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Teachable Moments in News Media—An Analysis of Audience Awareness, Enjoyment, Interest, Opinion Formation, and Understanding (AEIOU) toward Science

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Abstract: In light of the increased time spent by people on watching the news via social media, what might be the communication impacts if science education could help in producing science news media for the public? The present study compared the audience levels of awareness, enjoyment, interest, opinion formation, and understanding (AEIOU) toward science experimentally between two groups: the general science communication (GSC) group (i.e., participants with general daily science news digestion) and the science edu-communication (SEC) group (i.e., participants who watched science news videos produced jointly by science educators, scientists, and news media production teams). As a result, those in the SEC group showed significantly higher levels of "interest", formed more scientific "opinions", and had better "understanding" than the GSC participants. In terms of creating an "additional opportunity" to develop science news media sustainably for the public, the present study confirms more salient outcomes when science educators are involved in the production of science news media.

Keywords: science edu-communication; science news media; scientific literacy in media (SLiM); science communication; AEIOU

1. Introduction

Humans are spending increasing amounts of time consuming media on the Internet. The Nielsen Total Audience Report showed that audiences in 2019 spent more time every day (one hour and 24 min) than in 2018 using streaming services, TV-connected devices, smartphones, TV, etc., to watch media across their "screens" [1]. Some science educators have suggested that these are valuable moments for teaching since science learning can take place more than ever on multiple public media sources (such as YouTube, Facebook media, broadcast TV, or Internet-based TV) [2–5]. However, these potential teachable moments are less likely to be arranged for educational purposes (and without assistance from science educators) most of the time.

While the news on social media can foster or hinder trust in science [6], how the materials are embedded in and communicated via the media can be very critical and may interfere with the public understanding of science [7]. One survey conducted to determine Italian citizens' perceptions and attitudes toward the current COVID-19 crisis reported that 35% of citizens were largely disoriented from the mixture of multiple pieces of information that they encountered from TV news, social media, and friends and relatives and were unable to verify the validity of the sources [8]. The impact of the flood of (incorrect) information was shown to be significant. While more catastrophic diseases and natural disasters are expected to arise continually on this planet, what the news media producers can do to provide sound and solid science information to the public on how sustainable life and development can be achieved by science and technology has been investigated [9].

In recent years, the fields of science communication and science education have trended toward collaboration in regard to overlapping topics [10]. The primary reason for this advancement is that both sides share the same goal: "to educate, engage, and entertain the public with and about science" [11]. Each field has varied approaches to achieve this overarching goal, yet each field remains similar in its insistent public advocacy for science to ensure that the public "possess things in common" [12]. This common intention (i.e., understanding of science) has served as the foundation to encourage discussions of social and scientific developments further, driving the collaboration between science education and science communication. To explore and enhance this collaboration, both fields have started to exchange perspectives, professional experiences, and theories to enrich each field's efficacy [13].

Thus, as the field of science communication has been explored by science education, it is reasonable to study the effectiveness of the communication process of delivering science content to the public, as the process shapes the public's socio-epistemic views of scientific information [14,15]. Courses about the field of science communication have been initiated recently; interestingly, the initiation was undertaken by experts in science education. Bray, France, and Gilbert [16] highlighted several needs and social skills, rather than technical skills, that should be introduced to science communication students so that they may interpret and demonstrate a broader understanding of scientific and social issues to the public. The purpose of transforming science learning into science communication involves portraying science as an ongoing process [17].

If science educators could help incorporate the instructional elements while collaborating with journalists, streaming program producers, social media contributors, etc., to generate teachable science communication products, the final products can be more relevant or even popular for viewers [7]. For example, while journalists are skilled in using vivid and "common language" to narrate live experiences to the public, science educators can elucidate scientific concepts for journalists, photographers, or computer graphics creators to produce content for the public. As a result, a proposal of collaboration through "Science Edu-Communication" [9] would seem particularly appropriate.

2. Theoretical Framework of the AEIOU Approach for "Science Edu-Communication"

Science edu-communication is a joint concept for merging the terminologies and methodologies from both the science education and science communication fields. To this end, the concept of "scientific literacy", as stressed by science education [18–20] and a similar goal by science communication, using such concepts as "public engagement", "public awareness of science", "public understanding of science", and "scientific culture" [21–24], should be integrated. The use of different concepts/terms also seems to stem from a desire to prove their independence by following "their own track" [25]. Irrespective of the domains of each of these concepts/terms, there is a considerable overlap in their aims. Burns et al. [26] categorized the aims of these concepts/terms into five broad personal responses to science in an attempt to provide a shared goal from the perspectives of science education and science communication. According to their work, recipients of any form of effective science communication should be able to express or determine their: Awareness (A), including familiarity with new aspects of science; Enjoyment (E), or other affective responses, e.g., appreciating science as entertainment or art; Interest (I), as evidenced by voluntary involvement with science or its communication; Opinions (O), the forming, reforming, or confirming of science-related attitudes; and Understanding (U) of science, its content, processes, and social factors [26].

These five goals correspond to themes in the field of science education. The above definition of *Awareness* echoes the emphasis of "Science Education" on the ability of learners to understand the science relevant to daily life and emerging concepts of technologies and to engage in discussions regarding socio-scientific issues [27]. The definition of *Enjoyment* in science education implies "the enjoyment of science learning experiences". Though the understanding of enjoyment in science education is different from that in science communication, both fields aim for people to respond positively to science and appreciate the user experience or outcomes of science and technology [28]. As for *Interest*, their acknowledgments are similar due to the common driving force prompting people to engage with science and discover science-related concepts and phenomena. Studies have been conducted in many countries on how scientific interest can be influenced with suitable educational strategies using different methods [28–30]. *Understanding*, for educational purposes, implies that the viewer experience of science is not only about understanding the knowledge of science but also about an improved understanding of the process of science, nature of science, and interactions among science, technology, and society [31,32]. Finally, *Opinion* implies that when interacting with socio-scientific issues, such as moral issues in developing artificial intelligence technology, one should be able to express some views and positions and make decisions [33].

The current study seeks to examine how a science edu-communication (SEC)-initiated news video can impact audiences' levels of awareness, enjoyment, interest, opinion formation, and understanding toward science (AEIOU). The following research questions were used to assist the analysis of the current study.

1. Do SEC-initiated news videos have an effect on audiences' attitudes toward science (AEIU)?
2. As audiences possess different levels of scientific literacy (high/low) in media, do SEC-initiated news videos have an effect on audiences' attitudes toward science (AEIU)?
3. Do SEC-initiated news videos have an effect on audiences' "opinion formation" (O)?

3. Research Methodology

Participants

Data were collected from 121 undergraduate students enrolled in two liberal education courses (i.e., both titled "Environment and Communication") in northern Taiwan. The course was an introductory course in surveying public communication theories, media literacy, and its theories and applications in mass media production, etc. Statistics on the demographics of the participants are shown in Table 1. It is worthwhile to point out that male students seemed less interested in taking this class than female students (37 vs. 84), and students in non-science majors demonstrated more interest in such a course than those with science majors (91 vs. 30). However, a possible explanation of the percentages of science and non-science major participants might derive from the nature of this university located in northern Taiwan. According to a current student composition report of this school, across 33 undergraduate programs, only nine programs were categorized as science-related (percentage of science major programs: 27.3%; percentage of students in science majors: 27.9%). This study included a wide range of university students in terms of gender and major. The university-wide composition of science/non-science majors was similar to the composition of the sample participants in this study. As for gender, the university-wide composition of males was 42.3% (N = 6658) to that of females at 57.7% (N = 9058). With a composition of gender and science/non-science majors similar to that of the university, the findings of the current study may be generalized to the university-wide context. Although the composition of the school might have been a factor in the current course's enrollment and the potential composition of non-science major students in terms of gender and in taking this course, this difference in the interest toward science between science and non-science major participants is worth highlighting.

Table 1. Demographic statistics.

Measure	Category	Number	Percentage (%)
Gender	Female	84	69.4
	Male	37	30.6
	Total	121	100
Major	Non-science major	91	75.2
	Science major	30	24.8
	Total	121	100

It is also worthwhile to point out that these 121 participants were also characterized as "post millennials" (or "Generation Z" or "digital natives") who were born between 1996 and 2004 [34,35]. Combi argued that post millennials cannot imagine a world without the Internet [36]. Prensky remarked that the younger digital natives were born after 1994, whereas the "digital immigrants" were born after 1974 [35]. The digital natives treat the social media as their natural environment whereas the digital immigrants need to train themselves to use the media as if they were using foreign languages. Their media consumption patterns can vary widely from those of their parents' generation [37], which is a generation before the digital immigrants. The digital immigrants "adapt, but they understand that to a certain extent they belong to the past" [37]. Nonetheless, the news media are normally produced for a broader range of audiences across generations. As younger people may possess different perspectives toward the purpose of news media and how this media can be used, science communicators and educators should use the incremental teachable moments to create educational, entertaining, and engaging products for them. Thus, a clear trend in different types of media usage among the participants (i.e., social media usage increase and traditional media usage decrease) was found (see Figure 1) and is consistent with the literature [38].

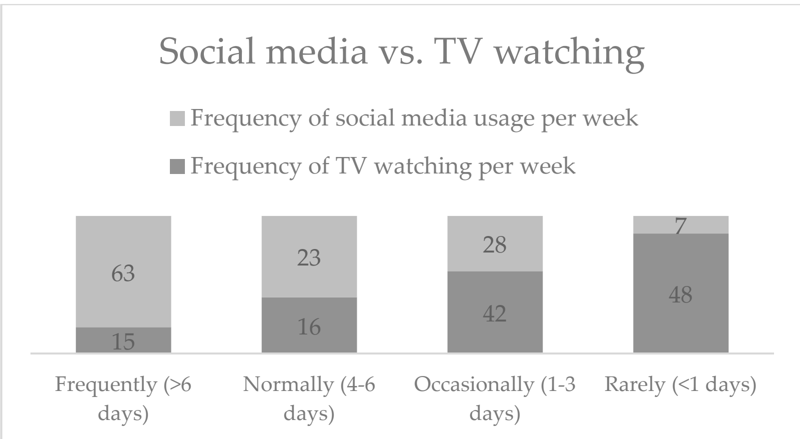


Figure 1. Frequency of social media usage and TV watching among the participants.

4. Materials

4.1. SEC-Initiated News Video

The "Different Science News" (DSN) series was initiated by a university science education research team from northern Taiwan. The series was produced collaboratively by the team and the largest cable TV news channel in Taiwan (named TVBS).

The DSN series used the SEC model [7], where a science educator takes the role of facilitator to influence the communication among scientists/interviewees and mass media experts (e.g., journalists, computer graphics makers, photographers, and broadcast TV program producers). To illustrate, DSN was structured with three components: (1) interviews with scientists to explain scientific topics and facts or demonstrate relevant/current research or technology with live demonstrations of science experiments; (2) relevance, to convey the content's relationship to daily life; and (3) animations to depict scientific procedural or conceptual knowledge. Although similar formats could be easily found in many other science news videos, DSN was the only science news series initiated and produced by science educators. With the goal of reflecting authentic Taiwanese lived experiences to the participants, the current study selected DSN videos that addressed earth science and related topics (i.e., earthquakes, typhoons, landslides, weather, and climate) and rearranged them as a single 30-minute video. See Figure 2 for a screen capture of the SEC news video.

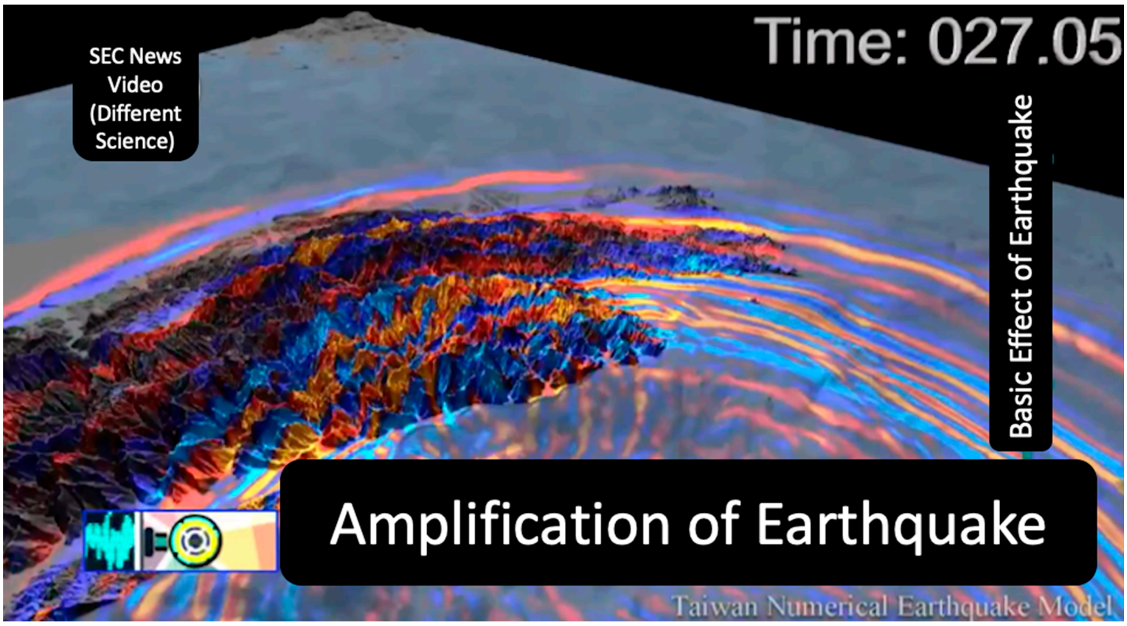


Figure 2. Screen capture of a science edu-communication (SEC) news video demonstrating how the "Basin Effect" amplifies earthquakes in Taipei, Taiwan.

4.2. Scale for SEC-AEIOU

Burns' definition of science communication was revised to develop an AEIOU-based instrument that would fit contemporary needs better [9,26]. The AEIOU dimensions were *Awareness*: being aware of the importance of science and technology and having a sense of the nature of science; *Enjoyment*: enjoying how current technology brings forth an enjoyable life experience; *Interest:* the desire to engage in more scientific issues, events, or activities; *Opinion formation*: forming opinions to support one's own views toward the scientific topics communicated; and *Understanding*: the comprehension of the communicated scientific topics. Such an instrument could be utilized in research settings and practices where the collaboration of science communication and science education is curated. In the current study, using such an assessment was critical for the analysis. More details of this tool are discussed in the methodology section. The SEC questionnaire was utilized to gain a better understanding of how the DSN video could have an impact on the participants' concepts toward science. Such a science communication experience could thus suggest further directions for research in science education and science communication.

4.3. Scientific Literacy in Media (SLiM) Test

The SLiM instrument served as an assessment tool to evaluate participants' scientific literacy when surrounded by daily news media [39]. The SLiM assessment was developed by mapping all of the scientific terms from the indexes of Taiwanese junior high school science textbooks to the most frequently appearing terms in online news articles from 2001 to 2002 (901,446 documents). The process generated 50 multiple choice question items containing the most discussed scientific concepts in both Taiwanese news articles and textbooks. The result of the SLiM assessment provided a source of background information on the participants. Specifically, participants' SLiM scores were used to evaluate whether there was a cross-over effect on their AEIOU after watching the SEC video. If an interaction between the SLiM scores and the SEC video was not found, it was assumed that the SEC video could have an effect on participants' SEC regardless of their SLiM scores. In other words, the SEC video could help promote the audience's SEC whether they possessed high or low scientific literacy (SLiM scores).

5. Procedure

There were two conditions in the experimental setting: general science communication (GSC: participants answered the questionnaire using what they knew without any review or pre-learning; $n = 57$) and science edu-communication (SEC: participants watched the SEC video and answered the questionnaire; $n = 64$). Prior to watching the video (i.e., only the SEC group watched the video) and answering the SEC questionnaire, both the GSC and SEC groups completed the SLiM test. It should be noted that due to Taiwan being an island with a high frequency of earthquake occurrence (e.g., approximately 22,000 per year and 214 sensible; in 1999, 49,919 earthquakes were recorded and 3003 were felt) [40], earthquake-related news is frequently reported in the media. Based on similar rationales, the other topics were typhoons, landslides, weather, and climate, which are frequently watched news topics on TV or social media. Thus, in the GSC group, participants were assumed to be already familiar with these topics and could proceed to answer the SEC questionnaire without watching the additional video source. With the help of two teaching assistants, approximately two hours were used for the entire process. Both the SLiM test and SEC questionnaire were paper-based due to the open-ended type of questions in the opinion formation dimension. SPSS statistical software was applied to analyze the quantitative data collected from the AEIU constructs. The experimental procedure is presented in Figure 3.

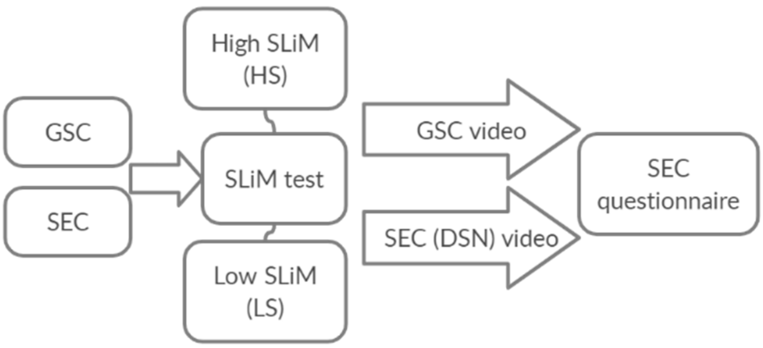


Figure 3. Flowchart of the experiment. (GSC: general science communication; SEC: science edu-communication; SLiM: scientific literacy in the media; DSN: difference science news videos).

First, a two-way analysis of variance (ANOVA) was performed to discern if there was an interaction between scientific literacy (HS/LS) and the experience of watching the SEC video (GSC/SEC) on participants' AEIU responses to science. If a statistically significant interaction was found, "simple main effects" would need to be determined. To analyze whether the SEC video had an impact on opinion formation, a qualitative analysis and the chi-square test of independence were utilized. The qualitative analysis was conducted to code open-ended answers under the categories of "common concepts" and "scientific concepts".

The participants' open-ended answers were coded and numbered into common concepts and scientific concepts by two researchers who conducted discussions to resolve inconsistent results. These results were then sent to a science educator to review the validity of the content, and a coding summary was then formed (see Figures 4 and 5). The results were then used to calculate the number of common concepts and scientific concepts present in participants' responses, turning qualitative data into quantitative data for chi-square testing. The chi-square test was utilized to determine whether there was a significant association between the concept type (common/scientific) and experience of watching the SEC video (GSC/SEC).

6. Results

6.1. The AEIU Results of the Two-Way ANOVA

A two-way ANOVA was conducted on the influence of the two independent variables (SEC, SLiM) on the participants' AEIU toward science. As seen in Table 2, the interaction effects of the AEIU were not significant at the 0.05 level. The main effect of SEC on scientific interest yielded an F ratio of $F(1117) = 4.285$, $p < 0.05$, indicating a significant difference between the SEC ($M = 12.81$, $SD = 2.86$) and GSC groups ($M = 12.05$, $SD = 3.23$). The SEC effect also showed a significant difference in scientific understanding between the SEC ($M = 1.88$, $SD = 1.13$) and GSC groups ($M = 1.18$, $SD = 1.07$), $F(1117) = 13.580$, $p < 0.001$. As for the SEC impacts on AE, they were both not significant: for A, $F(1117) = 0.032$, $p > 0.05$; for E, $F(1117) = 0.093$, $p > 0.05$. By contrast, the SLiM effects on AEI were significant except for understanding, indicating that participants' AEI were significantly different between the higher SLiM group (A: $M = 26.04$, $SD = 2.72$; E: $M = 11.11$, $SD = 1.88$; I: $M = 13.55$, $SD = 3.27$) and the lower SLiM group (A: $M = 24.66$, $SD = 3.20$; E: $M = 10.43$, $SD = 1.65$; I: $M = 11.60$, $SD = 2.59$). However, there was no significant difference for understanding between these two groups, $F(1117) = 2.628$, $p > 0.05$. In the first two research questions, these results suggest that the SEC video had an effect on scientific interest and understanding regardless of the SLiM performance, since there was no interaction between the SEC video and SLiM. Specifically, the results suggest that participants who watched the SEC video showed more interest and understanding toward science.

Table 2. Summary of awareness, enjoyment, interest, and understanding (AEIU) results according to the linear regression of the scientific literacy in media (SLiM) and the two-way ANOVA.

	Two-Way ANOVA					
	SEC (SEC/GSC) Group Effect		**SLiM (HS/LS) Effect**		**Group * H/LS Interaction**	
	MS	**F**	**MS**	**F**	**MS**	**F**
Awareness	0.294	0.032	56.190	6.139 **	0.006	0.001
Enjoyment	0.290	0.093	14.781	4.766 *	2.606	0.840
Interest	35.482	4.285 *	131.794	15.917 **	0.171	0.021
Understanding	16.488	13.580 **	3.191	2.628	4.429E-5	0.000

* $p < 0.05$, ** $p < 0.01$.

6.2. The Opinion Results from the Coding Analysis and Chi-Square Test

The participants' responses in the opinion formation dimension were collected as open-ended answers. Two questions were asked: "O1: What steps would you propose to assess Taipei's living conditions and environment?" and "O2: Which is safer, a taller or shorter building, in the event of an earthquake?" The answers were coded into two levels of concepts: common concepts (i.e., answers that addressed the question based on personal daily life experiences) and scientific concepts (i.e., answers that were tied to scientific "constructs" that were not likely to be gained naturally from personal observation but from ideas that were perceived from cultural or social institutions of science) [41].

All of the opinions formed were coded thoroughly by two science educators. Codes drawn as scientific concepts from O1 were the resonance effect or seismic wave, etc. Codes drawn as common concepts from O1 were escape or the age of the building, etc. Codes drawn as scientific concepts from O2 were soil liquefaction or soft soil, etc. Codes drawn as common concepts from O2 were soil and water preservation or human activities, etc. Figures 4 and 5 present concept maps for the codes for O1 and O2.

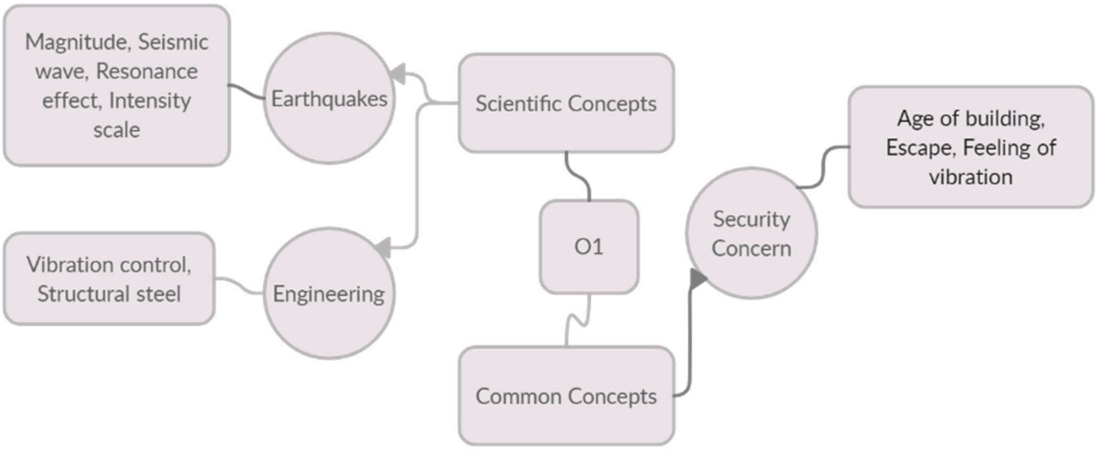


Figure 4. Concept map coded from the Opinion 1 open-ended question.

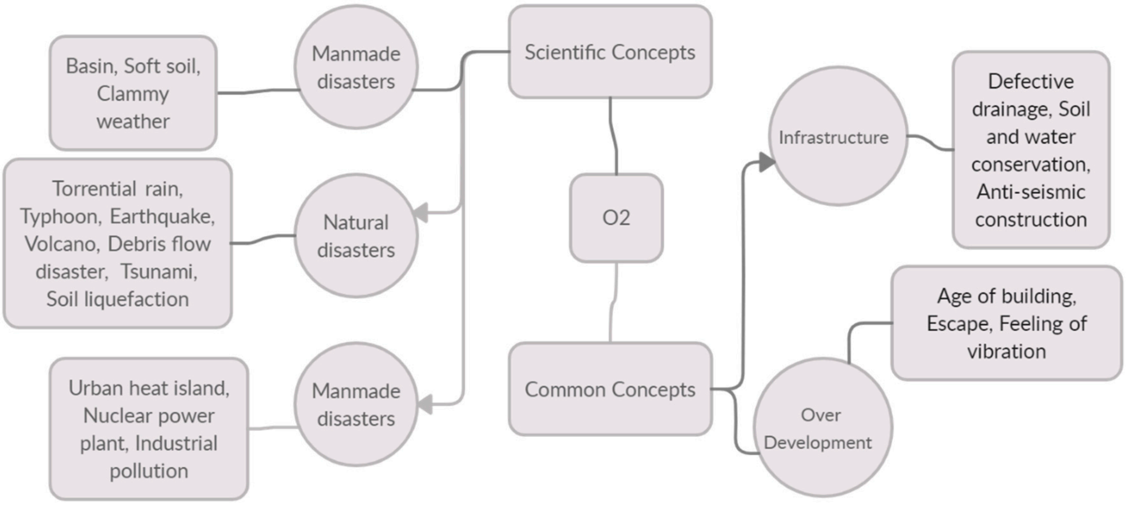
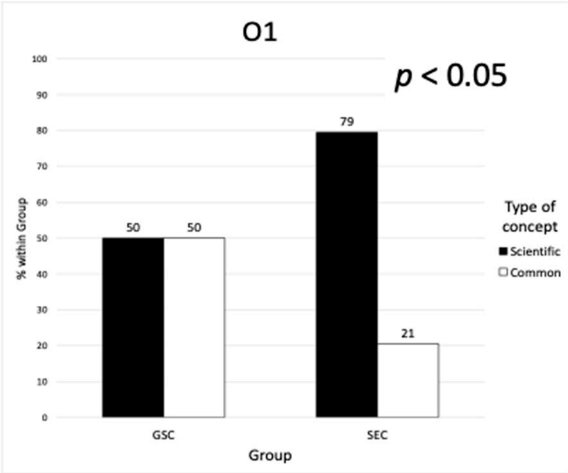


Figure 5. Concept map coded from the Opinion 2 open-ended question.

After the coding process identified the opinion items for the scientific concepts and common concepts, two chi-square tests were utilized to understand whether opinion formation might have been influenced by the SEC video (see Table 3 and Figure 6). The numbers of scientific concepts revealed by the participants were significantly different between the GSC and SEC groups in O1, X^2 (1, n = 128; $p < 0.01$) but not in O2, X^2 (1, n = 185; $p > 0.05$). However, the overall opinion formation was significant, X^2 (1, n = 313) = 14.51, $p < 0.01$. In the third research question, the results suggest that the SEC video effectively promoted the use of scientific concepts in the participants' opinion formation.

Table 3. Chi-square results of the opinion items.

Item	Group	Scientific Concept		Common Concept		X^2
		N	%	N	%	
1	GSC (N = 50)	25	50	25	50	p = 0.000
	SEC (N = 78)	62	79	16	21	
2	GSC (N = 68)	53	78	15	22	p = 0.069
	SEC (N = 117)	103	88	14	12	



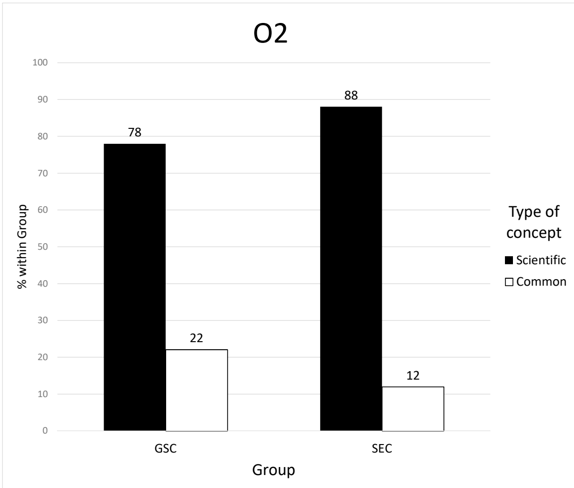


Figure 6. Distribution of the types of concepts (scientific vs. common) between the two questions in opinion formation in the two groups (GSC and SEC).

7. Discussion

The following discussion is arranged according to the framed AEIOU perspectives. In addition, the "media effect" and "instructional effect" are also discussed.

Awareness. Mass media has significant potential for fostering connections among society, science, and technology in an optimistic manner, albeit with some reservations [15]. Moreover, contemporary cases from media can also promote learners' understanding of the nature of science [42]. However, the media environment in Taiwan frequently encounters and broadcasts incomplete or even erroneous information and content [7]. TV, especially, has been found to be a primary source of information for citizens regarding issues dealing with science. Tsai et al. [43] investigated the effects of exposure to pseudoscientific TV programs on Taiwanese citizens' scientific beliefs. Their research found that exposure to pseudoscientific TV programs could ultimately foster negative or arbitrary attitudes in society toward science. Furthermore, Huang [44] listed 10 types of mistakes that occur most frequently in TV reports in Taiwan, one of them being that articles frequently omit the methodological causes and effects of phenomena, which limits the public's access to understanding and interacting with the nature of science. These potential effects of mass media on citizens' perceived awareness of the importance of scientific advances and the nature of science have also been reported in other countries [45–49]. For this reason, an environment of pseudoscience might have contributed to the low public awareness level of science and thus made discerning "scientific awareness" through the current questionnaire more difficult.

Enjoyment. Stories selected for the SEC video in the current study were of the "big science" variety [50], such as earthquake engineering, global climate change, and the detection of volcanic eruptions. Results from the study indicate that the topic of big science did not improve participants' feelings that science was of personal relevance to them or connected to an enjoyable life experience. Why could people not relate big science to their daily life? Apart from the high threshold required for scientific understanding and the complicated nature of the science knowledge in big science, there might be other ways to answer this question. The reasons could be the public's preferred content and media coverage. Most people were in favor of easier-to-understand and daily life-related science content. Bucchi [51] concluded that people pay more attention to issues relevant to personal life, such as diet, health, and medication, instead of to science and technology. While a national survey in Taiwan revealed that 73.9% of the public's preferred topics related to medication and health information [52], a report in the US showed that 59% of the public regarded medication and health information as the most attractive topics in the field [2]. Generally, participants have not been receptive to big science topics. Nonetheless, Segev and Baram-Tsabari [53] observed the public information-seeking behavior online in which searches for several specific terms, such as global warming, stem cells, intelligent design, and large hadron collider, correlated closely with the media attention that the public received. Their findings indicated that media played a role in shaping the public's focus toward science. Unfortunately, C.-C. Lin [54] reported that Taiwanese science and technology-related news only accounts for less than 0.2% of the overall amount of news media in Taiwan. In the US, science and technology coverage also make up a small percentage of all news in the traditional media—less than 2% annually between 2007 and 2012 [2].

People have lived in a science and technology media-starved environment for a long time. They have been relatively unreceptive to the life experiences of enjoyment derived from big science. However, if media is so important, how can media effectively connect big science to daily life? The key to this problem might lie in how we narrate science content and package it into a compelling story. The key component in persuading an audience is usually not the consistency of the content communicated but rather the connection of the audience to a story and daily life [2]. Instead of completely explaining technical scientific knowledge in detail, if a news story can connect to a concept that people value or easily engage with, it can effectively communicate a convincing perspective to the public and eventually communicate the positive values of science development to promote an appreciation and enjoyment of the work of science and technology. It is clear that raising public awareness and enjoyment of science is not achievable in a short time span due to the complexity of the media environment and the time required to change that ecosystem. Media should start to recognize their role in actively shaping perceptions about science and take relevant actions.

Interest.Feliú-Mójer [55] recommended that an effective collaboration between scientists and journalists could foster public interest in science. The results of the current study provide preliminary empirical evidence in agreement with this statement. Scientists and journalists have not always worked well together, encountering difficulties in communication through popular language or media that require simplification and struggling with minimizing terms that are too technical. Meanwhile, journalists have not had the adequate science training to fully comprehend explanations from scientists and, consequently, would interpret science out of context [44]. This common scenario in journalism creates barriers between staff and scientists. In SEC production, science educators play the role of facilitating conversations between scientists and journalists. It was observed that more constructive conversations took place between journalists and scientists during production [7]. Meanwhile, ideas capturing more effective science communication that could evoke audiences' scientific interest emerged and were incorporated into SEC. Moh (2014) introduced the concept that successfully transforming scientific knowledge brings the content one step closer to effective science communication. Moh concluded that "what to say" and "how to say it" are two indispensable elements in effective communication. In the same vein, "how to say it" is mainly the task of journalists, whereas the role of the facilitator is to transform the knowledge from scientists and communicate "what to say" to journalists through popular language. Transforming science knowledge is the greatest strength of the science educator. Journalists can then be the learners, and scientists the source of teaching material and content. Utilizing the expertise of a science educator, journalists might better understand science, brainstorm more ideas to discuss with scientists, and eventually bring "what to say" and "how to say it" into an effective communicable form. Therefore, this collaboration helps fulfill the purpose of promoting scientific interest effectively.

Opinion Formation. Participants in the SEC video group formed significantly more scientifically accurate opinions to support their reflections than those in the general science communication group. The SEC video was a well-structured video that had specific components of scientific concepts embedded in each section. The results were consistent with those of previous studies [56,57] using well-funded and designed videos with major ideas embedded in each video section. This structure provided more scientific ideas that the audience could converse about and relate to daily life. When encountering scientific issues relevant to daily life or social–scientific issues, the audience might form more opinions with which to engage in discussion.

Understanding. The participants' comprehension of the covered scientific topics was analyzed as understanding toward science communication. Understanding was then used to compare the SEC group to the GSC group. The results showed that SEC participants demonstrated significantly higher levels of comprehension than the GSC group.

Animation Effect. Although animations are frequently seen in science news and videos, animations containing reasonable amounts of information designed by experienced educators or instructional designers are rare. Visualizations designed for communication purposes can be either too simple or too complicated for audiences members' working memory [58]. Working memory is defined as the cognitive space that an individual possesses to process received information temporarily while making connections to the components of memory stored in one's long-term memory [59]. One might need less working memory to process and store messages (processing, storing, and connecting information can be seen as a type of "mental effort") if the information received is more familiar. Information overload (also termed "cognitive overload") [60] can thus refer to visualizations made for science communication that are overly complicated. With overly complicated videos, audiences can barely process unfamiliar information (i.e., too much or excessively complicated scientific concepts are illustrated in the animation) since the working memory can already be full from attempting to process the information. Thus, while the audience may receive relevant information, the science content fails to deliver its message. All animations made in the SEC news video were approximately 20 s in length (i.e., each news video was approximately 90 s long in total). Each animation concentrated on conveying only one scientific concept to deliver an optimal amount of information and ensure an expected positive animation effect in comparison to the normal condition of science communication.

Instructional Effect.All scientific topics presented to the participants and surveyed in the experiment were authentically relevant to the Taiwanese living condition. The participants' pre-existing high exposure (i.e., facing these authentic crises both in real life and in daily general science communication from the Taiwanese media) to these topics (related to earthquakes, volcanos, earthquake-resistant structures, and ocean acidification) did not promote understanding of science in this study. News media informs instead of educates [61]; however, promoting understanding of science through the news video format might be one of the most effective means of education. Studies have proven that citizens can learn effectively from TV science news/programs [3,62]. In other words, if science communication providers could deliver products that contain instructional components to some extent, the media (video, news articles, etc.) can serve as an effective educational means to promote science learning for the public. The present study utilized the SEC video, which included carefully examined scientific animations and contained reviewed content regarding local news related to science and technology. The video allowed for a comparison of participants' general exposure to a normal science communication environment (GSC). It was found that the SEC condition might serve as a possible model for promoting better public scientific understanding.

8. Conclusions and Implementation

The current study explored how participants' perceived science awareness, enjoyment, interest, opinion formation, and understanding (AEIOU) might respond to different conditions of science communication, with either general science communication (GSC) or science edu-communication (SEC)-produced videos. The framework of the research tool in this study was based on a definition of science communication and developed as the scale for SEC. It was found that, considering the audiences' scientific literacy in the media (SLiM), the SEC condition significantly benefited interest, opinion formation, and understanding in participants whether they previously possessed high or low scientific literacy. Awareness and enjoyment did not benefit from the described scientific communication.

However, such an overall outcome might be understandable given the relatively short duration of the experiment in question, which only involved the opportunity to provide two hours of SEC video exposure. This study was also not without limitations. Participants aged 18–25 were the only sample in the current study, which may limit the generalizability of the results to all age groups. As for sample recruitment, the participants were those interested in gaining a better understanding of the interdisciplinary issues between science communication and the environment. It might be the case that these participants differed somewhat from other members of the general population. Thus, future studies would benefit from using more representative samples of students or people in a university or the general population.

This study offers an important contribution, demonstrating a positive impact from news/program media on public perceptions about science. Meanwhile, these results are encouraging for scholars and professionals interested in linkages between science communication and science education. Not only did the results suggest that the SEC video positively affected audiences' AEIOU, they also indicated the potential utility of an interdisciplinary model of collaboration that is still being widely explored, namely, science edu-communication. While achieving a robust science communication environment for the public is not a simple task, neither is shifting the public's perspectives of AEIOU. However, if the science edu-communication model of collaboration is further developed and sustained in various media avenues, an atmosphere where the public not only learns (Awareness and Understanding) about and appreciates (Enjoyment) science but also wants to engage (Interest and Opinion Formation) in science could be formed and actively promoted.

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