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How can ecology-based civics learning media *"PKN Ekologi"* foster ecological competence in students?

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Abstract
This study aims to evaluate the effectiveness of learning media in Citizenship education learning for junior high school students. PKN Ecology is a digital-based learning media that adopts the principle of augmented Reality. This study was conducted using a quasi-experimental method with the control and experimental classes taken from students of SMPN 11 Madiun City, East Java. The number of students used as the research sample is 83, n = 83, consisting of 42 in the experimental and 41 in the control classes. The results showed that the Ecological Civics Media was proven to impact improving ecological competence for middle school students positively. In addition, ecological civics media has been proven to increase student interest in enhancing learning.

Keywords: civic education; ecological citizenship; environmental awareness.

Introduction

Currently, environmental damage has become a complex problem and is a concern throughout the world. However, it is less severe than other aspects of life, like economics and politics. Since it refers to a complex and multidimensional problem related to politics, law, and technology, the best thing to do is to solve it through education (Berkowitz et al., 2005; Dobson, 2007; Krasny et al., 2015). In particular, citizenship education is a multifaceted field of study with a cross-scientific context (Wahab & Sapriya, 2011) focusing on the concept of political democracy for the rights and obligations of citizens to bring up civic knowledge, civic disposition, civic skills, civic commitment, and civic competence. Civic Education is evolving to include various components such as fundamental education, political education, moral values education, national character education, legal education, and human rights. The focus of the study can vary depending on its starting point (Winataputra & Budimansyah, 2007). The

importance of civic education in addressing environmental challenges underscores the urgency of our work in this field.

If civic education deals with citizen issues regarding the environment, the concept of protection refers to citizen political participation in the government concerning environmental policy (Scoville, 2016; Symons & Karlsson, 2018). Moreover, education can empower citizens to take action to address environmental challenges. Consequently, this subject is vital for enhancing students' awareness of environmental issues through the lens of knowledge, skills, disposition, commitment, and competence (Baldwin, 2012).

A relatively new development in civic study emerged. It raises the environment as the focus of citizenship issues and is often explained in several concepts such as Ecological citizenship, environmental citizenship, and sustainable citizenship (Hayward, 2012; Micheletti et al., 2012; Usmi & Murdiono, 2021). Civic ecology emphasizes that individuals should actively shape political policies related to the environment (Valencia Sáiz, 2005). Then, civic ecology is expected to be used to promote and develop 'green' political organizations (Krasny et al., 2015).

Moreover, in every educational process, an educator needs to consider the characteristics of the students to ensure that the learning outcomes can be optimally successful. However, environment learning must move to digitalization considering the current type of students and their conditions after the new-normal implementation. Indeed, this will lead to theoretical debates as the digitalization technology used is even alleged to be the cause of environmental damage (Akçayır & Akçayır, 2017; Briz-Ponce et al., 2017; Bulman & Fairlie, 2016; Fu & Hwang, 2018). For example, digitalization is inseparable from the use of electricity. Until the composing process of this article, the largest source of electricity supply in Indonesia comes from fuel/fossil and burning coal, which is harmful to the environment (Meilani & Wuryandani, 2010).

Technology plays a significant role in enhancing civic education, particularly in teaching character. With the growing attitudes and values of environmental concern, technology offers the best solution. This is especially relevant as we currently teach the millennial generation, which prioritizes technology in their activities. As a result, the media and teaching methods need to adapt (Kotz, 2016). In addition to education, addressing environmental issues requires a multidisciplinary approach, especially in the fields of science and social sciences. Preserving the environment necessitates a combination of human behavior, knowledge of nature, political policies, and laws related to its usage.

Concerning this, media refers to a tool used to convey messages (Bovee, 1997) from one person to another. In teaching and learning, teachers mostly use media to assist them in teaching-learning. It implies that the media becomes a means to convey information and achieve learning objectives (Tan, 2003). Therefore, learning media can take any form as long as it can help teachers to transfer knowledge, especially ecological civic education. With the development of technology and human life, the media used in learning media also developed. Thus, the learning media can adjust to the development of students. Millennials and Gen Z are now part of the higher education landscape. The Z generation, growing up in the digital era, gains knowledge independently through the internet. This phenomenon differs from the previous generation, gaining knowledge through parents' and teachers' direct assistance (Palfrey & Gasser, 2011). It brings several changes in student learning styles, from verbal/visual to virtual learning styles (Proserpio & Gioia, 2007). Therefore, educators must adopt new methods and media to connect with students (Wankel, 2009).

Especially in Ecology, many studies reveal that a large portion of practice is needed to achieve its goals (Dolan et al., 2015; Jagers et al., 2009). Unfortunately, during the COVID-19 pandemic, this participation has become challenging. It forces educators to be capable of implementing the appropriate media to achieve the learning goals with less practice. With the advancement of technology and the emergence of Society 5.0, creating a more equitable and

inclusive class environment is possible. Considering the advantages of Society 5.0 values, such as the accumulation of data in Big Data, the use of technology, and the implementation of spacious physical activities, the best media to teach ecological civic education is Virtual Reality (VR). VR is an interactive computer simulation that responds to the user's actions and state. It can replicate the user's presence or enhance sensory feedback, allowing for an immersive experience in a simulated environment (Mihelj et al., 2014). VR is a technology used for creating simulated experiences designed to fully engage users in a virtual space, allowing them to feel as though they are physically present and to interact as if they were in that environment. VR immerses users by engaging their senses—visual, auditory, and potentially haptic—creating an illusion of reality (Sanchez-Vives & Slater, 2005). VR learning focuses on engagement, interaction, and imagination (Zhang et al., 2017). Engagement through VR media includes physical engagement and mental engagement. Physical engagement is the feeling of being physically present in the non-physical world. Cognitive engagement refers to involvement and a sense of 'being' in the task environment. Interaction refers to the user's ability to see changes in activity on the screen through movements and responses. Imagination means that the Virtual Reality environment triggers the capacity of the human mind to perceive, imagine, and creatively feel. The potential of VR technology to revolutionize civic education and environmental protection is a reason for optimism about the future.

As an interactive technology, VR has at least three main characteristics. First, VR provides experiences. VR makes it possible to recreate the apparent world and create a new world, and It offers experiences that help individuals grasp concepts and learn to perform specific tasks effectively. It is repeatable in a safe environment (Chow et al., 2017). This initiated the development of learning media. Educational learning media should align with the needs of the community. The community plays a role in collecting and providing information about actual problems faced as subjects of civic education studies. Through this media, the community can provide/collect information through the PKN Ecology website and application/www.pknekologi.com. This media is a medium for collecting information or Big Data. Teachers and students can access it to find learning materials. This media is something new because it can combine three elements of education, namely society, students, and teachers. This can also be capital to strengthen civic education learning in Indonesia and develop towards a maximum continuum because it is tied to schools and the community.

Method

This research project took place at State Junior High School no. 11 in Madiun City, East Java, Indonesia, over the course of September and October 2023. The school adopted an online learning platform for educational purposes. The study used a quantitative approach and implemented a random cluster technique for sample selection. Specifically, it involved two 7th-grade classes, one serving as the experimental group and the other as the control group, totalling 83 students. The research process encompassed three distinct phases of data collection: 1) conducting an analysis of problems and needs, 2) assessing the effectiveness of the research instrument, and 3) evaluating the responses of the students involved.

Results and Discussion

At this stage, the researcher observed the implementation of Civics learning in class VII of SMP Negeri 11 Madiun, a school carefully selected for its high Adiwiyata level, namely Mandiri. This selection was made after considering several schools in the city of Madiun with an independent Adiwiyata level. The aim is to describe the learning that has been implemented and analyze the advantages and disadvantages of the learning. Hence, the researcher used the side random method to determine the sample and selected SMP Negeri 11 Madiun. In this stage, the researchers also investigate the learning model and media implementation to observe the need for learning models and media for students and teachers.

Data collection is carried out using a comprehensive survey approach, involving the distribution of questionnaires that address the challenges and requirements of students in online learning. The purpose of this approach is to gather comprehensive data on the issues and needs faced by students. A sample of 83 students was obtained for this study, and a descriptive method was applied to examine the data.

Following a meticulous analysis of students' and teachers' needs, this research embarks on the second phase, employing a unique quasi-experimental design with an unequal control group (Creswell, 2016). This stage involves two distinct classes with similar characteristics. One class receives special treatment using the developed media, while the other class serves as the control group. The only difference between the two classes is the application of different learning media.

Several steps in this stage cover: (1) Both classes get a questionnaire to determine their initial abilities before taking action, and (2) One of the selected classes gets learning using the learning media of Civics Ecology. Afterwards, the researchers evaluate the learning results to determine the distinction between the experimental and control groups.

Table 1.
The Treatment the experimental class and the control class

Students	Pre-test	Treatment	Post-test
VIII A	X_1	O	X_2
VIII B	X_3	-	X_4

Note: X1 = Pre-test experimental class; O = treatment (Learning media for Civic Ecology) ; X2 = Post-test experimental class X3 = Pre-test control class;; X4 = Post-test control class;

The sample of this study is 83 students (n = 83), with 42 students in the experimental class and 41 students in the control class. In addition to almost the same number, the characteristics of students, curriculum, class facilities, and assessment tools are the same.

Before being fully implemented, the learning media and all the devices used are tested for validity by civic education experts. The learning tools tested for validity are 1) learning media, 2) lesson plans, and 3) learning assessment instruments. The Score of indicates the Validation results. The validation results indicate that all aspects met the valid criteria. It implies that all of them were reliable.

Table 2.
Validity and Reliability of Learning Civic Education with Civic Education Ecology models and media

Component	Score	Content Validity	Construct Validity		Reliability	
1. Lesson plan	3.44	Very Valid	3.33	Very Valid	0.96	Reliable
2. 2. Learning Media Civic Education Ecology	3.38	Very Valid	3.62	Very Valid	0.74	Reliable
3. Test Instruments	3.68	Very Valid	3.66	Very Valid	0.73	Reliable

The content prepared in this lesson has been fully integrated with Civics Ecology learning media in the application and the pknekologi.com website.

Table 3 portrays the determination of the effectiveness of Civics learning with Civic Education Ecology media. Table 3 indicates that there are differences in pre-test and post-test abilities between the control and experimental classes. The lowest pre-test Ecological Competence score was 0.48 (Experimet Class) and 0.40 (Control Class), while the highest was 1.10 (Experiment Class) and 1,30 (Control Class). In post-test Ecological Competency, the lowest score was 1.40 (Experiment Class) 0,30 (Control Class), and the highest was 2.65 (Experiment Class) 2.29 (Control Class). The mean Ecological Competency score differed between the pre-test and post-test: the lowlest mean of the pre-test was 0.83 (Experiment

Class) and 0.50 (Control Class), and the highest was 2.34 (Experiment Class) and 1.28 (Control Class).

Table 3.
Pretest and postest

		Group Experiment N=42	Group Control N=41
Lowest Score	Pre-test	0.48	0.04
	Post-test	1.40	0.30
	Mean	0.83	0.47
Highest Score	Pre-test	1.10	1,30
	Post-test	2.65	2,29
	Mean	2.32	1,28

In determining the difference between the two research classes, this research employs the statistical test Mann-Whitney non-parametric inferential statistics ($\alpha = 5\%$) through the normality test. This research distributes the data with normal distribution in the controlled class, p (Sig.)= 0.025 (Pre Test) and 0.317 (Post Test). In the experimental class distributes the data with random distribution, because the value of Shapiro-Wilk Normality Test in Experiment class is p (Sig.)= 0.0024 for pre Test (Not Normal), p (Sig.)= 0.000 for post Test (Not Normal). Moreover, the Levene Statistic Homogeneity Test shows that the data do not exhibit homogeneity.

The Mann-Whitney test results indicate a significant difference between the results before and after the test in both classes, and the hypothesis is accepted. Based on the effect size, they have substantial effect categories. However, the experimental class shows a greater value than the control class. It is because the tested class has experienced learning with Civics Ecology learning media that motivates students and provides them with a different experience than the learning media used in a conventional method.

Table 4.
Mann-Whitney Test

Mann-Whitney Test		Cohen's d-effect size	
Group	p (sig.)	d-effect size	Category
Experiment Group	0.000	1.89	Very Large
Control Group	0.000	1.58	Very Large

From the data analysis on Ecological Competence results, the pre-test score of the control and experimental classes are in a low category. However, after implementing the Civic Education Ecology learning media, there was an increase in the experimental group on all indicators of ecological competence. The increase in N-gain skills is in the high and medium categories. The smallest increase of N-Gain is at indicator (2) Participation in environmental conservation activities. For this indicator, the students show less interest and participation in public organizations concerning the environment.

From the results of the data analysis available in Table 4, there is an increase in value (N-gain) on each indicator. In the experimental class there was a greater increase in each indicator, but the increase (N-gain) in the control class looks smaller. The lowest increase in N-gain indicates being able to consider the possibility of an Environmental crisis (E) because students cannot analyze in depth various possible environmental damage caused by human actions.

The results of the N-Gain analysis show that the average in the experimental class is 0.696 (middle criteria), while the control class is 0.278 (low criteria). Therefore, the value of N-Gain ecological competencies in the experimental class is higher than in the control class. In addition, the normality test results on N-Gain data show the random distribution in the experimental group. At the same time, the control class has a normal distribution because many high-value

data points are present in the N-Gain value. In addition, the findings from the homogeneity test indicate that the data is homogeneously distributed.

Table 5.
Improvement of Ecological Competence for each indicator in both classes

Group		Ecological Competence indicator							
		1		2		3		4	
Eksperiment	X1	1.01	H	1.04	H	0.96	H	0.99	H
	X2	1.80	H	2.05	H	2.26	H	2.48	H
	<g>	0.40	M	0.52	M	0.64	M	0.74	H
Control	X3	1.22	H	1.10	H	1.15	H	1.34	H
	X4	1.62	H	1.60	H	1.64	T	1.56	H
	<g>	0.22	L	0.26	L	0.26	L	0.13	L

Notes: X1 (pre-test experimental class); X2 (post-test experimental class); X3 (pre-test control class); X4 (post-test control class); 1 (Self-responsibility to a sustainable environment); 2 (Human and Environmental Rights); 3 (Participation in environmental conservation activities); 4 (Anti-Anthropocentrism); 5 (Able to consider the possibility of an Environmental crisis); L (low); M (middle); H (height)

Consequently, the Mann-Whitney test, a non-parametric inferential statistic, is utilized to ascertain the significance of the profit differences between the two classes. There is a significant difference between the n-gain of the control and the experiment class. This is because using Civic Education Ecology learning media can help students increase their ecological competence. Besides, the Civic Education Ecology learning design is developed based on problem-based learning and supported by Augmented Reality technology. Thus, it can train students to get used to solving environmental problems in the community.

Students implementing Civic Education Ecology learning media can ultimately have beneficial competencies to overcome citizenship problems in the environmental field. It differs from conventional learning models as it needs to train students in problem-solving. It aligns with some research results concerning the project emphasizing more aspects of Ecological Competence, such as analyzing and choosing the right concepts and principles needed in problem-solving. This implies that civic education ecology learning media is better than conventional classes. Students can think analytically, acquire skills, and back their reasoning with scientific evidence to seek alternative solutions. Civics Learning Media will facilitate this process by offering worksheets and structured assignments for practice.

From a learning theory perspective, findings in this research strengthen the learning theory suggested by John Dewey that the class should be a laboratory for solving real-life problems (Arends et al., 2001). In addition, Civic Education Ecology learning media utilizing VR can add sensory feedback information to one or more senses in a way that immerses the users in a simulation or virtual environment (Mihelj et al., 2014). Thus, students feel as if they were there, feeling and behaving as if they were in a virtual environment. The main advantage of learning with VR is that it emphasizes engagement, interaction, and imagination (Zhang et al., 2017). Engagement through VR media includes physical and mental engagement. Physical engagement is the feeling of being physically present in the non-physical world. Besides, cognitive engagement refers to involvement and a sense of 'being' in the task environment. Interaction refers to the user's ability to see changes in activity on the screen through

movements and responses. Imagination means that the VR environment triggers the capacity of the human mind to perceive, imagine, and creatively feel.

The analysis results show that 1) Students in the experimental class achieved an average problem-solving score of 2.32, The score is considered part of the high category, and 2) Increasing the ability of students' Ecological Competence has a p-value <0.05. It implies that it differs significantly; 3) The experimental class has an effect size of 1.95, placing it in the enormous category; 4) For the experimental class, the N-gain value is considered medium, and 5) The experimental and control classes had a p-value of less than 0.05, indicating a significant difference between them. Thus, Civic Education Learning with Civic Education Ecology Learning Models and Media can help students improve their ecological citizenship competencies.

A survey of 42 students revealed (n = 42) that their responses to Civics learning activities with Civic Education Ecology Learning Models and Media can help students improve their ecological citizenship competencies. The analysis results show that the average score for the category is 25,58%, strongly agrees with 53,48%, and disagrees with 20,94 %. Thus, this learning activity belongs to the very positive criteria for students. Using Civic Education Ecology Learning Models and Media is considered more innovative and exciting by students than conventional learning as it focuses on class and ordinary learning without using technology that bores the students. Civic education study, a tiresome subject discussing theory, uses Civic Education Ecology learning media to make students more enthusiastic and interested as it presents a virtual experience that is different and similar to reality.

Conclusion

Civic ecology learning models and media have shown the potential to enhance students' ecological competence in understanding the rights and responsibilities of citizens. The study's learning tools demonstrated validity and reliability for each learning component. The developed civics ecology learning media proved effective in boosting students' ecological competence and fostering positive engagement in learning, as evidenced by the higher N-Gain in the experimental class compared to the control class. Further research is recommended to enhance these findings, particularly in evolving technology and student characteristics. Based on these results, we encourage educators to consider using the developed learning media or creating similar concepts, given its proven effectiveness in enhancing students' ecological understanding.

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