Informal education of aerosol science by animation – Theory and practice

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Abstract. Aerosol science is a scientific field with abstract and figurative characteristics. The object we are facing is extremely tiny matter, but its influence is actually happening to us. Therefore, how to make the general public aware of the basic nature of aerosol science and technology, making effective strategies is an important task for aerosol science researchers. This paper proposes a science education method that uses animation as an informal education method for aerosol science. First, to explore how to deal with the main methods of aerosol science in informal education. Then, the relevant knowledge of aerosol is deconstructed, classified, and then the textbook is constructed by animation. There are a total of forty-two episodes of the animations built, all placed on YouTube. This result is now available for web users to browse and collect user responses for future improvements.

1. Introduction

1.1 Research Background

Fine aerosols can cause a significant environmental impact, which includes respiratory diseases (i.e., asthma, decreased lung function, cough, cardio-pulmonary diseases, etc.), cardiovascular disease, cerebrovascular disease, and lung cancer. Therefore, the public should be aware of its harm. According to the literature, exposure to outdoor air pollutants can cause respiratory diseases in children, such as asthma and allergic rhinitis. [1], the worsening of symptoms [2, 3], the onset of disease and treatment [4, 5], hospitalization [6-8], decreased lung function [9] and so on.

Unfortunately, fine aerosols are very abstract concepts that cannot be seen or touched, so there must be good courses to educate the public. It comes from everywhere in the world [10-12] good environmental education, the public will be allowed to practice actions against environmental protection. Published by IUCN, UNEP and WWF in 1991, "Caring for the Earth-A Strategy for Sustainable Living” implied that there are nine principles for sustainable survival: 1. Respect and care for the life community; 2. Improve the quality of human life; 3. Preserve the vitality and diversity of the Earth; 4. Reduce the depletion of non-renewable resources; 5. Stay within the limits of the Earth's load; 6. Change personal attitudes and habits; 7. Let the community take care of their environment; 8. Provide a national framework to integrate development and conservation; and 9. Establish a global alliance. It can be seen
that environmental education is not only making the public understand the harm of environmental pollution, but also turning this understanding into the power of action.

Animation is considered a great environmental education tool. Because the animation contains diverse and interesting material, it can attract the interest of the viewer, making it a possible ideal tool for environmental education. Animation can also present many abstract and unexplained concepts, which is in line with our goals for the prevention and control of fine aerosols. Therefore, if we can use animation as an educational medium, producing a series of albums related to knowledge of fine aerosol, it can be very effective in promoting the prevention and treatment of fine aerosol. Chen explored the "children's influence on the natural environment from economic development" and the behavioral changes of schoolchildren after watching the animation from Miyazaki's animation [13]. It can be seen that a well-designed animated album may have a good effect on the knowledge, attitude, and behavioral intentions of the learner.

To sum up, this series designed an animation course on the management of fine suspension particles.

1.2 Research Purpose
In the past, research groups in Taiwan have conducted research on environmental education courses on fine aerosols. Ye and others conducted a series of studies on the development and promotion of environmental education courses for air pollution topics such as fine aerosols on campus. These include high school, middle school, vocational colleges, and higher vocational colleges [14, 15]. In addition to the application of experiential teaching strategies to enhance the environmental value and self-efficacy of middle school students, it also introduces scientific and technological skills and innovative teaching into the fine suspension particle prevention education curriculum. The results of the assessment, including the relevant knowledge of fine aerosols, have been officially published and applied.

In the field of environmental education, scholars have begun to discuss its application results. Its multifaceted and digital learning characteristics should also be applied to the prevention and control of fine aerosols. How to use it to enhance the environmental literacy of learners is a research field worthy of further exploration. If we can deeply analyze the content presentation and learning effects, designing teaching units and conducting relevant teaching experiments, it will be of great help to the future of fine aerosols education. [16]

2. Literature review

2.1 Research and literature on the environmental impact of fine aerosols
Fine aerosols can cause adverse environmental and health effects, including reduced visibility [17], concentrated aerosols causing inflammation in the lungs of rats [18], affecting blood pressure and cardiac contractility [19]. It can also cause inflammation in the lungs, respiratory allergies, alveolar macrophages, and epithelial damage [20, 21].

Ostro et al. found that every 10 g/m³ of PM₁₀ increased the average mortality rate by 1% [22]. Increased pneumonia (RR, 1.049; 95% CI, 1.002-1.098) [23] and hospitalization rates for cerebral hemorrhage (RR, 1.15; 1.01-1.10) (Yang et al., 2005) were also observed. Hospitalization rates for cardiovascular disease [24], septic heart disease [25], chronic obstructive pulmonary disease [26], asthma [27], acute conjunctivitis [28], and allergic rhinitis [29] were some critical finding that should be pointed out.

2.2 Informal Education and research and literature on the application of animation in environmental education
The animation is a trend that combines art and video media, and it is an inevitable trend in teaching. With the advancement of digital technology, the use of animation in education is flourishing, and the education of animation is becoming more and more important. Animation education has the characteristics that cannot be replaced by other courses, so the construction and application of animation education are surely in need.
At present, animation education has been widely established in all levels of education. Taipei Environmental Protection Agency has established many animated films for environmental education. http://www.dep-tee.gov.taipei/ct.asp?xItem=89219415&ctNode=68737&mp=11000A Tainan Environmental Protection Bureau has also established an environmental education animation game area. http://epb2.tainan.gov.tw/tnepb_edu/mode03.asp?m=201403191748221&t=sub

In regard to teaching, Chen has done research on the environmental education literacy of Miyazaki's cartoon animation (Chen, 2007). Other scholars have also made relevant discussions on animation. Since there are still few single-theme animation curriculums planned or produced in environmental education, studies analyzing its teaching effectiveness are still lacking.

3. Research methods
This study contains several major core concepts, namely
  1. Environmental education concept with the theme of "drama-style animation"
  2. The curriculum design concept based on the "fine suspension particle prevention"
These two core concepts form the basis of this research, and the author also uses these two core concepts to develop relevant research methods.
The design of the teaching method in this research includes the following main items:
  1. Education Connotation and Curriculum Development
  2. Construction of the concept map of the course
  3. Subject theme and learning structure
  4. Design of animation
  5. Designed example

4. Results and discussion

4.1 Education Connotation and Curriculum Development
In this study, the teaching content of the main knowledge of fine aerosols was designed. The previous research has already produced relevant results. Therefore, the relevant content is further enhanced in this study.

4.2 Construction of the concept map of the curriculum
  1. Knowledge, technology, and value are included in the development of the curriculum and presented in the form of a conceptual map.
  2. Knowledge of fine aerosols, including: (1) the main source of fine aerosols (2) the main health hazards of fine aerosols (3) industrial pollution sources of fine aerosols (4) the natural source of fine aerosols (5) the method of controlling fine aerosols (6) how to avoid the harm of fine aerosols, and (7) the distribution of fine aerosols throughout the world.
  3. Course concepts in skills, including: (1) preventive actions, such as the use of low-pollution vehicles (2) indirect actions, such as saving energy (3) practical actions, such as manufacturing technology (4) promote actions, such as promoting the propaganda (5) cooperative actions, such as promotion with other groups, and (6) actions on environmental sensitivity.
  4. Concepts of environmental emotions and values, including: (1) values (2) attitude towards the environment (3) attitude towards culture (4) attitude towards health (5) views on environmental protection activities (6) views on corporate social responsibility (7) views on ecological conservation (8) concern about inequality and injustice, and commitment to human rights and the harmonious resolution of conflicts (9) paying attention to the challenges faced by human society, defining the processes required for sustainability, and the changes needed to implement them (10) having a balanced judgment to determine priorities in conflict (11) acceptance of a sustainable lifestyle and commitment to change (12) real attention to the rapid challenges of the global society requires long-term planning to build a complex future (13) having a sense of expectation and a positive personal and social vision in the future (14) emphasizing the importance and value of individual responsibility and action.
4.3 Subject themes and learning architecture

The subject of the course will include the following

| No. | domain                                      | Subject                                                                                                                                 |
|-----|---------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| 1   | Sustainable development and environmental protection | 1. The relationship between the economy and environmental protection? 2. Fairness of generations? 3. Is the environment sustainable? 4. Is environmental disaster a natural disaster or a human disaster? |
| 2   | Fine aerosols and health knowledge          | 1. cardiovascular disease, 2. upper respiratory tract diseases, 3. gastrointestinal diseases, 4. cancer, 5. Asthma, 6. Allergies, 7. Mortality |
| 3   | Source and control of fine aerosols         | 1. The source of fine aerosols in factories, vehicles, construction sites, etc. 2. The source of fine aerosols in nature. 3. Control technology of fine particles 4. How to reduce the source of fine aerosol pollution and prevent suspended particles |
| 4   | Preventive action of fine aerosol           | 1. How to reduce pollution discharge? 2. When dust storm comes, what should I do? 3. Don't barbeque in front of the door. 4. Indoor sources of fine floating particles |
| 5   | Healthy life without the risk of fine aerosol | 1. The connotation and promotion of the "5S Movement", Sort, Set, Shine, Standardize, Sustain, 2. Clean management 3. Good habits at home 4. Environmental management to prevent the harm of fine particles |

4.4 Design of animation

The design of animation teaching method consists of two parts, one is the design of the animation course, and the other part is the design of the teaching method.

For the design of the animation course, this study adopts the curriculum design with the theme of "drama-style animation". In each course, there is a vivid and interesting script. This script will cover the content of the knowledge in the course.

After the animation is produced, each teacher can adopt different teaching methods. Since the clarification of the environmental value involves the learner's cognition, the teacher can use various skills to guide the students into the field of inquiry learning in the teaching curriculum, including observation, experiment, questioning, comparison, generalization, expression, application, reasoning, and other possible ways. With a vivid plot, teachers could have more possibilities in teaching.

As for the teaching method, "problem-based learning" refers to teachers in the teaching process, with practical issues as the core, encouraging students to conduct group discussions to cultivate students' active learning, critical thinking and problem-solving skills.

The division of teaching activities in "problem-solving teaching" can be divided into three stages: "discovering problems", "determining problems", and "handling problems". This method, in conjunction with animation teaching, is expected to have good results. The stage of this teaching process is divided as follows:

Stage 1. Discover the problem:
This stage is mainly to enable students to "observe the situation, detect the problems, care about the situation, and accept the problems", referred to as "causing motivation." With this cognitive problem, students must feel interested or harvest a need to deal with it. With this psychological need, students can pay attention to this problem and look for its solution.
Second, it is necessary to design a good teaching strategy to stimulate students’ eager to learning. There are several principles for the design of teaching strategies for this: (1) the teaching materials are students who are interested in, and it can attract people and (2) the problem arises is that the student who can do it, and the nature is clear, as well as the answer is unknown.

Stage 2. Identify the problem:
A good "problem" must be clear and open. The so-called "clear" means that the nature of the problem is very price and well-defined. The so-called "openness" means that the answer is unknown and remains to be explored. This stage relies on teachers to guide, organize, integrate, generalize, provide high-level concepts that integrate these experiences, and think in an effective direction.

Stage 3. Handle the problems:
This stage of teaching activities should be carried out in the context of "learners solve their own problems." The student is the master of the activity and the teacher is in the position of the facilitator. This stage can be subdivided into several small paragraphs, and the activities of each paragraph may differ depending on the problem.

The content of the activity can be described as follows: (1) propose a hypothesis, form strategy (2) planning work, arrange process (3) perform various activities (4) organize, analyze, and interpret data and (5) consolidation and comprehensive application.

4.5 Designed Example
In this study, a total of twenty-nine animations were presented and placed in Youtube's public channel as themes for teachers to watch. Because of time and funding constraints, all animations are presented in Chinese, and the relevant plots have not yet been added. The URLs and contents of each animation are shown in Table 2.

| No. | Theme | Web site |
|-----|-------|----------|
| 1   | What kinds of air pollution are there? (A1-1) | https://www.youtube.com/watch?v=stOVzEtq1H0 |
| 2   | Is PM$_{10}$ a suspended particle? (A2-1) | https://www.youtube.com/watch?v=vjBZ6BHX3ZA |
| 3   | How small is PM$_{2.5}$? (A3-1) | https://www.youtube.com/watch?v=VoigvX8omY |
| 4   | What is the haze? (A4-1) | https://www.youtube.com/watch?v=Vlojq_vX8omY |
| 5   | What is more harmful to health, PM$_{2.5}$ or PM$_{10}$? (A5-1) | https://www.youtube.com/watch?v=axq9fIcvtKs |
| 6   | Can PM$_{2.5}$ enter the body by breathing through the alveoli? (A6-1) | https://www.youtube.com/watch?v=0aMwQX69MuU |
| 7   | Is PM$_{2.5}$ prone to respiratory irritation? (A7-1) | https://www.youtube.com/watch?v=YoigvXyW3U |
| 8   | Is PM$_{2.5}$ likely to cause coughing? (A8-1) | https://www.youtube.com/watch?v=sz86s99MM |
| 9   | Does PM$_{2.5}$ cause difficulty breathing? (A9-1) | https://www.youtube.com/watch?v=KiofOF05854 |
| 10  | Exposure to PM$_{2.5}$ may cause arrhythmia? (A10-1) | https://www.youtube.com/watch?v=KiofOF05854 |
| 11  | Has the World Health Organization listed PM$_{10}$ and PM$_{2.5}$ as first-class carcinogens? (A11-1) | https://www.youtube.com/watch?v=0vXW4XW59MhG |
| 12  | Will the firecracker increase PM$_{2.5}$ concentration? (A12) | https://www.youtube.com/watch?v=ZBHgCkfIreQ |
| 13  | Burning gold paper will increase PM$_{2.5}$ concentration? (A13) | https://www.youtube.com/watch?v=LncQ6qbialw |
| 14  | Will PM$_{2.5}$ occur during food barbecue? (A14) | https://www.youtube.com/watch?v=C59aOCf500y |
| 15  | Does the mosquito coil increase the PM$_{2.5}$ concentrations? (A15) | https://www.youtube.com/watch?v=bh2vCuBuRsxQ |
| 16  | Do kitchen fumes increase PM$_{2.5}$ concentrations? (A16) | https://www.youtube.com/watch?v=MLepNympBRw |
5. Conclusions
In this study, the curriculum focused on the prevention and control of fine aerosols was designed, and the animations used for informal education were designed using problem-based learning principles. The preliminary results are placed on the Youtube website for public use, and the content of these animations achieve shows it can achieve the initial goal of this study. However, as mentioned before, this study is still limited to the use of Chinese instructions, and there is no complete case in the construction of the animated plot. Therefore, in the future, it is necessary to convert the content of this animation into English to achieve the goal of internationalization. In addition, the author is planning to strengthen the plot design of each sub-question so that the results of this research can be implemented on more occasions of informal education.
Reference

[1] Lee IM, Tsai SS, Ho CK, Chiu HF, Yang CY. (2007). Air pollution and hospital admissions for congestive heart failure in a tropical city: Kaohsiung, Taiwan. Inhalation toxicology 19(10): 899-904.

[2] McConnell R, Berhane K, Gilliland F, Molitor J, Thomas D, Lurmann F, et al. (2001). Prospective study of air pollution and bronchitic symptoms in children with asthma. American Journal of Respiratory and Critical Care Medicine, 168(7): 790-797.

[3] Vichit-Vadakan N, Ostro BD, Chestnut LG, Mills DM, Aekplakorn W, Wangwongwatana S, et al. (2001). Air pollution and respiratory symptoms: Results from three panel studies in Bangkok, Thailand. Environmental Health Perspectives, 109: 381-387.

[4] Norris G, Young Pong SN, Koenig JQ, Larson TV, Sheppard L, Stout JW. (1999). An association between fine particles and asthma emergency department visits for children in Seattle. Environmental Health Perspectives, 107(6): 489-493.

[5] Stieb DM, Beveridge RC, Brook JR, Smith-Doiron M, Burnett RT, Dales RE, et al. (2000). Air pollution, aeroallergens and cardiorespiratory emergency department visits in Saint John, Canada. Journal of Exposure Analysis and Environmental Epidemiology, 10(5): 461-477.

[6] Lin M, Chen Y, Burnett RT, Villeneuve PJ, Krewski D. (2002). The influence of ambient coarse particulate matter on asthma hospitalization in children: Case-crossover and time-series analyses. Environmental Health Perspectives 110(6): 575-581.

[7] Lin M, Chen Y, Burnett RT, Villeneuve PJ, Krewski D. (2003). Effect of short-term exposure to gaseous pollution on asthma hospitalisation in children: a bi-directional case-crossover analysis. Journal of Epidemiology and Community Health 57(1): 50-55.

[8] Ostro B, Roth L, Malig B, Marty M. (2009). The Effects of Fine Particle Components on Respiratory Hospital Admissions in Children. Environmental Health Perspectives, 117(3): 475-480.

[9] Gotschi T, Heinrich J, Sunyer J, Kunzli N. (2008). Long-term effects of ambient air pollution on lung function - A review. Epidemiology 19(5): 690-701.

[10] Yao, J., Liu, W., Chen, W., Wang, G., Zeng, Y., Huang, Y., Lin, J. (2013). Effect of atmospheric parameters on fine particulate concentration in suburban Shanghai. Particulate Science 11(1), pp. 48-54.

[11] Lin, K.-M., Chen, W.-K., Yu, T.-Y., Chang, L.-F. (2014). The effects of Typhoon Morakot on concentration of airborne particulates derived from unvegetated riverbanks, Natural Hazards 74(2), pp. 555-567.

[12] Chen, W.-K., Li, T.-C., Sheu, G.-R., Lin, N.-H., Chen, L.-Y., Yuan, C.-S. (2016). Correlation analysis, transportation mode of atmospheric mercury and criteria air pollutants, with meteorological parameters at two remote sites of mountain and offshore island in Asia, Aerosol and Air Quality Research16(11), pp. 2692-2705.

[13] Ching-lin, Chen, C.L.; Wang, S.M. (2007) A Research on Environmental Concepts of School Children Affected by Animation ---Taking Hayao Miyazaki's Animations for Example, Master Thesis, Institute of Environmental Education, National Taiwan Normal University https://hdl.handle.net/11296/8a7a46.

[14] Chen, W.-K., Juang, Y.-R., Cai, D.-L. (2009). Courseware design and assessment methodology by fuzzy theory - A case study of energy saving course, Proceedings of the 2009 International Conference on Machine Learning and Cybernetics 5, pp. 3042-3048

[15] Chen, W.-K., Juang, Y.-R., Chang, S.-H., Chang, S.-H., Wu, C.-H. (2010). An Information technology-applied education model with interactive response systems, ICS 2010 - International Computer Symposium pp. 348-353.

[16] Chen, W.-K., Juang, Y.-R., Chang, S.-H., Wang, P. (2012). Informal education of energy conservation: Theory, promotion, and policy implication, International Journal of Technology and Human Interaction 8(4), pp. 16-44.

[17] Xie, S., Yu, T., Zhang, Y., Zeng, L., Qi, L., Tang, X. (2005). Characteristics of PM10, SO2, NOx and O3 in ambient air during the dust storm period in Beijing. Science of The Total Environment, 345(1-3): 153-64.
[18] Lei, Y.C. Chan, C.C., Wang, P.Y. Lee, C.T. and Cheng, T.J. (2004) Effects of Asian dust event particles on inflammation markers in peripheral blood and bronchoalveolar lavage in pulmonary hypertensive rats. Environmental Research 95 (2004) 71–76.

[19] Chang CC, Lee IM, Tsai SS, Yang CY. (2006). Correlation of Asian dust storm events with daily clinic visits for allergic rhinitis in Taipei, Taiwan. Journal of Toxicology and Environmental Health, A.69(3-4), 229-35.

[20] Okeson, CD, Riley, MR, Fernandez, A, & Wendt, JOL. (2003). Impact of the composition of combustion generated fine particles on epithelial cell toxicity: influences of metals on metabolism. Chemosphere, 51:1121–8.

[21] Becker S, Mundandhara S, Devlin RB, Madden M. (2005). Regulation of cytokine production in human alveolar macrophages and airway epithelial cells in response to ambient air pollution particles: further mechanisms studies. Toxicology and Applied Pharmacology; 207(Suppl.2): 269–75.

[22] Ostro BD, Hurley S, Lipsett MJ. (1999). Air pollution and daily mortality in the Coachella Valley, California: a study of PM10 dominated by coarse particles. Environmental Research, 81:231–8.

[23] Cheng MF, Ho SC, Chiu HF, Wu TN, Chen PS, Yang CY. (2008). Consequences of exposure to Asian dust storm events on daily pneumonia hospital admissions in Taipei, Taiwan. Journal of Toxicology and Environmental Health A.71(19): 1295-9.

[24] Chen YS, Yang CY. (2005). Effects of Asian dust storm events on daily hospital admissions for cardiovascular disease in Taipei, Taiwan. Journal of Toxicology and Environmental Health A.68(17-18): 1457-64.

[25] Yang CY, Cheng MH, Chen CC. (2009). Effects of Asian dust storm events on hospital admissions for congestive heart failure in Taipei, Taiwan. Journal of Toxicology and Environmental Health A. 72(5):324-8.

[26] Chiu HF, Tiao MM, Ho SC, Kuo HW, Wu TN, Yang CY. (2008). Effects of Asian dust storm events on hospital admissions for chronic obstructive pulmonary disease in Taipei, Taiwan. Inhalation Toxicology, 20(9): 777-81

[27] Yang CY, Chen YS, Chiu HF, Goggins WB. (2005). Effects of Asian dust storm events on daily stroke admissions in Taipei, Taiwan. Environmental Research, 99(1): 79-84.

[28] Yang CY. (2006). Effects of Asian dust storm events on daily clinical visits for conjunctivitis in Taipei, Taiwan. Journal of Toxicology and Environmental Health A. 69(18): 1673-80.

[29] Chang CC, Lee IM, Tsai SS, Yang CY. (2006). Correlation of Asian dust storm events with daily clinic visits for allergic rhinitis in Taipei, Taiwan. Journal of Toxicology and Environmental Health, A.69(3-4), 229-35.

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