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Exploring the primary school children's air pollution environmental education learning effectiveness and air quality protection intention through augmented reality material and air quality monitor instrument

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Abstract: In this paper, we develop air quality monitoring material based on the concept of Maker and using a simple and low-cost device development board, combined with temperature and humidity, PM 2.5 sensing elements. According to the teaching materials, the integration of the latest air pollution-related knowledge, the development of AR multimedia interactive teaching materials and monitoring instruction into the national air pollution environmental education in the environmental education courses of high degree students in the elementary school. This study compares learning motivation and learning performance of learning air pollution related knowledge and concept using different learning method, including multimedia teaching materials, air quality monitor instruments and augmented reality materials.

Keywords: Air pollution, AR, PM 2.5, teaching material

1. Introduction

Air pollution is becoming more and more serious and a global challenge of environmental protection. Air pollution is a hard-to-see, easy-to-prepare and highly toxic stealth killer, which has a great impact on health. Air pollution is the most important global health threat in the 21st century, the International Cancer Agency in 2013 has PM2.5 as a carcinogen, is considered a "global public enemy", the world moving up with the poor air pollution confrontation, World Health Organization said that air pollution has become the world's largest environmental health risks, Taiwan's air quality is actually "the end of the world class"!

The world is moving against the harsh air pollution, the World Health Organization said that air pollution has become the world's largest environmental health risks. Taiwan's air quality is "the end of the world class!" Air pollution is very serious, most consumers in Taiwan agree that the environment is air pollution, but the people for their own health awareness is very low, in addition to effective control or counseling means to reduce the economic development of pollution. Achieving the goal of protecting air quality is a fairly important issue, it is necessary to improve the environmental education through environmental action. Environmental action has been regarded as the primary goal of environmental education by most of the students, so as to solve the present and future environmental problems.

People's awareness of air pollution is generally inadequate, and the lack of awareness of warning and protective behavior. Although there are many studies to explore the students on air pollution and environmental education awareness and behavior, but on the air pollution-related teaching materials, textbooks are mostly limited to multimedia digital teaching materials. Many of the study mostly use custom textbooks, not with the school textbook air pollution unit. The combination of domestic laws and regulations, teaching materials are also lack of interaction. Many literatures confirm that the growth of reality can improve learning motivation and learning outcomes. For example, the studies of Furió et al., (2015), ElSayed et al., (2016) , Cai et al., (2014) , and Wu et al., (2013) use augmented reality in the learning context to improve learning motivation and learning performance, but the current air pollution-related teaching materials in the country has not yet updated the curriculum. In addition, many studies have explored the importance of children's awareness of air pollution and environmental education awareness and behavior. Air pollution-related environmental education is very important and should be educated on a small scale. However, it is less effective in exploring air pollution related teaching aids and whether AR interactive teaching materials could enhance students' awareness of air pollution education.

The aim of this study is to develop air quality monitoring material based on the concept of Maker and using a simple and low-cost device development board, combined with temperature and humidity, PM 2.5 sensing elements. According to the teaching materials unit, the integration of the latest air pollution-related knowledge, the development of AR multimedia interactive teaching materials and monitoring instruction into the national air pollution environmental education in the environmental education courses of high degree elementary school. This study compares learning motivation and learning outcomes of learning air pollution related knowledge and concept using different learning method, including multimedia teaching materials, air quality monitor aids and augmented reality material.

2. Literature Review

2.1. Air Quality Indicator (AQI) and PM2.5

The Environmental Protection Department (EPA) defines the Air Quality Standards as "Air Pollution Standards in Outdoor Air". When natural environments such as volcanic eruptions, forest fires, or anthropogenic burning of wood, coal , fossil fuels and other events, resulting in clean air composition changes, resulting in air pollution. Particulate matter (PM) is a mixture of solid and liquid particulate air pollutants suspended in the atmosphere. It’s diameter less than or equal to 10 microns (μm) are called PM10 and are less than or equal to 2.5 microns called PM2.5, about one-eighth of hair diameter. PM2.5 are more likely to adsorb toxic substances, such as heavy metals, toxic microbes and so on. PM2.5 is the world's largest environmental health risk. Many epidemiological studies have shown that PM2.5 easily attached to dioxin, polycyclic aromatic hydrocarbons and heavy metals and other harmful substances, long-term inhalation may cause allergies, asthma, emphysema, lung cancer, cardiovascular disease. Whether long or short exposure to high concentrations of PM2.5 environment, will improve the risk of respiratory diseases and death, especially for the sensitivity of the ethnic group is more significant (Executive Yuan Environmental Protection Agency, Understanding Fine Suspension Particle Manual, 2016).

Air pollution is important for children, and children are particularly in need of protection. Some literature refers to the impact of air pollution on children, such as (1) air pollution can affect children's cognitive ability, (2) traffic exhaust pollution may slow down the cognitive development of children, (3) indoor air quality seriously affect children's intelligence, (4) air pollution on school-age children's brain can also cause harm. Harvard University School of Public Health recent study shows that the more serious air pollution, children's IQ test results are worse, children in fresh air environment, their memory, vocabulary, learning ability, IQ and other aspects than in air pollution is better than children in air pollution area.

2.2. Air Pollution Monitor Instruments

Maker use a variety of devices development board, combined with temperature and humidity, PM2.5 sensor components based on the concept of Internet of Things. They combine open hardware and open software to monitor the air pollution situation, through simple, open source hardware and software, and cheap price. We want to drive the public attention to the quality of air and vigilance control, down to the promotion of schools at all levels of environmental education and campus air monitoring, but also through hands-on education concept, driven skill of technical turnover.

2.3. Augmented Reality (AR)

Augmented Reality made in 1990, in a way that is enhanced or supplemented by computer-generated sound, video, graphics or GPS data presented in a direct or indirect manner, in a real-world dynamic background and virtual message overlapping context (Miller & Dousay, 2015). AR can provide video to transfer information through the equipment as a medium to allow users to experience the reality of reality and the virtual world of mutual integration (Klopfer & Sheldon, 2010). The use of visual interaction effects and operation can enhance the experience (Dunleavy et al., 2009). AR can provide information that reality cannot be directly informed to the diversity of information presented in front of the vast majority of technical applications are used to enhance or supplement the real information. Therefore, AR in the field of computer science and educational science and technology has been a lot of research scholars to define the diversity of AR (wiki). Cai et al., (2014) argues that augmented reality can present experiments that cannot be simulated in the real world and overcome the obvious shortcomings (such as dangers) of real experiments, and consider AR has multiple representations of function. AR could present the concepts in different 3D representations to provide more thought and construction of knowledge, and has the function of connecting giant, microscopic and symbolic, so that students can learn more comprehensively understand the relationship between phenomena, scientific symbols or scientific representations.

2.4. The application of augmented reality in the learning field

AR technology can help learners to explore the link between the real world and virtual objects. AR system can supplement the course information through the text, graphics, video and voice combination into the student real learning environment. AR could produce the effect of simulation that allow students to operate the measurement of virtual 3D objects and learn more about the relationship between objects and space. AR applied to learn the concept of mechanical engineering, mathematical or geometric calculation and identification in higher education, and the use of AR technology in education is the focus of future development (Dalgarno & Lee, 2010).

At present, AR has been widely used in different disciplines (such as mathematics, physics, chemistry, biology, earth science, medicine, etc.). For example, Martin-Gutierrez et al., (2015) promote cooperation and self - learning in higher education through AR. Riera & Fonseca, (2015) explore the relationship between student participation and academic performance using AR technology for visual building models. Kamarainen et al., (2013) combined with environmental education experience in the local pond environment based on situational learning theory through the EcoMOBILE platform. Bujak et al., (2013) explores the application of the realities in the development of mathematics classroom, and proposes a framework of AR learning from the perspective of psychology, including physical, cognitive and situational factors. AR is currently considered to have the potential for teaching applications, and assisted learning can provide different learning possibilities for science in science education.

3. Research Model

The main purpose of this study is to explore whether learners use the "multimedia teaching materials" and the use of "air pollution detection box and the AR aids" for teaching activities, whether there have different on learning achievement and learning retention level between the three groups. A total of 84 schoolchildren, aged 12 years old, were chosen in this study. A total of 70 schoolchildren were enrolled in this study excluded who did not agree to participate in the experiment. The learners were divided into 20 control groups, 23 in the experimental group 1 and 27 in the experimental group in the experiment. The three groups of members had basic mental operation ability and had the skills to guide their use before the experiment. Three groups are air pollution multimedia teaching materials for the study area, experimental group 1 with air pollution AR teaching materials, experimental group 2 with air pollution detection box teaching aids.

The independent variables of this study are "Air Pollution Multimedia material". The learners were divided into three groups, namely, the experimental group using "air pollution multimedia teaching materials", control group using the "Air Pollution AR Interactive material and Air pollution monitor teaching instrument". We explore the learning performance of different multimedia and related teaching instrument and what the learning outcomes of learners of different learning styles are. We analyze whether their learning outcomes and learning retention situation is different between learning styles of students in different learning methods. In addition, we discusses whether differences in environmental concerns, learning motivation, gender, and cognitive load affect the learning outcomes and learning retention between different groups of students.

The measurement tool section is described below:

Environmental concerns. The scale of environmental concerns developed by the scale of environmental awareness and environmental concerns and other issues from Gao et al. (2014) as the air pollution environment attention measurement tools.

Learning style part. The way students learn is very different, each student has a different strengths and weaknesses, through effective teaching to strengthen or improve. The simplest and most common way to distinguish between different learning styles is based on sensory differentiation, often referred to as the VAK model (Visual, Auditory, and Kinesthetic). Visual students are best at dealing with visual information, hearing is the best way to listen to the way, and sports or touch-type students, often through the touch and exercise to learn. Learning style scale content refer the studies of Gholami and Bagheri (2003).

Learning motivation. Motivation is to promote the goal of achieving all the internal and external factors, is the basis of human action, but also to promote students to effectively carry out long-term meaningful learning elements (Maeng & Lee, 2015). ARCS motivational theory has a close relationship between Attention, Relevance, Confidence, Satisfaction, and the four main spindles to motivate students to learn motivations (Maeng & Lee, 2015).

Cognitive loading. Cognitive load theory has become one of the many theories used to integrate the knowledge and teaching design principles of human cognitive architecture, and has its influence in the field of educational psychology and instructional design theory (Paas et al., 2010). Cognitive load based on the reasons can be divided into three, respectively intrinsic cognitive load, extraneous cognitive load, and germane cognitive load. The assessment factor is the result of cognitive load, including mental stress, mental effort and work performance.

Air Pollution protection intention. The scale refer the EPD air pollution publicity manual, measure the subjects from the food, clothing, live, travel, education, music and other aspects, to achieve air pollution control. For example, the food part, I will Improve the diet structure, reduce cooking oil, eat less barbecue food, reduce the food barbecue process produced PM 2.5; clothing part, I will try to buy environmentally friendly clothing, and use water-soluble laundry products to reduce PM 2.5 and so on.

Learning effectiveness. The effectiveness of learning air pollution awareness, the scale refer the EPD air pollution publicity manual, the production of 25 air pollution awareness scale.

Learning satisfaction. Satisfaction refers to the consistency between an individual's expectation of experience and the actual outcome of his experience, and when he feels equal to or exceeds what he desires, on the contrary is not satisfied.

The relevant scale was submitted by two teachers in the southern part of the country, the evaluation of expert validity, as the basis for the experimental scale. Each question was scored using the Likert five-point scale, which was given a score of 1 to 5 from "very disagree" to "very agree".

4. Research Method

4.1. Air pollution multimedia teaching material development results

Air pollution multimedia video, video link for https://youtu.be/plyNLEZr4ZM. Related pictures shown in Figure 1, it can be watched to increase awareness of air pollution awareness through the video.

Figure 1. Air Pollution monitor video instrument

4.2. Air pollution monitor teaching material

The study builds air pollution monitoring aids through Webduino and related environmental sensors to enable people to build observation points at home in a way that allows students to understand the surrounding air quality, the Air monitoring platform, and the shell 3D printing and printing, the device uses open source hardware and software and environmental sensing device configuration, can monitor the environment temperature and humidity and PM2.5 and PM10 values, and through the OLED display temperature, humidity, PM2.5 and PM10 values, As shown in Figure 2. Air pollution monitoring instrument through the Webduino and related sensors, and through the 3D print made shell, to make air box teaching aids, through the air box can detect the environment temperature, humidity, PM10 and PM2.5 and other values.

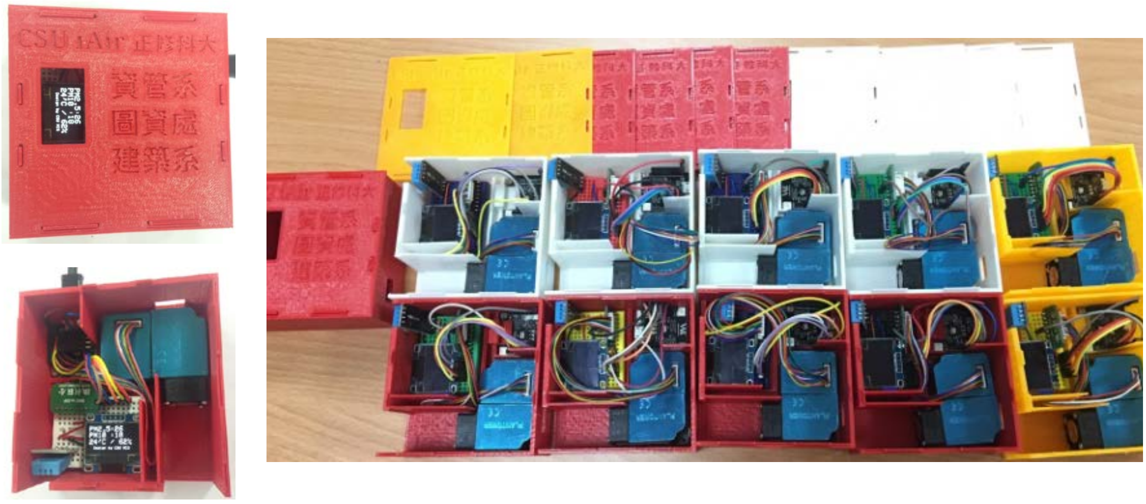


Figure 2. Air Pollution monitor instrument

4.3. Air pollution AR material

The study developed air pollution to expand the actual teaching materials, a total of 25 small cards, as shown in Figure 3. Each card has air pollution related knowledge, through AR animation, to increase awareness of air pollution awareness.

Figure 3. Air Pollution AR material

Figure 4. Air Pollution Environmental Education Promotion.

4.4. *Air pollution environmental education elementary school promotion activities*

We develop the air pollution publicity film, air pollution monitoring instrument and the expansion of real teaching material, to held air pollution environmental education activities in the elementary school, activities shown in Figure 4.

5. Research Results

5.1. *Reliability Analysis*

According to the consistency or stability between the results of the multiple tests, it is estimated how many measurement errors, reflecting the degree of the actual number of indicators, when the error ratio is low, the real score is high, the high reliability. In general, the composition of the reliability coefficient between 0 to 1, good test reliability to be 0.60 or more. According to the results of this study, the reliability coefficient of the 12 facets is between 0.6 and 0.92, which is in accordance with the standard value (Nunnally and Bernstein, 1994).

5.2. *Measurement model*

Reliability, convergence validity and discriminant validity analysis are shown in Table 1. The composition of each facet of each pattern is greater than 0.80, and the average Variance Extracted (AVE) of each facet is greater than 0.5% of the recommended value (Hair et al., 2006) is higher, and the higher the number of the average variance extraction (AVE) is higher than that of the measurement. The higher the reliability and convergence validity. In general, the measurement model has appropriate reliability, convergence validity and discriminant validity.

Table 1: Reliability, convergence validity and discriminant validity analysis results.

	M	SD	CA	CR	AVE	CL	CL*SEX	EC	INT	MTV	PFM	SAT
CL	3.78	0.72	0.85	0.87	0.53	0.73						
CL*SEX	5.34	2.04	0.98	0.98	0.89	0.45	0.94					
EC	4.24	0.57	0.90	0.92	0.60	0.47	0.08	0.77				
INT	4.11	0.66	0.94	0.95	0.67	0.50	0.18	0.75	0.82			
MTV	4.17	0.56	0.89	0.93	0.76	0.71	0.20	0.66	0.72	0.87		
PFM	85.54	7.38	0.91	0.96	0.91	0.11	-0.24	0.11	-0.04	0.10	0.96	
SAT	4.39	0.65	0.97	0.97	0.85	0.59	0.15	0.57	0.59	0.79	0.11	0.92

5.3. Structure Model

In this study, statistical software SPSS version 19.0 was used for statistical analysis and simulated using SmartPLS version 2.0. Based on the two-stage evaluation model and the Bootstrapping re-sampling technique, the standardized path analysis and significance are shown in Figure 5. The hypothesis is proposed based on the relationship between the relevant literature and the variables. In this study, Bootstrapping and no mother counting method are used to estimate the parameters. This study estimate the distribution of statistics through the re-sampling of the sample data),

This study estimate the parameters use the method of bootstrapping, a method of estimating nonparametric, through the re-sampling of the sample data to estimate the distribution of statistics. The results of the proposed hypothesis are as follows: Learning motivation ($\beta = 0.626$, $\beta = 0.394$) has a significant effect on learning satisfaction and air pollution protection intention; cognitive load ($\beta = 0.459$) had a significant effect on the learning performance; environmental concerns ($\beta = 0.459$) has a significant effect on air pollution protection intention. Finally, the impact of cognitive load on learning performance, the impact of girls is significantly greater than boys.

Thus, the hypothesis 1 to 6 in the study model, except hypothesis 1, the remaining hypothesis is true. The results show that the higher the cognitive burden is, the higher the learning achievement is, the higher the learning motivation is, the higher the learning satisfaction and the learning effect is. Finally, the higher the environmental concern of the school children, the air pollution prevention intention is higher. The explain ability of learning motivation to learning satisfaction is 63.6%. The explanatory ability of cognitive load to learning satisfaction is 29.2%. The explanatory ability is 64.8% of environmental concern to air pollution prevention intention.

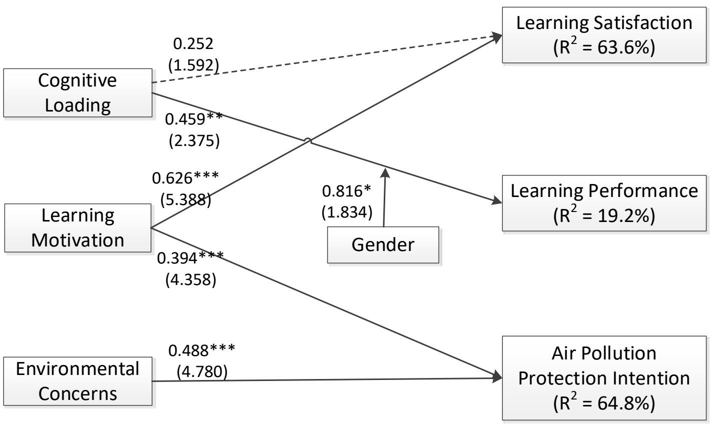
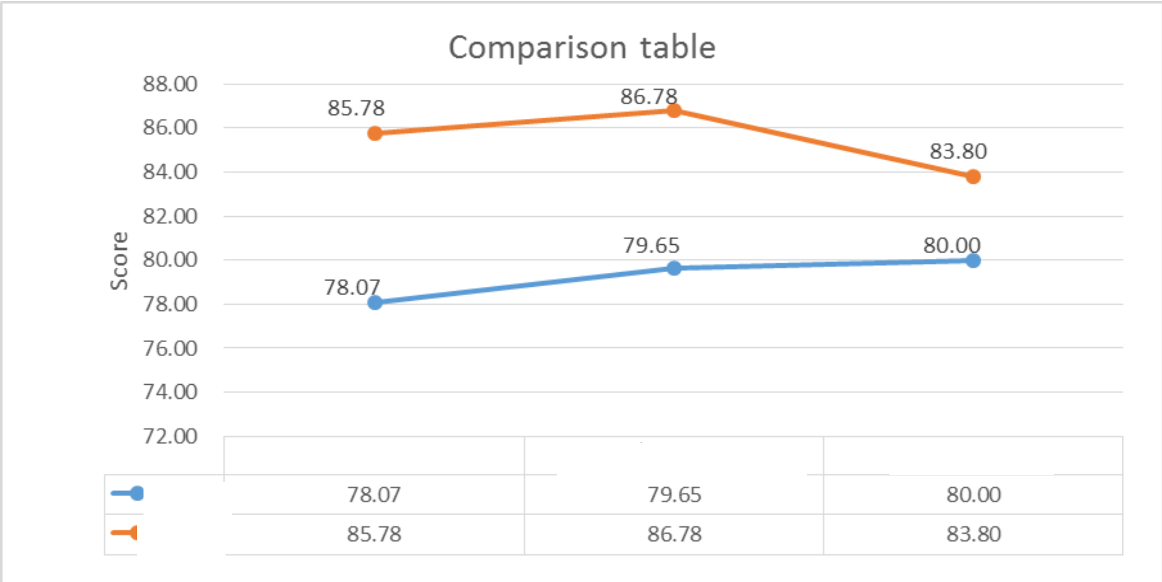


Figure 5. Research Model Results.

The comparison table about the pretest and posttest of the experimental group and the control group in the experiment is as shown in Figure 6. The results showed that the two groups of experimental results were higher than the experimental group, and the posttest and pre-measured progress than the experimental group, the results show that students' air pollution awareness is higher through the air pollution teaching aids and AR multimedia materials than students using video to learn.



(blue)	78.07	79.65	80.00
(orange)	85.78	86.78	83.80

Figure 6. The comparison table about the pretest and posttest of the experimental group and the control group

From the perspective of gender, the effectiveness of learning of boys is better than girls; and girls' air pollution control is the better than boys (See Table 2).

Table 2: The Comparison Table of gender, learning performance and prevention intention.

Gender	Numbers	Learning Performance	Air Pollution Prevention Intention
Male	40	87.10	4.12
Female	30	83.74	4.18

From the perspective of learning style, kinesthetic children’s learning performance and air pollution prevention intention will be better than visual and auditory students (See Table 3).

Table 3: The Comparison Table of learning style, learning performance and prevention intention.

Learning Style	Numbers	Learning Performance	Air Pollution Prevention Intention
Visual	21	84.95	4.02
Auditory	22	84.55	4.13
Kinesthetic	27	86.81	4.30

6. Discussions and Conclusions

With the rise of the design of the program, TMD - iAir intelligent life application will be combined with the implementation of 108 - year program design education, the concept of education, environmental pollution and the concept of Internet of Things into the program of education, so that the concept of programming with the current industry development trends and environmental issues, to enhance the school students in the learning program design, through the concept of secondary school and PBL, to learn the spirit of innovation, and experience the importance of environmental education, more understanding of the world of innovative applications.

From the research results, we can see that the students with higher learning load have better learning ability, and the learning motivation positively affects the learning satisfaction and learning achievement of the schoolchildren. The students with higher environmental concern and their air pollution prevention intention is also higher. From the analysis of the results, we can see that to strengthen the students' awareness of air pollution prevention and control, from the promotion of children's environmental concerns and their learning motivation to proceed. This study means that students from different learning methods to explore the teaching materials, air pollution teaching aids and the expansion of real learning materials, etc., which students learn motivation and learning better, and explore environmental performance of different learning styles of students

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