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Enhancing 21st Century Teachers Through Eco-Digital Pedagogy

Edi Kurniawan[1]*, Muhammad Akhyar[2], Chatarina Muryani[3], Asrowi[4]
[1-4]Universitas Sebelas Maret, Indonesia, Universitas Negeri Semarang, Indonesia
[2-4]Universitas Sebelas Maret, Indonesia

Abstract

Pedagogy plays an essential role in the learning process. Ecopedagogy and digital pedagogy are two of its derivatives. This study focuses on the combination of the two pedagogical models, namely Eco-Digital Pedagogy (EDY). It proposes to reveal the effectiveness of the implementation of the EDY model on the readiness of prospective 21st century teachers. This study's population was Geography students at Semarang State University (UNNES) in Indonesia. The data obtained were tested by paired t-test and strengthened by the N-Gain test. The results show that the implementation of the EDY model has proven effective in increasing the ability of prospective teachers, namely in 1) showing the leadership skills, 2) creating an environment that respects the diversity of students, 3) understanding every content they deliver, 4) facilitating learning to their students, and 5) reflecting on their teaching practices. This positive result indicates that the EDY model can be used to further develop the abilities of prospective teachers to generate better outputs in the learning process.

Keywords: Ecopedagogy, digital Pedagogy, eco-digital pedagogy, 21st century teachers

Introduction

Over years, globalization has been a huge challenge for many communities, including in education. Educational institutions must transform into the latest formats to keep up with trends in the 21st century. They have to generate more innovations related to various resources, especially related to the teachers' competence—as educators are said to be an influential factor in the learning process. Teachers must possess professionalism and competence to equip students to face the effects of globalization (Stojsic, Ivkov-Dzigurski, & Maricic, 2019).

UNESCO emphasizes the need for teachers to upgrade their knowledge and skills to be able to adapt and address economic, social, and cultural challenges and opportunities in the 21st century (Jacques, 1996). According to Nessipbayeva (2012), educators' competencies include leadership skills, fostering an inclusive environment, having a thorough understanding of the material, promoting independent learning, and reflecting on teaching practices.

Some characteristics are said to must be possessed by teachers nowadays, namely creativity, critical thinking, communication, and collaboration (4Cs). They should be capable of redesigning educational programs that meet the very current needs, primarily regarding information and communication technology (Calacar, 2020).

According to Gumus (2022), 21st century teachers must have several competencies, namely 1) innovative, solutive, and creative ways of thinking, 2) teaching equipment based on technology, communication, and information, 3) accountability as citizens which is realized through professionalism , and 4) a collaborative and cooperative way of working. The European Commission (2005) put forward the same thing, that 21st century teachers must have three main competencies, namely working with other people, technology, and society.

Daryanto & Syaiful (2017), citing the International Society for Technology in Education, stated four aspects related to the competence of 21st century teachers, namely 1) ability to facilitate and spark student creativity, 2) ability to become a model for learning and working in the digital era, 3) capability in encouraging and being a model of responsibility and digital society, and 4) ability to participate in the development of professional leadership.

Pedagogy plays a crucial role in teaching, especially for children, to develop their character and abilities (Sadulloh, 2018). Pedagogic concepts are significant for every teacher, as they encourage the development of the student's personality, mentality, and skills to deal with their problems independently. Teachers' roles are not limited to teaching, but also to shape students' personalities. In the 21st century, students' personalities and skills must be relevant to digitalization (Purfitasari et al., 2019).

Corresponding Author e-mail: edikurniawan@mail.unnes.ac.id
https://orcid.org/0000-0002-8394-9259

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The students' awareness and understanding of environmental issues are referred to as ecological competence. The goal of this competence is to educate students to understand environmental issues and apply ways to conserve and solve environmental problems that occur around them. Ecological aspects in the educational context must be mastered by students in the learning process so that ecological competence can be achieved (Muhaimin, 2015). The Ministry of Environment (2004) also states that ecological competence consists of several learning domains, including knowledge/understanding and awareness, attitudes/values, skills, and actions/participation. Ecological competence encompasses aspects of knowledge, understanding, and skills that include competence in environmental participation (Palmer, 1998).

The increasing complexity and speed of global changes highlights the need for greater attention to Education for Sustainable Development (ESD). This is because education is a critical requirement for achieving the Sustainable Development Goals (SDGs) and connecting with the trends that drive change in our lives (Burbules, Fan, & Repp, 2020)

In addition to an in-depth understanding of ecology and the use of its principles in the learning process, teachers must also pay attention to digital pedagogy. Digital pedagogy is an approach that is not only based on the teacher's skills in using technology, but also how the teacher as a facilitator uses technology to build thinking skills while developing the affective aspects of students (Purfitasari et al., 2019).

According to Toktarova & Semenova (2020), digital pedagogy includes four aspects: 1) environmental, namely the implementation of content and communication components in a digital education environment, 2) competence-based, namely the establishment and development of digital competence in teachers to create interactive and meaningful learning for students, 3) content-based, namely the creation of an educational product in digital form that provides new opportunities to educational subjects in the process of learning and cognitive communication, and 4) technological, namely various efforts that correlate with technology such as forms (synchronous, asynchronous), methods (active, interactive, etc.), tools (computers, laptops, smartphones), and teaching techniques (multimedia technology, cloud).

Meanwhile, according to Vaataja & Ruokamo (2021), the digital pedagogy dimension consists of three things: (1) pedagogical orientation, namely the teacher's perception of how learning should be directed, how individuals learn, and how they should be taught and guided, (2) pedagogical practices, which are related to the methods used by teachers in teaching, and (3) pedagogical competencies, namely the skills needed by a teacher to properly integrate digital technology into the learning process. All of these dimensions must be met to create a successful learning process.

According to research conducted by Pardinan and Loremia (2020), digital pedagogy effectively contributes to developing individual competencies in students. Similarly, research by Moreno, Calderon, and Arias-Estero (2021) suggests that combining Technological Pedagogical Content Knowledge (TPACK) with Collaborative Learning (CL) enhances the development of digital competencies and academic achievement of prospective teachers. The complexity of the relationship between technology, content, and pedagogy drives the improvement of digital competencies among prospective teachers. Therefore, this development is urgent and needs to be implemented.

According to Ahuja & Yadav (2019), academic performance of students who were taught using digital pedagogy was found to be better than those in traditional classrooms. This is because students are given equal opportunities to respond to every question and material presented by the teacher using digital technology.

Based on the description above, it can be concluded that one way to become a competent teacher in accordance with 21st century principles is to have awareness, knowledge, and ability to apply eco-pedagogy and digital pedagogy. This research focuses on the combination of the two pedagogical models, namely Eco-Digital Pedagogy (EDY). This study aims to determine the effectiveness of the implementation of the EDY model on the readiness of prospective 21st century teachers.

Research Methodology

The study focused on the impact of the EDY model implementation on students' readiness as prospective 21st-century professional teachers. In the study, quantitative research design was adopted. This study's population was students at the Geography Department, Faculty of Social Sciences, Semarang State University (UNNES) in Indonesia. Primary data was the result of an assessment of the performance of prospective teachers at the pretest and post-test stages. Meanwhile, secondary data was articles, books, and other references.

The data obtained were tested by paired t-test and strengthened by the N-Gain test. Effectiveness testing was carried out at two research stages to obtain more valid results, namely at the expanded trial stage (Stage 1) with 62 respondents and the wide-scale test stage (Stage 2) with 92 respondents. The five indicators used are 1) educators show leadership (X1), 2) educators create an environment that respects the diversity of students (X2), 3) educators understand every content they deliver (X3), 4) educators facilitate learning to their students (X4), and 5) educators reflect on their teaching practices (X5).

Each of these indicators comprises sub-indicators, which can be explained in the following description.

Research Results

The results of the study using related tables and figures as in the following.

Paired t-test was conducted to determine the level of significance of the effect of applying the EDY model on student readiness as prospective 21st-century professional teachers, whose results can be presented in Table 1 below.

Table 1 shows that the sig. <0.05 at Stage 1 and Stage 2. This shows that implementing the EDY model significantly affects student readiness as prospective 21st-century professional teachers both at Stage 1 and Stage 2.

Furthermore, the N-Gain test determines the effectiveness of implementing the EDY model. The results of the N-gain test are presented in Table 2 below.

Based on the results in Table 2, the average N-Gain Stage 1 and Stage 2 scores are in the moderate category, with a score increase of 24% at Stage 1 and 18% at Stage 2. These results indicate that the application of the EDY model significantly affects student readiness. The following is the frequency distribution of the N-Gain category.

Figure 1 shows that most students have experienced an increase in their readiness to become 21st-century professional teacher candidates after implementing the EDY model. The results also show that students in the low category at Stage 1 are still > 30%, while in Stage 2, students in the low category fall to 13%. That is, the application of the EDY model is consistent in increasing student readiness.

Testing the effectiveness of the EDY model also includes all sub-indicators to obtain more detailed and valid results. The following is a count of the five indicators and their sub-indicators.

The results of the paired t-test to determine the level of significance of the effect of applying the EDY model to the indicator and sub-indicators "educators show leadership" (X1) are presented in Table 3 below.

Table 1: General Results of Paired T-Test

	T count	*Sig. (2-tailed)*	*Description*
Stage 1	13,251	0.000	Significant
Stage 2	13.112	0.000	Significant

Table 2: General Result of Paired N-Gain

	Pre-test	*Post-test*	*N-Gains*	*Categories*	*Improvements (%)*
Stage 1	2,781	3,461	0.558	Medium	24,44
Stage 2	2,792	3,301	0.421	Medium	18,24

Table 3 demonstrates that the sig. < 0.05 for each sub-indicator (X1). The average score of X1 is generally good at Stage 1 and Stage 2. This shows that the application of the EDY model hones the leadership of prospective teachers. They have better attitudes and qualities in leading the class, leading in schools, carrying out teaching professions, supporting schools and students, and demonstrating high ethical standards after implementing the EDY model.

Then, the N-gain test was also carried out to determine the effectiveness of implementing the EDY model.

Table 4 shows that the average N-Gain value at Stage 1 and Stage 2 is medium to high. That way, the implementation of the EDY model can be declared effective. In general, the improvement percentage of X1 is > 20% in both Stage 1 and Stage 2, with an average post-test score of> 3.3.

The next indicator is that "educators create an environment that respects the diversity of students" (X2). The results of the paired T-test are presented in Table 5 below.

Table 5 conveys that the sig. < 0.05 for each sub-indicator. The average score of X1 at both Stage 1 and Stage 2 is generally good. This shows that the application of the EDY model hones prospective teachers' understanding regarding the diversity of student backgrounds. They have better attitudes and qualities in providing an environment that supports positive relationships between students, nurtures the learning environment, embraces diversity in schools, adapts learning for students with special needs, and can work collaboratively with student guardians after implementing the EDY model.

Then, the N-gain test was also carried out to determine the effectiveness of implementing the EDY model on indicator X2.

Table 6 shows that the average N-Gain value on the indicator and sub-indicators X2 at both Stage 1 and Stage 2 is in the moderate category. That is, the implementation of EDY can be said to be quite effective. In general, the improvement percentage of X2 is not much different, namely 21% at Stage 1 and 18% at Stage 2, with an average post-test score > 3.3.

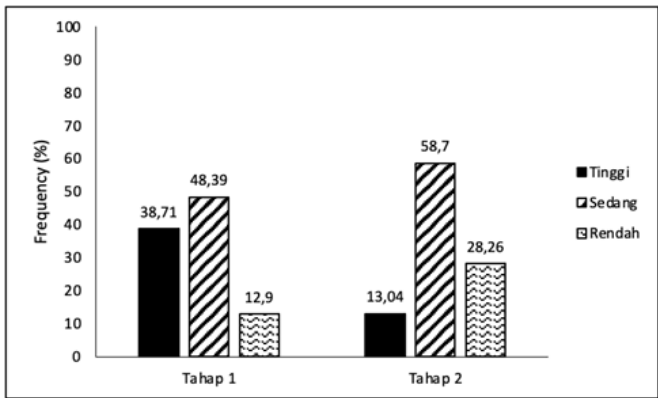

Fig. 1: Distribution of N-Gain Category

The next indicator in the EDY model is "educators understand every content they deliver" (X3). Following are the results of the significance with paired t-test.

Table 7 shows that the sig. < 0.05 for each sub-indicator. The average score of X3 is generally good at Stage 1 and Stage 2. This shows that applying the EDY model hones the understanding of

Table 3: *Result of Paired T-Test on Indicator and Sub-Indicators X1*

	Sub-Indicators	T count	Sig. (2-tailed)	Description
Stage 1	X1.1	17033	0.000	Significant
	X1.2	11,729	0.000	Significant
	X1.3	9.167	0.000	Significant
	X1.4	5,322	0.000	Significant
	X1.5	4,994	0.000	Significant
	Average X1	13,733	0.000	Significant
Stage 2	X1.1	8,960	0.000	Significant
	X1.2	7,471	0.000	Significant
	X1.3	8004	0.000	Significant
	X1.4	7,629	0.000	Significant
	X1.5	7,862	0.000	Significant
	Average X1	12,943	0.000	Significant

Table 4: Result of N-Gain Test on Indicator and Sub-Indicators X1

	Sub-Indicators	*Pre*	*Post*	*N-gain*	*Categories*	*Improvements (%)*
Stage 1	X1.1	2,410	3,577	0.734	High	48.46
	X1.2	2,505	3,570	0.712	High	42.49
	X1.3	2,657	3,375	0.535	Medium	27.01
	X1.4	3.016	3,560	0.553	Medium	18.05
	X1.5	3,054	3,554	0.528	Medium	16.37
	Average X1	2,728	3,527	0.628	Medium	29.28
Stage 2	X1.1	2,724	3,259	0.419	Medium	19.63
	X1.2	2,764	3,228	0.375	Medium	16.78
	X1.3	2,750	3,193	0.354	Medium	16.11
	X1.4	2,834	3,476	0.550	Medium	22.63
	X1.5	2,743	3,464	0.573	Medium	26.29
	Average X1	2,763	3,324	0.453	Medium	20.29

Table 5: *Result of Paired T-Test on Indicator and Sub-Indicators X2*

	Sub-Indicators	T Count	Sig. (2-tailed)	Description
Stage 1	X2.1	4,041	0.000	Significant
	X2.2	6,961	0.000	Significant
	X2.3	8,921	0.000	Significant
	X2.4	5,922	0.000	Significant
	Average X2	8,214	0.000	Significant
Stage 2	X2.1	8,558	0.000	Significant
	X2.2	6,790	0.000	Significant
	X2.3	6,771	0.000	Significant
	X2.4	5,471	0.000	Significant
	Average X2	11.317	0.000	Significant

prospective teachers towards the material. They can develop and implement effective learning, create material according to personal abilities, understand the interrelationships of particular subject areas or disciplines, and make relevant teaching in 21st-century learning.

The test results to determine the effectiveness of implementing the EDY model on indicator X3 are presented below.

Table 8 demonstrates the average N-Gain values for indicator and sub-indicators X3 at Stages 1 and 2, categorized as moderate to high. That is, implementing the EDY model is quite very effective. In general, the improvement percentage of X3 is similar, namely 16% at Stage 1 and 27% at Stage 2, with an average post-test score > 3.3.

The next indicator is "educators facilitate learning to their students" (X4). The following is its significance test.

Table 6: Result of N-Gain Test on Indicator and Sub-Indicators X2

	Sub-Indicators	*Pre*	*Post*	*N-Gains*	*Categories*	*Improvements (%)*
Stage 1	X2.1	2,952	3,339	0.369	Medium	13.11
	X2.2	2,823	3,419	0.507	Medium	21.14
	X2.3	2,495	3,312	0.543	Medium	32.76
	X2.4	2,944	3,544	0.569	Medium	20.41
	Average X2	2,803	3,404	0.502	Medium	21.42
Stage 2	X2.1	2,489	3,359	0.576	Medium	34.93
	X2.2	2,976	3,310	0.326	Medium	11.23
	X2.3	2,812	3,239	0.360	Medium	15.21
	X2.4	2,948	3,370	0.401	Medium	14.29
	Average X2	2,806	3,319	0.430	Medium	18.29

Table 7: Result of Paired T-Test on Indicator and Sub-Indicators X3

	Sub-Indicators	*T Count*	*Sig. (2-tailed)*	*Description*
Stage 1	X3.1	8,587	0.000	Significant
	X3.2	12,196	0.000	Significant
	X3.3	8,529	0.000	Significant
	X3.4	9,445	0.000	Significant
	Average X3	11,963	0.000	Significant
Stage 2	X3.1	7,919	0.000	Significant
	X3.2	7.153	0.000	Significant
	X3.3	7,717	0.000	Significant
	X3.4	8,693	0.000	Significant
	Average X3	10.115	0.000	Significant

Table 8: Result of N-Gain Test on Indicator and Sub-Indicators X3

	Sub-Indicators	*Pre*	*Post*	*N-gain*	*Categories*	*Improvements (%)*
Stage 1	X3.1	2,706	3,444	0.570	Medium	27.27
	X3.2	2,806	3,677	0.730	high	31.03
	X3.3	2,763	3,430	0.539	Medium	24.12
	X3.4	2,781	3,449	0.548	Medium	24.03
	Average X3	2,764	3,500	0.595	Medium	26.62
Stage 2	X3.1	2,766	3,228	0.374	Medium	16.70
	X3.2	2,893	3.313	0.379	Medium	14.50
	X3.3	2,830	3,297	0.399	Medium	16.52
	X3.4	2,882	3,311	0.383	Medium	14.87
	Average X3	2,843	3,287	0.384	Medium	15.63

Table 9 points out that the sig. < 0.05 for each sub-indicator (X4). The average score of X4 is generally good at Stage 1 and Stage 2. This shows that the application of the EDY model hones the ability of prospective teachers to facilitate their students. They better understand students' intellectual, physical, social and emotional development so that they can plan appropriate learning by using appropriate methods, materials and technology to develop the ability to think critically and solve problems.

The test results to determine the effectiveness of implementing the EDY model on indicator X4 are presented below in Table 10.

Based on the results in Table 10, the average N-Gain score for indicators and sub-indicators X4 at Stage 1 and Stage 2 is categorized as moderate. Applying the EDY model to the sub-indicators and indicator X4 is quite effective. In general, the improvement percentage of X4 is not much different, namely 23% at Stage 1 and 17% at Stage 2, with an average post-test score > 3.2.

The last indicator is "educators reflect on their teaching practices" (X5). The significance test results of indicators and sub-indicators are explained as follows.

Table 11 shows that the sig. < 0.05 for each sub-indicator (X1). The average score of X5 is generally good at Stage 1 and Stage 2. This shows that the application of the EDY model hones the reflection abilities of prospective teachers. They can analyze student learning, link professional growth to their professional goals, and engage effectively in complex and dynamic environments to enhance learning.

Table 9: Result of Paired T-Test on Indicator and Sub-Indicators X4

	Sub-Indicators	T Count	Sig. (2-tailed)	Description
Stage 1	X4.1	9,658	0.000	Signi cant
	X4.2	6,355	0.000	Signi cant
	X4.3	8006	0.000	Signi cant
	X4.4	8,281	0.000	Signi cant
	X4.5	7,382	0.000	Signi cant
	X4.6	5,864	0.000	Signi cant
	X4.7	7,856	0.000	Signi cant
	X4.8	8,873	0.000	Signi cant
	Average X4	10.154	0.000	Signi cant
Stage 2	X4.1	7,560	0.000	Signi cant
	X4.2	8,906	0.000	Signi cant
	X4.3	6,560	0.000	Signi cant
	X4.4	6,651	0.000	Signi cant
	X4.5	7,024	0.000	Signi cant
	X4.6	6005	0.000	Signi cant
	X4.7	6,458	0.000	Signi cant
	X4.8	8,870	0.000	Signi cant
	Average X4	10.11	0.000	Signi cant

Table 10 *Result of N-Gain Test on Indicator and Sub-Indicators X4*

	Sub-Indicators	Pre	Post	N-Gains	Categories	Improvements (%)
Stage 1	X4.1	2,730	3,435	0.556	Medium	25.85
	X4.2	2,806	3,409	0.505	Medium	9:46 p.m
	X4.3	2,731	3,473	0.585	Medium	27.17
	X4.4	2,849	3,387	0.467	Medium	18.87
	X4.5	2,802	3,379	0.481	Medium	20.58
	X4.6	2,871	3,427	0.493	Medium	19.38
	X4.7	2,629	3,419	0.576	Medium	30.06
	X4.8	2,756	3,433	0.545	Medium	24.58
	Average X4	2,772	3,420	0.528	Medium	23.40

en, the measurement of the e ectiveness of applying the EDY model to the indicator and sub-indicators X5 is stated as follows.

Based on the results in Table 12, the average N-Gain score on the indicator and sub-indicators X5 at Stage 1 and Stage 2 is categorized as moderate. is means that the EDY model

	Sub-Indicators	*Pre*	*Post*	*N-Gains*	*Categories*	*Improvements (%)*
	X4.1	2,807	3.215	0.342	Medium	14.52
	X4.2	2,601	3,214	0.438	Medium	23.54
	X4.3	2,873	3,250	0.334	Medium	13.11
	X4.4	2,839	3,237	0.343	Medium	14.04
Stage 2	X4.5	2,761	3,234	0.382	Medium	17.13
	X4.6	2,853	3,283	0.374	Medium	15.05
	X4.7	2,717	3,255	0.419	Medium	19.80
	X4.8	2,751	3,251	0.400	Medium	18.17
	Average X4	2,775	3,242	0.381	Medium	16.82

Table 10: Result of N-Gain Test on Indicator and Sub-Indicators X4

	Sub-Indicators	*Pre*	*Post*	*N-Gains*	*Categories*	*Improvements (%)*
	X4.1	2,730	3,435	0.556	Medium	25.85
	X4.2	2,806	3,409	0.505	Medium	9:46 p.m
	X4.3	2,731	3,473	0.585	Medium	27.17
	X4.4	2,849	3,387	0.467	Medium	18.87
Stage 1	X4.5	2,802	3,379	0.481	Medium	20.58
	X4.6	2,871	3,427	0.493	Medium	19.38
	X4.7	2,629	3,419	0.576	Medium	30.06
	X4.8	2,756	3,433	0.545	Medium	24.58
	Average X4	2,772	3,420	0.528	Medium	23.40
	X4.1	2,807	3.215	0.342	Medium	14.52
	X4.2	2,601	3,214	0.438	Medium	23.54
	X4.3	2,873	3,250	0.334	Medium	13.11
	X4.4	2,839	3,237	0.343	Medium	14.04
Stage 2	X4.5	2,761	3,234	0.382	Medium	17.13
	X4.6	2,853	3,283	0.374	Medium	15.05
	X4.7	2,717	3,255	0.419	Medium	19.80
	X4.8	2,751	3,251	0.400	Medium	18.17
	Average X4	2,775	3,242	0.381	Medium	16.82

Table 11: Result of Paired T-Test on Indicator and Sub-Indicators X5

	Sub-Indicators	*T count*	*Sig. (2-tailed)*	*Description*
Stage 1	X5.1	6,787	0.000	Signi cant
	X5.2	5,931	0.000	Signi cant
	X5.3	9,562	0.000	Signi cant
	Average X5	9,761	0.000	Signi cant
Stage 2	X5.1	6,745	0.000	Signi cant
	X5.2	7.153	0.000	Signi cant
	X5.3	8,511	0.000	Signi cant
	Average X5	9.165	0.000	Signi cant

Table 12: *Result o f N-Gain Test on Indicator and Sub-Indicators X5*

	Sub-Indicators	Pre	Post	N-gain	Categories	Improvements (%)
Stage 1	X5.1	2,978	3,516	0.526	Medium	18.05
	X5.2	2,847	3,435	0.510	Medium	20.68
	X5.3	2,685	3,403	0.546	Medium	26.73
	Average X5	2,837	3,452	0.529	Medium	21.67
Stage 2	X5.1	2,833	3,341	0.435	Medium	17.90
	X5.2	2,799	3,342	0.452	Medium	19.42
	X5.3	2,679	3,310	0.477	Medium	23.53
	Average X5	2,771	3,331	0.456	Medium	20.23

has quite a practical effect on the readiness of prospective teachers on the sub-indicators and indicator X5. In general, the improvement percentage of X5 is not much different, namely 22% at Stage 1 and 20% at Stage 2, with an average post-test score > 3.3.

Discussion

The study results indicate that applying the Eco-Digital Pedagogy (EDy) learning model effectively increases student readiness as prospective 21st-century professional teachers. The model implementation and student activities are in the high category and have grown at each stage. The results of the Paired T-Test also showed significant results. It means there was an increase from before and after implementing the EDy learning model. All variables and sub-variables show substantial results both in the expanded trial phase and the effectiveness test stage with moderate to high score increases. Therefore, the EDy learning model is feasible and effective in improving students' teaching skills and readiness.

The results showed that based on the N-Gain analysis, the score increase in the expanded trial phase and the effectiveness test were both in the moderate category. However, the N-Gain value obtained in the expanded trial phase was slightly higher than in the effectiveness test stage. This result was due to differences in research subjects. In the limited trial, the EDy learning model was applied to final 5th-semester students, while in the testing phase, the effectiveness of the EDy learning model was used on early 4th-semester students.

This result is relevant to the study from Yuksel & Saglam (2018), which states that competency differences exist between second-year, third-year, and fourth-year prospective teacher students. Tasdemir, Iqbal, & Asghar (2020) state that experience and practice are essential factors that determine the teaching readiness of teacher candidates. The results of a study by Valtonen et al. (2021) also state that teacher candidates' ability increases each year. Similar results were also shown in a survey by Afalla & Fabelico (2020).

The results of the analysis per variable show that the one with the highest N-Gain score is the X1 variable; namely, educators show leadership. In the expanded trial (stage 1) and the effectiveness test (stage 2), variable X1 gets the highest N-Gain score, indicating that variable X1 receives the highest score increase. An important factor influencing the high effectiveness of the EDy model in increasing the leadership of teacher candidates is that in the EDy model, teacher candidates get a direct description from the lecturer on how to lead and organize learning in class. Lecturers provide real examples and illustrations of how to manage class strategies through real examples by the lecturers during course.

The educator variable shows that leadership is essential to be mastered by teacher candidates. Teachers should not just be teachers (Helterbran, 2010). An effective teacher must be a leader for his students (Bolkan & Goodboy, 2009). Teacher leadership is crucial for improving the quality of learning both inside and outside the classroom (Suryana, Widiawati, & El Widdah, 2019). Leading teachers will be able to demonstrate outstanding classroom management skills and possess skills to drive student academic success (Singh & Singh, 2022; Warren, 2021). The lead teacher will play three prominent roles in the class: role models, facilitators, and mediators (Espania, 2012). Study results from Calderone, Kent, & Green (2018) show that students who are taught by lead teachers obtain better academic scores. The results of a similar study were also conducted by Espinosa & Gonzales (2023); Khan et al. (2020); Nafia & Suyatno (2020), Peter et al. (2020), Shen et al. (2020), Tesik (2017), Trigueros, et al. (2020); Zhao & Zhang (2022). Besides the academic domain, teacher leadership is essential to forming good student character (Ningsih & Wijayanti, 2018).

Lecturers provide examples through actual learning practices in teaching students. Students are also allowed to practice leading through the role-play stage. At that stage, students make presentations as if teaching in front of the class. The role-play stage will enhance the student experience in delivering material and leading classes. The results of a study by Moreno-Guerrero et al. (2020) show that the role-play method assisted by educational videos effectively improves teacher candidates' skills. The results of studies from Hidayati & Pardjono (2018), Kilgour et al. (2015), Romero-Hall, Adams, & Osgood (2019), Scharfenberg & Bogner (2019) and Crow & Nelson (2016) also show similar results.

In variable X2, the environmental educators who respect the diversity of students, the N-Gain value obtained by students in stage 1 is the lowest among other variables. Meanwhile, in stage 2, variable X2 receives an N-Gain value in the middle category compared to other variables. These results can be a critical evaluation for implementing the EDy model to pay more attention to the competency formation of teacher candidates to make them respect the diversity of students in learning.

The teacher's ability to understand the diversity of students and integrate multicultural values in learning development is not an easy challenge to achieve (Ariana et al., 2019). Teachers in curriculum management and learning act as planners, executors, managers or organizers, and evaluators. Hence, teacher awareness of multicultural elements is critical (Choi & Lee, 2020; Yuan, 2018). Teachers must ensure all students get meaningful learning experiences (Edward & Joseph, 2014). However, research shows that teacher education programs can still not educate teacher candidates to be skilled in managing multicultural classrooms (Ramsey, 2004). Many cannot accommodate multicultural students (Castro, 2010; Kim & Jeon, 2017).

In variable X3, understanding the teaching content well, there is quite a striking disparity between students at stage 1 and stage 2. Variable X3 contains sub-variables and indicators closely related to teachers' professional abilities. This variable must be an essential concern because, as a geography teacher, an individual must understand geography learning (Zarni, Maryani, & Setiawan, 2019). Geography learning should be directed at building students' spatial thinking skills (Webster, 2015) and using geospatial technologies such as Geographic Information Systems (GIS), Remote Sensing (PJ), and Global Positioning Systems (GPS) (Gersmehl, 2008). More specifically, geography teachers need to have a diverse knowledge of natural sciences (e.g., geomorphology, water resources, biology, and climate) and social sciences (e.g., nations, history, archaeology), able to explain relationships between social phenomena, natural events, and geographic space, and teach geographic knowledge (Karaca, 2020; Pirbhai-Illich & Martin, 2020). In addition, relevant to EDy learning, geography teachers must have professional skills to teach education for sustainable development (ESD).

Another variable that gets a reasonably high N-Gain score compared to other variables at stage 1 but a low score compared to other variables at stage 2 is variable X4; educators facilitate learning for their students. Then, variable X5 becomes a variable that gets a low N-Gain score for stage 1 students but a high N-Gain score among other variables for stage 2 students. This means that for fourth-semester students, the EDy learning model becomes an essential factor for improving their reflection ability to enhance their performance in teaching in class. This happens because the EDy learning model facilitates students to develop their pedagogical skills through group work and role-play activities. In addition, reflection and evaluation activities using peer assessment and self-assessment are also necessary for students to reflect on their abilities.

The results of this study indicate that the EDy learning model can effectively be implemented into various courses from the early semester to the final semester to improve the abilities and readiness of 21st-century prospective teacher students. The EDy model contains the principles of contextual learning and cooperative and collaborative learning through discussion and group work. Relevant contextual understanding is consistent with constructivist learning theory, which focuses on how individuals make sense of their world (Perin, 2011). Several studies have proven the effectiveness of contextual learning in improving student learning outcomes, including a survey by Tamur et al. (2020), Acharya et al. (2020), Sung et al. (2019), and Khaefiatunnisa (2015). Collaborative and cooperative learning is also effective (Jony, 2020) and is very useful because it can bring many benefits in terms of social, psychological, academic, and assessment (Laal & Ghodsi, 2012; Sidgi, 2022).

The EDy model also applies 21st-century skills-based learning through active learning and innovative technology. It also involves more meaningful learning through role-play. The use of technology in education is essential and provides enormous benefits (Ghavifekr & Rosdy, 2015; Haleem et al., 2022). Role play is also claimed to be an effective strategy for developing pedagogical content knowledge in prospective teacher students (Hume, 2012).

After getting knowledge from lectures, students are expected to apply the EDy learning model in teaching practice in class to make them more skilled and prepared. The application of the EDy learning model by students can be achieved through micro-teaching and field learning practice activities (PPL) at school. Lecturers must provide more teaching practice opportunities for teacher candidates. Practicums such as microteaching have positively impacted prospective teachers' readiness (Brouwer & Korthagen, 2005; Kilic, 2010). Experiential learning through practical activities in schools also provides an extraordinary experience for the competency development of prospective teachers (Vega, 2008; Ismail & Jarrah, 2018).

Conclusions and Implications

In the 21st century, the ability of teachers to integrate learning, technology, and noble principles such as caring for the environment is important. The findings in this study show that the implementation of Eco-Digital Pedagogy, which is a combination of ecopedagogy and digital pedagogy, can improve the readiness and competence of prospective teachers in five aspects, namely in 1) showing the leadership skills, 2) creating an environment that respects the diversity of students,

3) understanding every content they deliver, 4) facilitating learning to their students, and 5) reflecting on their teaching practices. This positive result indicates that the EDY model can be used to further develop the abilities of prospective teachers to generate better outputs in the learning process. Furthers studies of EDY are expected to provide broader information to enhance the learning process.

References

Acharya, K. P., Budhathoki, C. B., Bjonness, B., & Devkota, B. (2020). School gardening activities as contextual scaffolding for learning science: participatory action research in a community school in Nepal. Educational Action Research.

Afalla, B. T., Fabelico, F. L. (2020). Pre-service teachers' pedagogical competence and teaching efficiency. Journal of Critical Review, 7(11), 223-228.

Ahuja, S. & Yadav, D. (2019). Effect of digital pedagogy interventions in rural areas. MIER Journal of Educational Studies, Trends & Practices, 9(2), 227-240.

Ariana, Y. K., Ulfatin, N., Imron, A., Maisyaroh. (2019). Teacher awareness about multicultural in curriculum management and instructional development in senior high school. Advances in Social Science, Education and Humanities Research, 381, 100-107.

Bolkan, S. & Goodboy, A. (2009). Transformation leadership in the classroom: Fostering student learning, studeng participation, and teacher credibility. Journal of Instructional Psychology, 36(4), 296-305.

Brouwer, N. & Korthagen, F. (2005). Can teacher education make a difference ? American Educational Research Journal, 42(1), 153-224.

Burbules, N. C., Fan, G., & Repp, P. (2020). Five trends of education and technology in a sustainable future. Geography and Sustainability, 1(2), 93-97.

Calacar, G. B. (2020). Teaching the 21st century skills: Teachers' competence, practice, and challenges. Journal of World Englishes and Educational Practices, 2(2), 81-91.

Calderone, S., Kent, A., & Green, A. (2018). Teacher leaders and student achievement: Can the dots be connected ? Revista Electronica de Educacao, 12(2), 395-407.

Castro, F. G., Barrera Jr, M., & Holleran Steiker, L. K. (2010). Issues and challenges in the design of culturally adapted evidence-based interventions. Annual review of clinical psychology, 6, 213-239.

Choi, S. & Lee, S. W. (2020). Enhancing teacher self-efficacy in multicultural classrooms and school climate: The role of professional development in multicultural education in the United States and Sout Korea. AERA Open, 6(4), 1-17.

Crow, M. L. & Nelson, L. P. (20). The effect of using academic role-playing in a teacher education service-learning course. International Journal of Role-Playing, 5, 26-34.

Daryanto & Karim, S. (2017). Pembelajaran Abad 21. Gava Media.

Edward, M. & Joseph, C. (2014). Reflections on the role of the teacher in promoting multicultural pedagogy in teaching and learning at secondary school. International Journal of Education and Research, 2(4), 265-276.

Espania, D. (2012). Exploring two classroom teachers' experiences as they aspire to become literary instructional leaders. Doctoral Dissertation, University of Washington. University of Washington Libraries.

Espinosa, V. F. & Gonzalez, J. L. (2023). The effect of teacher leadership on students' purposeful learning. Cogent Social Sciences, 9(1), 1-12.

European Commission. (2005). Common European principles for teacher competences and qualifications.

Gersmehl, P. 2008. Teaching Geography. Guilford Press.

Ghavifekr, S. & Rosdy W. A. W. (2015). Teaching and learning with technology: Effectiveness of ICT integration in schools. International Journal of Research in Education and Science, 1(2), 175-191.

Gumus, A. (2022). Twenty-first-century teacher competencies and trends in teacher training. Educational Theory in the 21st Century: Science, Tecchnology, Society, and Education, 243-267.

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. Sustainable Operations and Computers, 3, 275-285.

Heltebran, V. R. (2010). Teacher leadership: Overcoming "I am just a teacher syndrome". Education, 131(2), 363-371.

Hidayati, L. & Pardjono, P. (2018). The implementation of role play in education of pre-service vocational teacher. IOP Conf. Series: Materials Sciences and Engineering, 296(012016), 1-5.

Hume, A. (2012). Primary connections: Simulating the classroom in initial teacher education. Research in Science Education, 42, 551-565.

Ismail, S. A. A. & Jarrah, A. M. (2019). Exploring pre-service teachers' perceptions of their pedagogical preferences, teaching competence and motivation. International Journal of Instruction, 12(1), 493-510.

Jacques, D. (1996). Learning: the treasure within; report to UNESCO of the International Commission on Education for the Twenty-first Century (highlights). Retrived from https://unesdoc.unesco.org/ark:/48223/pf0000109590

Jony, M. S. (2020). Exploring the effectiveness of cooperative learning at secondary level in Bangladesh. International Journal of Educational Research Review, 5(1), 93-99.

Kayacilar, C. & Karaca, A. (2020). Teacher candidates' views about land art in geographical education. Review of International Geographical Education, 10(4), 549-583.

Khaefiatunnisa, K. (2015). The effectiveness of contextual teaching and learning in improving students' reading skill in procedural text (A Quasi experimental study of the second grade students at one vocational school in Bandung). Journal of English & Education, 3(1), 80-95.

Khan, A. A., Asimiran, S. B., Kadir, S. A., Alias, S. N. (2020). Instructional leadership and students academic performance: Mediating effects of teacher's organizational commitment. International Journal of Learning, Teaching and Educational Research, 19(10), 233-247.

Kilgour, P. W., Reynaud, D., Northcote, M. T., & Shields, M. (2015). Role-playing as a tool to facilitate learning, self reflection and social awareness in teacher education. International Journal of Innovative Interdisciplinary Research, 2(4), 8-20.

Kilic, A. (2010). Learned-centered micro teaching in teacher in Duzce University, Education Science, Turkey. Education International Journal of Instruction, 3(1), 77-100.

Kim, J. & Jeon, H. (2017), Anti-multiculturalisn and the future direction of multicultural education in South Korea. Curriculum Perspectives, 37(2), 181-189.

Laal, M. & Ghodsi, S. M. (2012). Benefits of collaborative learning. Procedia – Social Behavioral Sciences, 31, 486-490.

Moreno, L., Calderon, A., Arias-Estero, J. L. (2021). Digital pedagogy and cooperative learning: Effect on the technological pedagogical content knowledge and academic achievement of pre-service teachers. Revista de Psicodidactica, 26, 53-61.

Muhaimin (2015). Implementasi Model Pembelajaran Berbasis Masalah Lokal dalam mengembangkan kompetensi ekologis pada Pembelajaran IPS. Sosio didaktika. Social science educational journal, 1(2).

Nafia, Z. I. & Suyatno, S. (2020). The effect of teachers' leadership on students' motivation in Al-Islam Tambakbayan Elementary School. Universal Journal of Educational Research, 8(5), 1907-1915.

Nessipbayeva, O. (2012). The competencies of the modern teacher. Bulgarian Comparative Education Society (pp. 148-154). Kyustendil, Bulgaria: Bulgarian Comparative Education Society. Retrieved from https://eric.ed.gov/?id=ED567059

Ningsih, V, H. & Wijayanti, W. (2018). Teacher leadership in building student character: Educational challenges in the 21st century. Advances in Social Science, Education and Humanities Research, 326, 519-522.

Palmer, J. A. (1998). Environmental Education in the 21st Century: Theory, Practice, Progress and Promise. London: Routledge.

Pardinan, E. G. & Loremia, R. A. (2020). Digital pedagogy analysis on technology trend relevant to education 4.0. International Journal of Scientific & Tchnologicy Research, 9(8), 390-399.

Perin, D. (2011). Facilitating Student Learning Through Contextualization (Assessment of Evidence Series). Community College Research Center.

Peter, A. J., et al. (2020). Review on impact of teacher leadership. International Journal of Advance Research and Innovative Ideas in Education, 6(6), 2364-2369.

Pirbhai-Illich, F. & Martin, F. (2020). Fundamental British values: Geography's contribution to understanding difference. Primary Geography, 103, 23-25.

Purfitasari, S., Masrukhi., Prihatin, T., & Mulyono, S, E. (2019). Digital Pedagogy Sebagai Pendekatan Pembelajaran di Era Industri 4.0. Prosiding Seminar Nasional Pascasarjana (PROSNAMPAS) 2 (1), 806-811.

Ramsey, P. G. (2004). Teaching and learning multicultural in a diverse world education for young children. Teachers College Press.

Romero-Hall, E., Adams, L., & Osgood, M. (2019). Examining the effectiveness, efficiency, and usability of a web-based experiential role-playing aging simulation using formative assessment. Journal of Formative Design in Learning, 3, 123-132.

Sadulloh, U., Muharram, A., Robandi, B. (2018). Pedagogik (Ilmu Mendidik). Alfabeta.

Scharfenberg, F. & Bogner, F. X. (2019). A role-play-based tutor training in preservice teacher education for developing procedural pedagogical content knowledge by optimizing tutor-student interactions in the context of an outreach lab. Journal of Science Teacher Education, 30(5), 461-482.

Shen, H., Wu, H.,Reeves, P., Zheng, Y., Ryan, L., & Anderson, D. (The association between teacher leadership and student achievement: A meta-analysis. Educational Research Review, 31, 1-19.

Sidgi, L. F. S. (2022). The benefit of using collaborative learning strategy in higher education. International Journal of English Literature and Social Sciences, 7(6), 217-224.

Singh, A. K. M. & Singh, H. S. S. J. (2022). The relationship of teachers' leadership competency with 21st century teacher. International Journal of Academic Research in Economics and Management and Sciences, 11(1), 28-55.

Stojsic, I., Ivkov-Dzigurski, A., & Maricic, O. (2019). The readiness of geography teachers to use mobile devices in the context of immersive technologies integration into the teaching process. Geography Pannonica, 23(2), 121-133. DOI: 10.5937/gp23-20762

Sung, H., Hwang, G., Chen, C., & Liu, W. (2019). A contextual learning model for developing interactive e-books to improve students' performances of learning the Analects of Confucius. Interactive Learning Environments, 30(2), 1-14.

Suryana, A., Widiawati, W., El Widdah, M. (2019). Leadership approach: Developing teacher leadership skills in the classroom. Advances in Social Science, Education and Humanities Research, 400, 381-368.

Tamur, M., Jehadus, E., Mandur, K., Nendi, F. (2020). Assessing the effectiveness of the contextual teaching and learning model on students' mathematical understanding ability: a meta-analysis study Assessing the effectiveness of the contextual teaching and learning model on students' mathematical understanding ability: a meta-analysis study. Journal of Physics Conference Series, 1657(1):12067.

Tasdemir, M. Z., Iqbal, M. Z., & Asghar, M. Z. (2020). A study of the significant factors affecting pre-service teacher education in Turkey. Bulletin of Education and Research, 42(1), 79-100.

Tesik, K. A. (2017). Teaching, leading, and learning in the 21st century classroom. Educational Doctoral. Paper 319.

The Ministry of Environment Indonesia, (2004). Environmental Education Policy. Ministry of Environment.

Toktarova, V. I. & Semenova, D. A. (2020). Digital pedagogy: analysis, requirements, and experience of implementation. Journal of Physics: Conference Series, 1961 (2020), 1-5.

Trigueros, R., Padilla, A., Aguillar-Parra, J. M., Mercader, I., Lopez-Liria, R., & Rocamora, P. (2020). The influence of transformational teacher leadership on academic motivation and resilience, burnout and academic performance. International Journal of Environmental Research and Public Health, 17, 7678, 1-12.

Vaataja, J. O. & Ruokamo, H. (2021). Conceptualizing dimensions and model for digital pedagogy. Journal of Pacific Rim Psychology, 15, 1-12.

Vega, V. A. (2008). Practice Teaching Handbook. Books Atbp. Publishing Corp: Mandaluyong City, Philliphines.

Warren, L. L. (2021). The importance of teacher leadership skills in the classroom. Education Journal, 10(1), 8-15.

Webster, M. L. (2015). GIS in AP human geography: A means of developing students' spatial thinking?. The University of North Texas.

Yuan, H. (2018). Preparing teachers for diversity: A literature review and implications from community-based teacher education. Higher Education Studies, 8(1), 9-17.

Yuksel, I. & Saglam, S. Are preservice teachers competent enough ? A cross-sectional analysis of ELT pre-service teachers' perceived teacher competences. European Journal of Education Studies, 4(11), 205-228.

Zarni, E., Maryani, E., & Setiawan, I. (2019). Teacher's pedagogic competence in implementing the scientific approach in learning geography. Advances in Social Science, Education and Humanities Research, 335, 775-781.

Zhao, H. & Zhang, J. (2022). The influence of class teachers' leadership behavior and personal characteristics on student academic performance: A study of fuzzy qualitative comparative analysis citing H middle school as a case study. Best Evidence in Chinese Education, 10(2), 1357-1373.