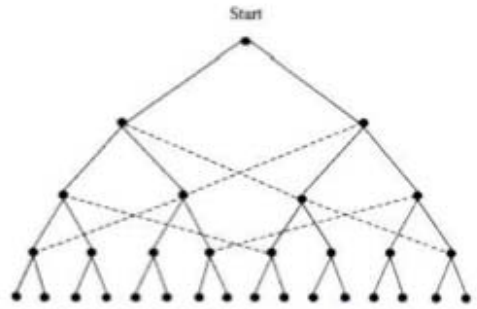

圖 2-3-17、階層式互動模型

(Ryan, 2003)

Figure 2-5: Hyper narrative type 4: hierarchy [16]

5. Web

The Web structure of hypertext narratives is a nonlinear text structure. It allows for storytelling without a specific starting point or a particular development of the story. The audience can randomly interact with the text and create multiple versions of a story themselves. Web structure includes pure web and partial web types (See Figure 2-6).

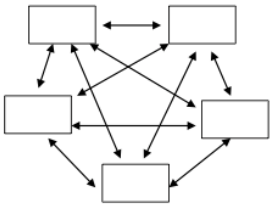

圖 2-3-20、單純網狀結構形式

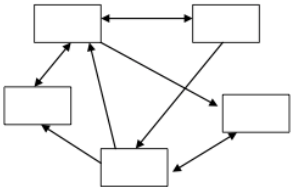

圖 2-3-21、部分網狀結構形式

(Horton, 1990)

Figure 2-6: Hyper-narrative type 5: Web [16]

Based on the literature review regarding hypertext narrative types, the researchers combine the "sequence with alternatives" type and the "hierarchy" type to create an interactive video to tell a scientific issue regarding invasive species and environmental protection for this study. The type two "sequence with alternatives" can be easier to be applied on the Youtube platform and offers the audience some options to create different stories provided the producers create some adequate nodes in an interactive video. In addition, sequences using an alternatives type and a hierarchy type are simpler than web structure so the audience would not find themselves lost in too complicated of a hypertext, therefore the researchers choose it for design this study's interactive video.

Conversely, hypertext narrative is also typically used for online game design. For content users, hypertext narrative is at times more like a digital game-based learning (DGBL); it allows the audience to play different roles, enjoy some fun or make some choices during the learning process. As Zhang [18] noted, some studies showed that digital game-based learning is more efficient than traditional learning process. Therefore, based on our literature review, the researchers have two hypotheses for this study and our experiment regarding linear vs. interactive popular science videos:

H1: Viewers who watch the interactive popular science video can learn more knowledge regarding "invasive species" due to interactive video having better communication effectiveness.

H2: Viewers who watch the interactive popular science video feel more satisfied with the interface design and have a more satisfied viewing experience compared with the audience who watch the linear version.

III. RESEARCH METHOD

In this application paper, the researchers produced two popular science videos regarding "Invasive species" and invited Dr. Chin-Cheng Yang, who is an Assistant Professor for the Master program for Plant Medicine of the National Taiwan University (NTU), to participate in this popular science videos production. Yang is a famed expert of the research field of pest management and invasion biology in Taiwan. Yang and his students from NTU helped the researchers to produce science-related popular videos and review the correction of related science knowledge regarding invasive species and introduced species of these videos. We also invited Mr. Jun-Liang Chen who works for Taipei Postproduction Corp. to produce animations for both linear and interactive popular science videos for this study and Chen is also a co-author of this paper. Below are the procedures for this study to produce interactive vs. linear popular science videos.

Shown below are several scenes from the linear science popular video the researchers produced. We made the video as a common in-depth news reporting style of narrative to discuss the scientific issue regarding "Invasive species". During the linear version videos we interviewed four experts to discuss this issue.

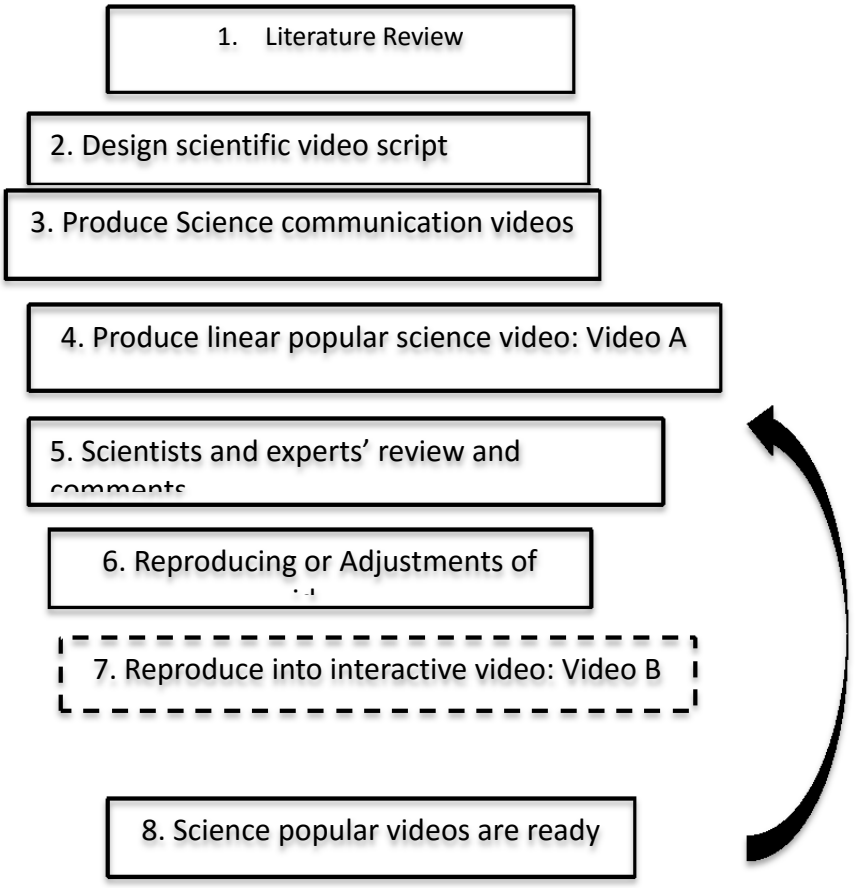

Figure 3-1: The procedures for producing interactive vs. linear popular science videos

Figure3-2: One scene from our linear science popular video

Figure3-3: One scene from our linear science popular video, an interviewed expert of the video Dr. Chin-Cheng Yang from NTU.

Figure3-4: One scene from our linear science popular video, an interviewed expert Dr. Zong-Chi Lin

Then the researcher re-edited the short film (Video A/ the linear version) and added some more animations and buttons or options, and used Youtube platform functions to produce our second video (Video B, See Figure 3-5), the interactive popular science video. Below is a figure showing the procedure of options of our interactive science popular video, how we cut and edit the linear version into different parts and used options to connect them. One can see there are different options or buttons on several "nodes" of this scientific story which a viewer can choose during the watching of the video and their personal choice would change the story telling; they can also obtain correct answers regarding some questions of invasive species and environment protection during their viewing.

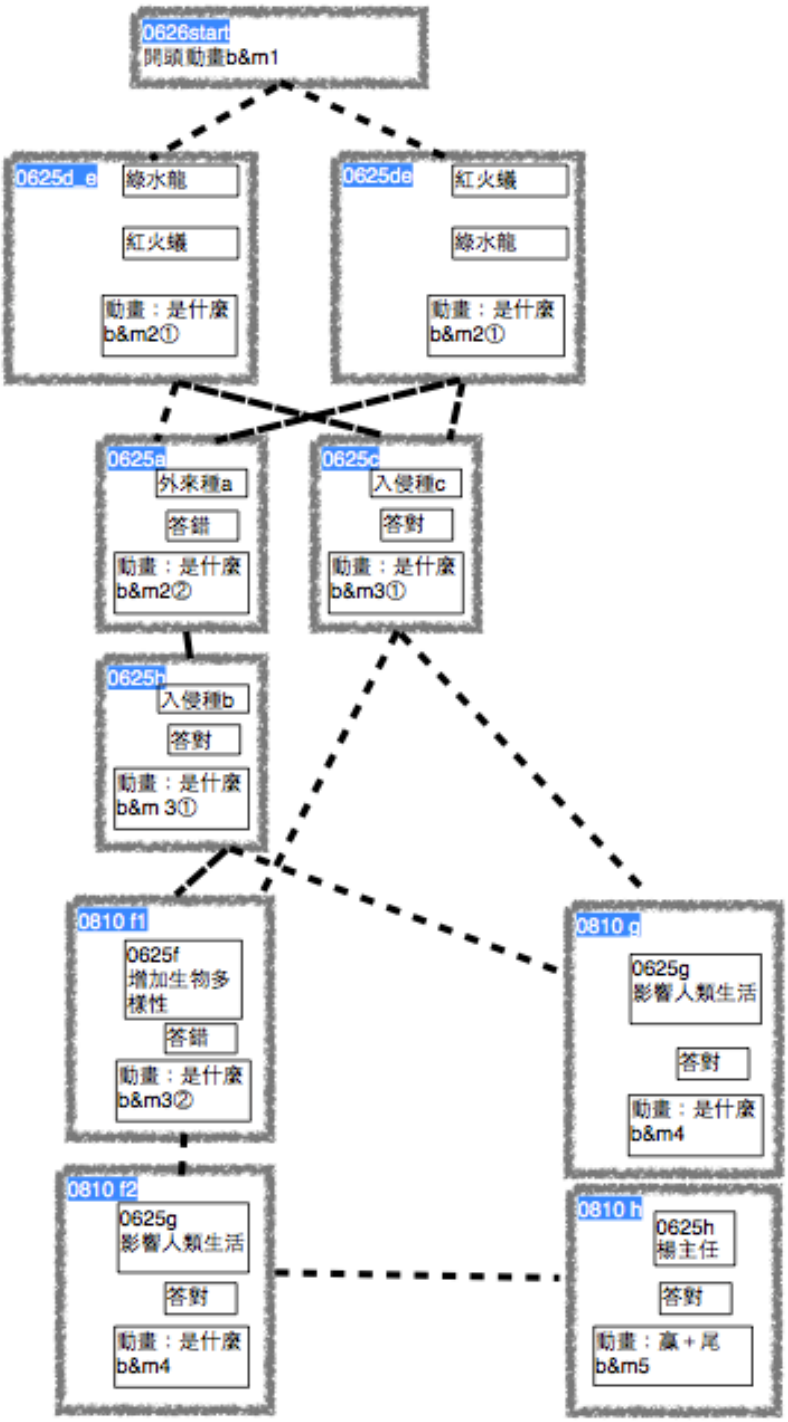

Figure 3-5: The procedure of options of our interactive science popular video: it shows there are different options or buttons which audience can choose during the video.

Figure 3-6: In this example from the interactive popular science video, there are two buttons on the scene so viewers can choose between them to move to the next section of the story.

Figure 3-6 is one scene from the interactive science popular video. There are two buttons on the scene; the researchers ask the audience a question with two possible answers. One is the correct one. Regardless of whether the audience answers correctly, they move into different storytelling and the video emphasizes or corrects their science knowledge during the following videos they watched.

Here is an example (See Figure 3-7) regarding ways we use the Youtube platform to arrange an interactive video. As mentioned in the literature review, there are some marketing people and bloggers that create interactive videos on Youtube with the purpose of making their advertisements or videos interactive with viewers so as to create more clicks or increase the audience's attention.

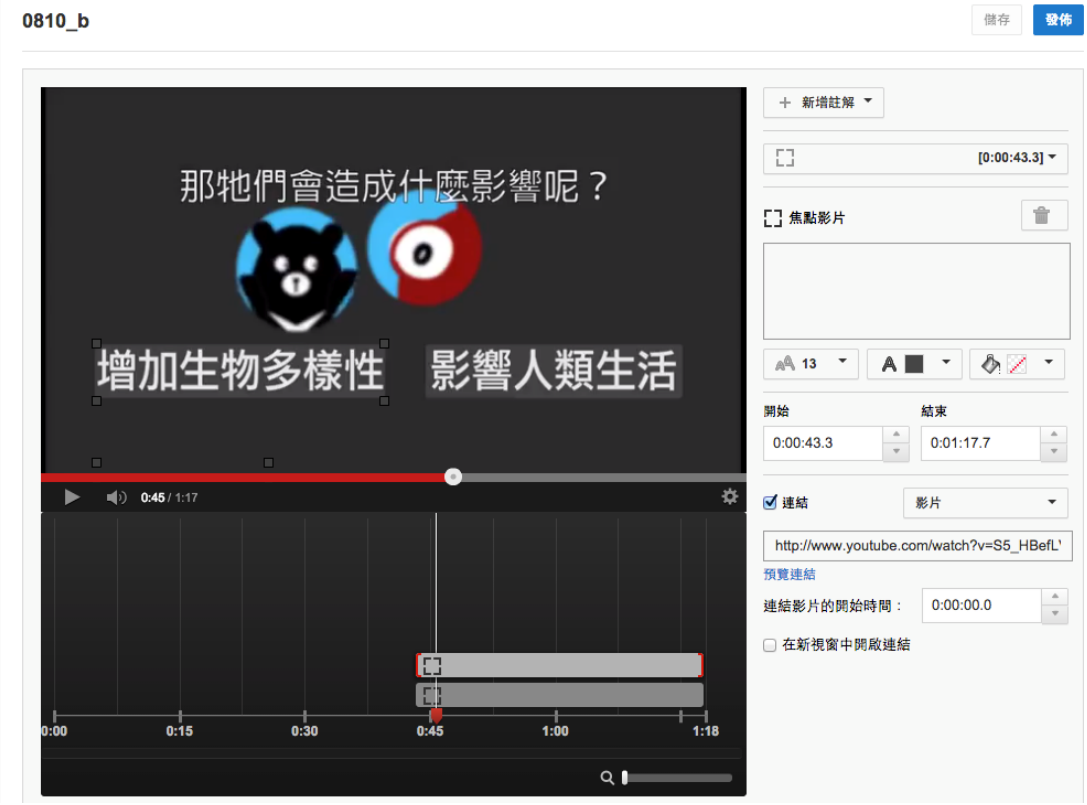

Figure 3-7: The Youtube platform offers these functions for people to create and edit interactive videos

After the researchers finished producing the linear narrative version vs. the interactive version of popular science videos regarding invasive species and environmental protection, the researchers began investigating which narrative style had greater effectiveness with the audience's comprehension of this issue.

The researchers then launched an experiment with 50 persons primarily found online via some posts and advertisements. The interviewees for this experiment were ages 15 to 34 and were found online via posts and advertisements. Based on several reports of internet users' surveys and analysis in Taiwan, most internet users are in that age range. The validity of this experiment depended on face validity and expert validity of the questionnaire design. The researchers invited Dr. Chin-Cheng Yang, who is an Assistant Professor for the Master program for Plant Medicine of the National Taiwan University (NTU), along with his graduate school students to participate in the design and review of questions in the questionnaire for this study. We also launched a pretest involving an experiment with 10 interviewees to make sure the reliability of every set of the questionnaire for this experiment was higher than .70. The reliability of questions of the survey questionnaire for formal experiment was higher than .88.

In short, both the videos have an identical story and use animation, but the interactive video was re-edited and re-arranged from the linear version and during the interactive video there were several questions asked with the viewers needing to select an answer to be able to continue to watch the interactive video; even when their answers were wrong they would be reminded of the correct information during the following video watching.

IV. ANALYSIS

A. Sample analysis

50 persons attended this experiment: 15 of them are male (30% of the sample) and 35 of them are female (70% of the sample) (See Table 4-1). Most of them (32%) are 21 to 25 years old. 56.0% of them heard or knew about "invasive species" but did not know very much the concept. Most of them learned about "invasive species" from their high school classes. 12% of them watch popular science videos very frequently during their daily life. 48% of them sometimes watch popular science videos (See Table 4-2).

TABLE 4-1: SAMPLE ANALYSIS: GENDER

Gender	Frequency	Percentage
Male	15	30.0
Female	35	70.0
Total	50	100.0

TABLE 4-2: SAMPLE ANALYSIS: THE FREQUENCY OF WATCHING POPULAR SCIENCE VIDEOS

How frequently do you watch popular science videos during daily life?	Frequency	Percentage
Very frequently	6	12.0%
Sometimes	24	48.0%
Seldom	19	38.0%
Never watch them	1	2.0%
Total	50	100.0%

B. Compare communication effectiveness between linear vs. interactive popular science videos

TABLE 4-3: TOTAL COMMUNICATION EFFECTIVENESS OF LINEAR VS. INTERACTIVE VIDEOS

		N	Mean	Standard Deviation
Effectiveness	Linear version	25	10.72	1.86
	Interactive version	25	12.32	2.27

TABLE 4-4: T-TEST FOR THE TOTAL COMMUNICATION EFFECTIVENESS OF LINEAR VS. INTERACTIVE VIDEOS

T-test		
T	df	Significance Testing
-2.727	48	.009

The researcher used 14 questions to examine two groups of popular science video viewers' comprehension and their knowledge regarding the invasive species concept. Based on Table 4-3 and Table 4-4, these data analysis showed that the average scores of scientific knowledge regarding "invasive species" the viewers can obtain. Those who watched interactive version can average 12.32 which is much higher than those viewers watching the linear version. And the t-test showed that t=-2.727, df=48, p=0.009<0.05, meaning there was a significant difference of the learning results regarding this "invasive species and environment" issue between two groups who watch linear vs. interactive videos.

C. Compare the satisfaction with the interface designs between linear vs. interactive popular science videos

The researchers used four questions to examine how the viewers from two groups feel satisfied with the operation and interface with two videos. These four questions included: "The animation, graphics and tables of this video can help you understand those concepts clearly.", "The style of explanation used in this video can help you focus on learning this topic", "The animation, graphics and tables of this video can help you pay more attention on learning.", and "The animation of this video can help you learn about some complicated concepts."

The results showed that although the interactive popular science video has a bit more interesting interface designs or some more interesting animation, there are no significant differences of the level of satisfaction regarding the interface between the linear vs. interactive videos.

TABLE 4-5: SATISFACTION WITH THE INTERFACES OF LINEAR VS. INTERACTIVE VIDEOS

	Mean	Standard Deviation
Linear version	3.87	.62
Interactive version	4.11	.50

TABLE 4-6: T-TEST FOR THE SATISFACTION WITH THE INTERFACES OF LINEAR VS. INTERACTIVE VIDEOS

T-test		
T	Df	Significance Testing
-1.504	48	.139

Based on Table 4-5 and Table 4-6, the researchers found that viewers who watched the interactive popular science video would have a higher satisfaction with the interface designs than those viewers who watched the linear version (4.11>3.87). However there is no significant differences between these two groups after applying t-test (t=-1.504, df=48, p=.139 >.05).

D. Compare the satisfaction with the viewing experience between linear vs. interactive popular science videos

The researchers used eight questions when examining the satisfaction of viewing experience of the linear vs. interactive popular science video viewers. These questions included: "The storytelling in this video makes me feel it is interesting", "The way to choose answers or to know your answers are right and wrong (interactive style) in this video makes you feel it is interesting", "I'd like to watch this video again. I agree that this video is helpful with learning about the 'invasive species' issue", "I'd like to share this video with others actively", "I like the way this video is produced", "The viewing time is suitable", and "I'd like to watch similar popular science contents".

Based on Table 4-7 and Table 4-8, this study found that the viewers who watched the interactive version regarding invasive species had a more satisfied viewing experience than those viewers who watched the linear version (3.88>3.58), and there's a significant difference between the viewing experience of the linear vs. the interactive version viewers (t=1.692, df=47, p=0.0485<.05) after t-test.

TABLE 4-7: SATISFACTION WITH THE VIEWING EXPERIENCE OF LINEAR VS. INTERACTIVE VIDEOS

	Mean	Standard Deviation
Linear version	3.58	0.67
Interactive version	3.88	0.55

TABLE 4-8: T-TEST FOR THE SATISFACTION WITH THE VIEWING EXPERIENCE OF LINEAR VS. INTERACTIVE VIDEOS

T-test		
T	df	Significance Testing
-1.692	47	.0.0485

V. CONCLUSION

Based on our literature review, linear vs. interactive popular science video production and experiments, this study has several conclusions listed below:

1. How should a scientist tell a scientific story using interactive videos? How does one make a scientific story more effective?

   Based on the literature review and our experiment, for online interactive popular science videos, if the producer can find an adequate hyper-narrative type to arrange some "nodes" to allow viewers to answer questions or decide how the story will continue, it can create more interest and engagement. When a scientist or a popular science content producer produce a science story via an interactive video, he/she should arrange the story with thought towards each "node" (options or choices making in the story sequence) to get the audience's attention and interest. Then after the viewers make some decision, they would have a desire to explore more information and then have more clicks or share behaviors (Actions).
2. Compare the communication effects of interactive vs. linear popular science videos. Which approach has better communication effects? Which one can make audience

remember more and learn more scientific knowledges?

Based on the results of our experiment, the researchers found that for viewers of two groups, linear vs. interactive versions, their knowledge regarding the invasive species issue which was described in both videos was different after the experiment. Those who watched interactive version can obtain an average score of 12.32 which is much higher than those viewers watching the linear version ($t=-2.727$, $df=48$、$p=0.009<0.05$). Hypothesis 1, Viewers who watch the interactive popular science video can learn more knowledge regarding "invasive species" due to interactive video has better communication effectiveness, was supported.

Also, though the interactive popular science video has more interesting interface designs or more interesting animation, and the viewers who watched the interactive video tend to have higher average satisfaction scores than those viewers who watched the learner version. But there are no significant differences between these two groups after t-test. The researchers assumed that both videos have identical information and main graphics, tables and animations. The linear version was likewise a well-produced in-depth news story so there was not a great difference regarding the satisfaction of interface design. However, those viewers who watched the interactive version regarding invasive species had a more satisfied viewing experience than those viewers who watched the linear version ($3.88>3.58$, $t=1.692$, $df=47$, $p=0.0485<.05$), they tend to feel more interested in the interactive video and would like to watch it again. These results partially support Hypothesis 2: Viewers who watch the interactive popular science video feel more satisfied with the interface design and have a more satisfied viewing experience compared with the audience who watch the linear version.

At the end, the researchers have suggestions for future popular science studies or practical production regarding interactive videos. The cost to produce online interactive videos is affordable and those platforms, such as Youtube, offer free channels for popular science producers to post their interactive videos online. This not only can lower the production cost of popular science contents but also can allow popular science content producers to get greater attention from internet users since now the internet is actually the most important media for the society. Also, in this study, the researchers produce the linear version of popular science video first, and then re-edited it into the interactive version.

The impact of this paper was in clearly showing that for the purpose of reducing the cost of popular science contents and enhancing the comprehensive efficiency of popular science online videos, interactive online videos would be an improved methodology for scientists or popular science content producers. In future studies or productions, planning two different scripts for linear vs. interactive videos before productions should be considered so that both versions can be more adequately designed according to their individual strengths. Furthermore, following the declining use of CD sets and disks, there should be other platforms for all persons, most especially children and youth, to acquaint themselves with popular science content via interactive functions. Interactive videos on YouTube might be one of the best ways to gradually replace functions of CD-ROMs disks for the learning of scientific knowledge. Also there should be increased research or application papers to produce a greater number of popular science videos and to investigate how to use interactive online videos to accelerate the acceptance of popular science contents.

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