AUGMENTED REALITY DESIGN ON CLIMATE CHANGE FOR IMPROVING CROSS-GENERATION AWARENESS

INTAN MAHARANI IBRAHIM[1,2], KARIM SURYADI[1,*],
CECEP DARMAWAN[1], SITI NURBAYANI[1]

[1]Universitas Pendidikan Indonesia, Bandung, Indonesia
[2]SMP Negeri 25 Kota Bekasi, Indonesia
*Corresponding Author: karimsuryadi@upi.edu

Abstract

This research aims to explain the process of designing Augmented Reality (AR) media about climate change specifically to increase awareness across generations. The method used is Design-based Research, through the stages of analysis, design, development, and evaluation. The results of the research are in the form of card-shaped media as markers and application software called ClimateChange_AR. Several validation tests were carried out on the product, namely in terms of material, media, and readability for representatives of the Millennial Generation (Gen-Y) and Post-Millennial Generation (Gen-Z) with a validation percentage in terms of material, media, and readability respectively of 90.20, 85.25, and 90.50%. Apart from that, a limited media trial was also carried out on 20 Millennial Generation (Gen-Y) and 20 Post-Millennial Generation (Gen-Z) people, where the results showed an increase in awareness of climate change with medium category and the need for action to reduce the factors that cause climate change. happen. It can be concluded that the AR media developed is very suitable for use and is expected to increase awareness across generations in protecting the earth and reducing factors that cause climate change. It is recommended for further research to test its effectiveness and use across generations with a wider scope.

Keywords: Awareness, Climate change, Cross-generational.

1. Introduction

Human activities, particularly the combustion of fossil fuels, have increased the concentration of greenhouse gases in the atmosphere since the Industrial Revolution, resulting in global climate change and global warming [1, 2]. Climate change has become one of the top ten ecological problems confronting humans relating to cross-generational awareness [3]. Many reports regarding climate change and its impact has been well-documented [4-7]. In the climate change study, the term cross-generational awareness was into five components: knowledge, climate-friendly behaviour, multiplicative actions, attitude, and personal concern [8].

How to slow down, adapt to, and safeguard the environment including human awareness of multi-generation in the face of climate change has become a hot topic in the international community [9]. In the early 1990s, the United States, the United Kingdom, and the Netherlands assumed the lead in performing climate change and awareness research, followed by other countries [10]. To deal with climate change, scholars have been researching cross-generational awareness in the earth's ecosystems [11]. This climate change has had a significant impact on the concept of sustainable development [12]. Climate change and cross-generational awareness are also interdisciplinary research subjects that include environmental science, geographical area, forest products, atmospheric sciences, environmental engineering, and social science [13, 14].

Climate change could pose global and unprecedented threats to humanity [15]. Climate change is expected to create intense heat waves, acute droughts, and air pollution, as well as the danger of catastrophic flooding, which might lead to water scarcity, food insecurity, and malnutrition [16]. Similarly, analysts believe that climate change will exacerbate the effects of pollution and environmental issues, posing serious dangers to human health and safety [17]. Climate change, according to the World Health Organization, will have a significant impact on human health in a variety of ways, including disruptions in drinking water supplies, nutritional food composition, and safe housing [18]. These climate change issues necessitate more expansive imaginations that are responsive to the situated and interconnected worlds that we inherited and transmit throughout time, generations, and species [12, 19].

Given the current and possible impacts of climate change on humans, ecosystems, and the environment, worldwide analysts believe that severe action is required to study, reduce, and mitigate climate change to avoid future devastating and costly consequences related to awareness [20]. Similarly, sustainable approaches and innovative technologies are being used to predict and comprehend the effects of climate change on numerous sectors. That is why sustainable development goals (SDGs) has been one of the hot topics to solve issue in climate change, including putting it in all education levels [21-25].

The use of computational approaches such as artificial intelligence [26-28], the Internet of Things [29-32], and deep machine learning [33- 37] is one such strategy to solve current problems in the world [38].

Technology that is simple but interactive and in line with developments in the Y and Z generations [39]. one of which is Augmented Reality (AR) [40-41], wherewith AR abstract things can be visualized as real, and give a more real impression in presenting interactive video elements by scanning markers. [42]. Therefore, the novelty in this research is the creation of AR about climate change

that is adapted to the characteristics of Gen Y and Gen Z, with the hope that this AR can increase cross-generational awareness of climate change and the need for action to reduce the factors that cause climate change that occurs.

2. Literature Review

In addition to the strictly scientific components of climate research, much contemporary interest has been driven by the accumulation of observational and modelling information on the ways humans influence the climate system, involving cross-generational knowledge [43]. To review and coordinate the scientific community's research activities in this area, the United Nations Environment Program and the World Meteorological Organization established the Intergovernmental Panel on Climate Change (IPCC) in 1988; its assessment reports are issued every 4-6 years [44]. The ARs describe scientific advances, unresolved problems, and bottlenecks in our ability to detect, model, analyse, and predict the evolution of the climate system by assembling systematic reviews of pertinent scientific literature [45]. Evolution of climate models across the first four IPCC assessment reports, ranging from the early 1990s to the mid-2000s [46].

Many climatic variables are now being remotely sensed from the most remote areas of the globe. For example, they measure the overall intensity and spectral parameters of emitted infrared and display noticeable and ultraviolet radiation, as well as complex algorithms relate these basic measurements to actual atmospheric properties such as temperature and the amount of cloudiness [47].

Because perceptions of climate change risk among generations are poorly understood, the theoretical model is based on environmental behaviour theory and incorporates current knowledge of how generations perceive the environment [48]. The Value Belief Norm (VBN) theory of environmentally responsible behaviour draws on several awareness-related behaviour theories to form a causal chain of variables: personal values, a set of beliefs about the environment, awareness of consequences, attribution of responsibility, and personal norms for environmental action [49]. Risk perception can be viewed as awareness of consequences using the VBN framework. Values help generate beliefs and influence risk perception (awareness of consequences) [50].

3. Research Methods

The research carried out is included in Design-based research (DBR). The research uses 4 steps, namely: analysis, design, development, and evaluation. Analysis the need for innovative delivery to cross generations, especially Gen-Y and Gen-Z who are already accustomed to the use of technology, regarding the importance of understanding climate change which is one of the ten ecological problems. The main problem faced by humans is related to intergenerational awareness. Then, the design stage was carried out in the form of an AR media design regarding climate change.

This was carried out as a development stage and validation tests were carried out from media experts. In addition to the validation test, a limited trial was carried out on 20 Generation Millennial (Gen-Y) people, they are aged 30 (2 people), 33 (8 people), 36 (4 people), and 39 (4 people) and 40 (2 people); and 20 Generation Post-Millennial (Gen-Z) people, they are aged 18 (12 people), 17 (8 people). The

instrument used to measure the knowledge, attitudes, climate-friendly behaviour, and multiplicative action of millennials and post-millennials was developed by researchers. Knowledge consists of 10 items with true (1) and false (0) statements, and attitude consists of 15 items with a Likert scale of 1-4. Researchers also conducted interviews about their opinions and action plans that they would carry out as agents of climate-friendly behaviour and were committed to carrying out multiplicative actions as a form of climate change awareness.

4. Results and Discussion

The results obtained from the Augmented Realty media using the DBR process on climate change include Analysis, Design, Development, and Evaluation.

The analysis was carried out by observing multigenerational human awareness in facing climate change, then analysing the need for innovative delivery to cross generations, especially the Millennial Generation and Post-Millennial Generation who are already accustomed to the use of technology, regarding the importance of understanding climate change which is one of the ten ecological problems.

The results of the analysis include: 1) each generation needs to be given treatment. Thus, there is an increased awareness of climate change which needs to be addressed and handled for sustainable development for a better future life, 2) the treatment given to increase awareness across generations must be provided using media assistance that suits the characteristics of the generation itself. One development that can be carried out is by adding the help of AR technology media which is adapted to the millennial and post-millennial generations by adding videos containing the causes and impacts of climate change. This is because AR can clarify explanation tasks in the interactive videos provided [51].

AR design is then created that is tailored to your needs. The sketch or story board for the AR is in Fig. 1. View page in the process running video is in Fig. 2. At the development stage in creating AR, this is done at the end of the media, where the user or validator considers it necessary to have a statement before exiting to choose whether to exit or not. Thus, the application after pressing the exit button does not exit immediately, shows about process login to the App ClimateChange.AR, Running AR until the end, that at the end an additional display of options likes suggestion from validator.
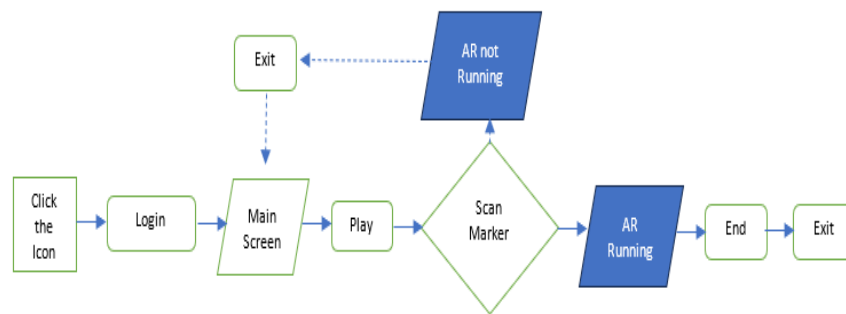

Fig. 1. Design sketch for AR.

Login App, and this page display at the beginning

Scan marker climate change.AR

If AR Finish, this final view before exiting

AR Running

Fig. 2. Process use the climatechange.AR App.

Step on evaluation, AR technology media about climate change was validated by language and media experts, where the indicators used included suitability of material, media, and readability [20]. Several validation tests were carried out on the product, namely in terms of material, media, and user readability. With validation percentages in terms of material, media, and readability of 90.20, 85.25, and 90.50% respectively. The AR media developed has validity in the very good category in terms of material, media, and legibility.

With the rapid development of technology today, there is a need for media or tools to explain information and encourage changes in awareness, especially in the millennial and post-millennial generations that are practical, effective, and interesting, and interactive with more meaningful functions. This can also be seen from the limited test results, where the average increase in awareness across millennial and post-millennial generations for all components is in the medium category (Table 1.). In this case, the choice of AR technology is aimed at achieving the tasks and goals of increasing cross-generational awareness as expected [51]. Providing clearer information will help media users understand the importance of conserving nature as an agent of sustainable development [52].

Table 1. Differences in knowledge, attitudes, climate-friendly behaviour, and multiplicative action before and after using AR.

Variable	Gen	Mean			Conclusion	
		Before	**After**	**Difference**	**N-gain**	**Category**
Knowledge	Z	4.18	8.24	4.06	0,70	High
	Y	3.45	7.35	3.90	0,60	Medium
Attitude	Z	42.85	49.91	7.06	0,41	Medium
	Y	45.35	50.24	4,89	0,33	Medium
Climate-friendly behaviour	Z	39.82	46.32	6.50	0,32	Medium
	Y	40,25	49.42	9,17	0,46	Medium
Multiplicative action	Z	30.56	45.81	15.25	0,52	Medium
	Y	41.36	50.21	8,85	0,47	Medium

5. Conclusion

Intergenerational awareness has recognized that planning for intergenerational impacts, and evolutionary awareness may be useful strategies for mitigating the

impacts of urbanization and climate change. The primary focus of researchers has steadily shifted from climate change goals to the social viewpoint of intergenerational consciousness studies over the previous decades. DBR was carried out by creating AR technology media about climate change with the results of development validation in the very valid category and very suitable for use across generations as a solution for implementing sustainable living. The result is increased awareness of climate change in the moderate category and the need for action to reduce the factors that cause climate change. It is recommended for further research to test the effectiveness and use across generations with a wider scope.

References

1. Driga, A.M.; Drigas, A.S. (2019). Climate change 101: How everyday activities contribute to the ever-Growing issue. *International Journal of Recent Contributions from Engineering, Science and IT*, 7(1), 22-31.

2. Perera, F. (2018). Pollution from fossil-fuel combustion is the leading environmental threat to global pediatric health and equity: Solutions exist. *International Journal of Environmental Research and Public Health*, 15(1), 16.

3. Diprose, K.; Liu, C.; Valentine, G.; Vanderbeck, R.M.; McQuaid, K. (2019). Caring for the future: Climate change and intergenerational responsibility in China and the UK. *Geoforum*, 105, 158-167.

4. Rahmat, A.; Mutolib, A. (2016). Comparison air temperature under global climate change issue in Gifu city and Ogaki city, Japan. *Indonesian Journal of Science and Technology*, 1(1), 37-46.

5. Asif, M.; Saleem, S.; Tariq, A.; Usman, M.; Haq, R.A.U. (2021). Pollutant emissions from brick kilns and their effects on climate change and agriculture. *ASEAN Journal of Science and Engineering*, 1(2), 135-140.

6. Jakhongir, S.; Kurbonov, K.; Muhabbat, H.; Salim, K.; Shavkat, M.; Khulkar, K.; Doniyor, K. (2023). Analyzing climate policy utilizing financial and energy industry models. *ASEAN Journal of Economic and Economic Education*, 2(2), 125-138.

7. Manullang, T.I.B.; Nandiyanto, A.B.D.; Suryadi, A.; Rochyadi, E.; Haerudin, D.; Muspita, R.; Sumiroh, E.; Manullang, L.S. (2021). Improving students with intellectual disabilities science process skills through photosynthesis experiment in enhancing climate change awareness. *Journal of Engineering, Science and Technology*, 16(3), 2368-2377.

8. Lee, T.M.; Markowitz, E.M.; Howe, P.D.; Ko, C.Y.; Leiserowitz, A.A. (2015). Predictors of public climate change awareness and risk perception around the world. *Nature Climate Change*, 5(11), 1014-1020.

9. Malhi, Y.; Franklin, J.; Seddon, N.; Solan, M.; Turner, M.G.; Field, C.B.; Knowlton, N. (2020). Climate change and ecosystems: Threats, opportunities and solutions. *Philosophical Transactions of the Royal Society B*, 375(1794), 20190104.

10. Degroot, D.; Anchukaitis, K.; Bauch, M.; Burnham, J.; Carnegy, F.; Cui, J., Luna, K.; Guzowski, P.; Hambrecht, G.; Huhtamaa, H.; Izdebski, A.; Kleemann, K.; Moesswilde, E.; Neupane, N.; Newfield, T.; Pei, Q; Xoplaki,

E.; and Zappia, N. (2021). Towards a rigorous understanding of societal responses to climate change. *Nature*, 591(7851), 539-550.

11. Almassi, B. (2017). Climate change and the need for intergenerational reparative justice. *Journal of Agricultural and Environmental. Ethics*, 30(2), 199-212.

12. Cramer, W. (2018). Climate change and interconnected risks to sustainable development in the Mediterranean. *Nature Climate Change*, 8(11), 972-980.

13. Brownlee. M.T.J.; Powell, R.B.; and Hallo, J.C. (2013). A review of the foundational processes that influence beliefs in climate change: opportunities for environmental education research. *Environmental Education Research*, 19(1), 1-20.

14. Hallberg-Sramek, I.; Nordström, E.M.; Priebe, J.; Reimerson, E.; Mårald, E.; and Nordin, A. (2023). Combining scientific and local knowledge improves evaluating future scenarios of forest ecosystem services. *Ecosystem. Services*, 60(1), 101512.

15. Kumar, A. (2018). Global warming, climate change and greenhouse gas mitigation. *Biofuels: Greenhouse Gas Mitigation and Global Warming*. 1-16.

16. Banholzer, S.; Kossin, J.; and S. Donner, S. (2014). The impact of climate change on natural disasters. *Reducing Disaster: Early Warning Systems for Climate Change*, 3(2), 21-49.

17. Maibach, E.W.; Kreslake, J.M.; Roser-Renouf, C.; Rosenthal, S.; Feinberg, G.; and Leiserowitz, A.A. (2015). Do Americans understand that global warming is harmful to human health? evidence from a national survey. *Annals of Global Health*, 81(3), 396.

18. Balbus, J.M.; Boxall, A.B.A.; Fenske, R.A.; McKone, T.E.; and Zeise, L. (2013). Implications of global climate change for the assessment and management of human health risks of chemicals in the natural environment. *Environmental Toxicology and Chemistry*, 32(1), 62-78.

19. Markkula, I.; Turunen, M.; and Rasmus, S. (2019). A review of climate change impacts on the ecosystem services in the Saami Homeland in Finland. *Science of the Total Environment*, 692(1), 1070-1085.

20. Capstick, S.; Whitmarsh, L.; Poortinga, W.; Pidgeon, N.; and Upham, P. (2015). International trends in public perceptions of climate change over the past quarter century. *WIREs Climate Change*, 6(1), 35-61.

21. Ekamilasari, E.; and Pursitasari, I.D. (2021). Students' critical thinking skills and sustainability awareness in science learning for implementation education for sustainable development. *Indonesian Journal of Multidiciplinary Research*, 1(1), 121-124.

22. Suryani, L.; and Hamdu, G. (2021). Education for sustainable development in science national exam questions of elementary school. *ASEAN Journal of Science and Engineering Education*, 1(1), 1-6.

23. Maheshvari, R. (2022). Study on economic, sustainable development, and fuel consumption. *ASEAN Journal of Economic and Economic Education*, 1(1), 41-46.

24. Ali, M.A.; Kamraju, M.; and Sonaji, D.B. (2024). Economic policies for sustainable development: Balancing growth, social equity, and

environmental protection. *ASEAN Journal of Economic and Economic Education*, 3(1), 23-28.

25. Maryanti, R.; Rahayu, N.I.; Muktiarni, M.; Al Husaeni, D.F.; Hufad, A.; Sunardi, S.; and Nandiyanto, A.B.D. (2022). Sustainable development goals (SDGs) in science education: Definition, literature review, and bibliometric analysis. *Journal of Engineering, Science and Technology*, 17(Special issue of ICMScE), 161-181.

26. Al-Khassawneh, Y.A. (2023). A review of artificial intelligence in security and privacy: Research advances, applications, opportunities, and challenges. *Indonesian Journal of Science and Technology*, 8(1), 79-96.

27. Alimi, A.E.; Buraimoh, O.F.; Aladesusi, G.A.; and Babalola, E.O. (2021). University students' awareness of, access to, and use of artificial intelligence for learning in Kwara State. *Indonesian Journal of Teaching in Scienc*e, 1(2), 91-104.

28. Agarry, R.O.; Omolafe, E.V.; Animashaun, V.O.; and Babalola, E.O. (2022). Primary education undergraduates' competency in the use of artificial intelligence for learning in kwara state. *ASEAN Journal of Educational Research and Technology*, 1(2), 111-118.

29. Soegoto, E.S.; Soegoto, H.; Soegoto, D.S.; Soegoto, S.W.; Rafdhi, A.A.; Saputra, H.; and Oktafiani, D. (2022). A systematic literature review of internet of things for higher education: Architecture and implementation. *Indonesian Journal of Science and Technology*, 7(3), 511-528.

30. Thapwiroch, K.; Kumlue, A.; Saoyong, N.; Taprasan, P.; and Puengsungewan, S. (2021). Easy-mushroom mobile application using the Internet of Things (IoT). *Indonesian Journal of Educational Research and Technology,* 1(2), 1-6.

31. Jebur, T.K. (2023). Greening the internet of things: A comprehensive review of sustainable IoT solutions from an educational perspective. *Indonesian Journal of Educational Research and Technology*, 3(3), 247-256.

32. Pantjawati, A.B., Purnomo, R.D., Mulyanti, B., Fenjano, L., Pawinanto, R.E., and Nandiyanto, A.B.D. (2020). Water quality monitoring in citarum river (Indonesia) using IoT (internet of thing). *Journal of Engineering, Science and Technology*, 15(6), 3661-3672

33. Faruk, A.; and Cahyono, E.S. (2018). Prediction and classification of low-birth-weight data using machine learning techniques. *Indonesian Journal of Science and Technology*, 3(1), 18-28.

34. Shamim, S.M.; Miah, M.B.A.; Angona, S.M.R.; and Al Jobair, A. (2018). Handwritten digit recognition using machine learning algorithms. *Indonesian Journal of Science and Technology*, 3(1), 29-46.

35. Thongnop, T.; Perpaman, T.; Kansiri, P.; Nuchda, W.; and Peungsungwan, S. (2021). Quality sorting of green coffee beans from wet processing by using the principle of machine learning. *ASEAN Journal of Science and Engineering*, 1(2), 63-66.

36. Obiwusi, K.Y.; Olatunde, Y.O.; Afolabi, G.K.; Oke, A.; Oyelakin, A.M.; and Salami, A. (2023). Evaluating the performance of supervised machine learning algorithms in breast cancer datasets. *ASEAN Journal of Science and Engineering*, 3(2), 179-184.

37. Thapwiroch, K.; Kumlue, A.; Saoyong, N.; Taprasa, P.; and Puengsungewan, S. (2021). Online assessment of electric circuit based on machine learning during covid-19 pandemic situation. *Indonesian Journal of Teaching in Science,* 1(2), 105-112.

38. Messaoud, S.; Bradai, A.; Bukhari, S.H.R.; Quang, P.T.A.; Ahmed, O.B.; and Atri, M. (2020). A survey on machine learning in internet of things: algorithms, strategies, and applications. *Internet Things*, 12(1), 100314.

39. Billano, G.C.; Cogollo, J.J.P.; Cruz, E.M.C.D.; Manahan, M.L.P.; Romualdo, S.N.D.; Rizaldo, T.J.T.; Abusma, S.H.P.; and Onia, S.M.F. (2021). Preference of generation z towards social interaction. *Indonesian Journal of Community and Special Needs Education,* 1(1), 41-46.

40. Bangkerd, P.; and Sangsawang, T. (2021). Development of augmented reality application for exercise to promote health among elderly. *Indonesian Journal of Educational Research and Technology,* 1(3), 77-80.

41. Albar, C.N.; Widiansyah, M.G.; Mubarok, S.; Aziz, M.A.; and Maulana, H. (2021). Application of augmented reality technology with the fuzzy logic method as an online physical education lecture method in the new normal era. *Indonesian Journal of Multidiciplinary Research*, 1(1), 35-40.

42. Wu, H.K.; Lee, S.W.Y.; Chang, H.Y.; and Liang, J.C. (2013). Current status, opportunities and challenges of augmented reality in education. Computers and Education, 62, 41-49.

43. Nabil, Z. F.; Haris, V.; Idrus, H.; Ayop, S.K.; and Alias, S.N. (2023). Development of a Physics Module Based on Augmented Reality Integrated with Al-Quran Verses on Electricity. *Sainstek: Jurnal Sains dan Teknologi*, 15(1), 61-68.

44. Donelson, J.M.; Salinas, S.; Munday, P.L.; and Shama, L.N.S. Transgenerational plasticity and climate change experiments: where do we go from here. *Global Change Biology,* 24(1), 13-34.

45. Van Beek, L.; Hajer, M.; Pelzer, P.; Van Vuuren,D.; and Cassen,C. (2020). Anticipating futures through models: the rise of Integrated Assessment Modelling in the climate science-policy interface since 1970. *Global Environment Change,* 65(1), 102191.

46. Torres, C.; Moranta, J.; and. Murray, I. (2022). The construction of a growth-oriented global climate agenda: a critical historical analysis. *Investigaciones Geográficas*, 77(1), 161.

47. Ghil, M.; and Lucarini, V. (2020). The physics of climate variability and climate change. *Reviews of Modern Physics,* 92(3), 035002.

48. Adjovu, G.E.; Stephen, H.; James, D.; and Ahmad, S. (2023). Overview of the application of remote sensing in effective monitoring of water quality parameters. *Remote Sensing,* 15 (7), 1938.

49. Skeirytė, A.; Krikštolaitis, R.; and Liobikienė,G. (2022). The differences of climate change perception, responsibility and climate-friendly behavior among generations and the main determinants of youth's climate-friendly actions in the EU. *Journal Environmental Management,* 323(1), 116277.

50. Fenitra, R.M.; Premananto, G.C.; Sedera, R.M.H.; Abbas, A.; and Laila, N. (2022). Environmentally responsible behaviour and knowledge-belief-norm in

the tourism context: the moderating role of types of destinations. *International Journal of Geoheritage and Parks*, 10(2), 273-288.

51. Mamun, A.; Hayat, N.; Mohiuddin, M.; Salameh, A.A.; Ali, M.H.; and Zainol, N.R. (2022). Modelling the significance of value-belief-norm theory in predicting workplace energy conservation behaviour. *Frontiers in Energy Research,* 10(2), 940595.

52. Thiounn, T.; and Smith, R.C. (2020). Advances and approaches for chemical recycling of plastic waste. *Journal of Polymer Science*, 58(10), 1347-1364.