Enhancing students' environmental concern of their cultural landscape heritage through STSE education approach

Sang Putu Kaler SURATA, I Gusti Agung Paramitha Eka PUTRI, and Dian TARININGSIH
Universitas Mahasaraswati Denpasar Jalan Kamboja 11A Denpasar-Bali, INDONESIA
E-mail address: kalersurata@gmail.com

Received 22 Sept., 2017
Revised 5 Jul., 2018

Contents

Abstract

We assessed the global and local environmental concerns of students using the Balinese Subak Cultural Heritage site as an authentic science, technology, social, and environment (STSE) learning situation. In total, 68 high school students from Bali Province, Indonesia, participated in two STSE learning approaches. Data were collected twice (before and after STSE implementation) using the new ecological paradigm (NEP) scale and its modification called the local environmental paradigm (LEP). Both approaches significantly enhanced students' pro-ecological views from being human-centered to environment-centered. Students in the participatory video class achieved higher NEP and LEP scores than those in the PowerPoint class. Our findings suggest that using cultural heritage with an interactive digital tool and authentic STSE grounds learning with a sense of place and provides practical experience in enhancing the students' environmental views.

Keywords: STSE, participatory video, PowerPoint presentation, human-centered views, environment-centered views

Introduction

Science, technology, society, and environment (STSE) education is conducted in a broader context by connecting science curriculum and instruction with aspects of technology, community, and the environment. The major goal of STSE is to develop a scientifically literate and social responsibility when making collective decisions. STSE prepares future citizens to interpret the human and societal dimensions of scientific practice and its consequences. More importantly, it also prepares learners to participate effectively in a technologically-orientated economy (Amirshokoohi, 2010; Lau, 2013; Akcay & Akcay, 2015). STSE "animates students' cultural self-identities, their future contributions to society as citizens, and their interest in making personal utilitarian meaning of scientific and technological knowledge" (Aikenhead, 2005, p. 392). The STSE curriculum has therefore been designed to help students develop skills that will enable them to become responsible citizens who make well-informed decisions (Amirshokoohi, 2010).

Aikenhead (2005) reported that STSE classes significantly improved students' understanding of social issues, attitudes towards science, thinking skills, and social responsibility. STSE helps connect learners' understandings of science and their

everyday lives (Kim et al., 2012). It can also help make physics more accessible to everyday students as well as those who wish to continue studying physics at university (MacLeod, 2013, p. 9). However, relatively few studies have examined the connection between STSE education and environmental concerns—particularly in the context of the relationship between global and local issues. Thus, it is imperative to develop an STSE approach and goals compatible with the current situation, students' views, and their local cultural context (Amirshokoohi, 2010). According to Zandvliet (2010), a localized and inclusive ecological framework of learning grounded in the local environment with social and scientific experiences allows students to develop valuable sociocultural and cognitive skills. These abilities are critical in today's teaching and learning situation to produce students who are active, innovative, and creative learners who can face the challenges of the 21st century (Husin et al., 2016).

This paper provides an STSE learning situation for environmental education centered around socio-scientific issues, place-based learning, and local culture. We focus on the most important cultural landscape heritage in Indonesia—the subak (the Balinese farmer organization of paddy field irrigation system). These farmers traditionally believed that water was a gift from a Goddess and thus must be a shared resource (Lansing, 2006). The system was enlisted by UNESCO (2017) as a world cultural heritage site because of its remarkable achievement in sustainable agriculture. Despite this recognition, the subak is still rarely included in the school curriculum today despite its rich variety of STSE resources (Surata et al., 2014). If students do not learn to understand their traditional wisdom, then it will threaten the preservation of the cultural heritage and hamper them from learning from the past (Surata, 2013). Moreover, the subak system has a diverse and extraordinary ancient heritage and is an excellent case of STSE education to involve students' understanding of science in the context of everyday life. This setting can explore environmental problems and solutions, commitment to social service, and contribute to a sustainable society (Marouli, 2002; Sobel, 2005; Meichtry & Smith, 2007; Surata & Vipriyanti, 2018)

Hence, by examining the subak system, we engaged students in interactive and authentic STSE situations to enhance their global and local environmental concern. The new ecological paradigm (NEP) from Dunlap et al. (2000) and its modification—the local ecological paradigm (LEP) (Surata, 2017)—was used to examine students' views. Here, rather than comparing STSE with traditional teaching methods, we only focused on STSE using two digital learning tools: PowerPoint presentation (PP) as conventional digital technology and participatory video (PV) as advanced digital technology.

Aims

The purpose of this survey is to evaluate the effect of authentic STSE learning situations on global and local environmental views of high school students and to compare the ability of PPs and PVs in enhancing the students' pro-environmental positions.

We then set out to answer the following questions:

1. Is there a significant difference between global and local environmental views of students before and after STSE learning?
2. Is there a significant difference in environmental views between students who take PP and PV classes?

The New Ecological Paradigm and the Subak Cultural Landscape

The NEP scale has been widely used to measure the effectiveness of environmental education programs (e.g. Manoli et al., 2007; van Heezik et al., 2012; Rideout 2014). It has also been applied to studies of diverse contexts and populations; for example, tourism contexts (Lück, 2003), examining environmental concerns and involvement in voluntary associations (Schuett & Ostergreen, 2003), and assessing the association between environmental concern and fertility (Arnocky et al., 2011).

The NEP was designed to gauge anthropocentrism (also termed egocentrism) in environmental attitudes and values (Dunlap et al. 2000). Theoretically, the NEP originates from the recognition of a dominant social paradigm (DSP). While the DSP upholds human dominance over nature and faith in progress and technology to solve all problems (including an ecological crisis), the NEP is based on both the notion that humans are a part of nature and that there are limitations to growth (Petegem & Blieck, 2006; Sudbury-Riley et al., 2016). The NEP highlights the disruption of ecosystems caused by humans exceeding environmental limits and provides an alternative worldview to the DSP that posits continuous progress and growth (Dunlap & Van Liere, 1978). According to the NEP view, nature is a limited resource—delicately balanced and subject to destructive human interference (Petegem & Blieck, 2006).

Over the past centuries, the activities of more than one thousand subak organizations on the island of Bali, Indonesia have formed the unique landscape of Bali attracting millions of tourists to the island each year. However, the subak is not merely a community unit that manages water irrigation and rice terraces. It is also a complex of religious and egalitarian democratic communities in which autonomous cooperation has remarkably formed sustainable rice farming with optimal results (Lansing, 2006; Fox, 2012).

In summary, the sustainability of the subak, which dates back at least a millennium, highlights environmental worldviews crystallized in the NEP scale. For example, the subak system embodies the ancient Balinese philosophy called Tri Hita Karana (three causes of goodness), which seeks to create harmony between humans and the spiritual realm, between humans and nature, and among humans (Salamanca et al., 2015). The philosophy is closely related to anti-anthropocentrism as well as anti-exemptionalism paradigms that recognize the intrinsic values of nature and human helplessness that are exempt from the constraints of nature.

The existence of water temple networks in managing the agro-ecology of rice terraces through massive ritual activities reflects a complex and adaptive effort of Balinese farmers to address the fragility and uncertainty of nature and to increase the carrying capacity of rice terraces to support a dense population for centuries (Lansing & de Vet, 2012). Meanwhile, without centralistic control of cooperation, Balinese farmers can sustain a productive farming system "in an ecosystem that is rife with water scarcity and the threat of disease and pests" (Lansing & Miller, 2005, p. 13). The existence of co-culture, e.g., cattle-rice or duck-rice, and polyculture, e.g., duck-cattle-rice or duck-fish-rice, (still practiced in the subak and mainly in Asia-Pacific regions) demonstrates the ability of a traditional rice agro-ecosystem to solve globally serious problems—particularly regarding increasing food security and diminishing ecological risk due to the growing impact of fertilizers and pesticides on the environment (Lansing & Kremer, 2011; Xiea et al., 2011). These holistic environmental views and behaviors were reformulated into new environmental terms: limit to growth, nature's balance, and eco-crisis paradigms on the NEP scale (Dunlap et al., 2000).

PowerPoint Presentations and Participatory Video

PPs support learning objectives by designing learning content that can be taught as smaller units of learning. Furthermore, PPs can be potentially reused, can stand alone, and are accessible meaning that they meet the "just enough" and "just-in-time" requirements of learners (Sathiyamurthy & Geetha, 2012, p. 49). According to Hayama & Kunifuji (2012, p. 26-27), Slides are becoming an important part of presentations because visual information can promote a better understanding of the presentation content." Fortunately, several digital media tools such as scanners, digital cameras, and graphics files offer enhanced graphic and video learning materials and can automatically generate slides (Sathiyamurthy & Geetha, 2012, p. 49).

However, Nouri & Sahid (2005) found no conclusive evidence that the use of PP improves short-term or long-term memory although it can improve student attitudes toward the instructor and class presentation. Another study also revealed that PP

presentations are less helpful than the lecture method in material comprehension and effectiveness (Sewasew et al., 2015).

Meanwhile, Atkinson and Mayer (2004) stated that the common problem of PP was the overuse of slides containing excess information. Consequently, aside from the audience needing more time to view such slides, they may be unable to accurately grasp the slide content (Hayama & Kunifuji, 2012). Hence, Issa et al. (2013) suggested that educators consider multimedia principles when designing lecture slides and abandon the use of the word- or bullet point-based presentations. Furthermore, Paoletti et al. (2012) suggested, "Concise text—an outline of main points, which summarizes key information—should also be more useful than a redundant text or a presentation that paraphrases the linguistic form of the spoken message."

The PV is an iterative process in the community for documenting ideas or issues affecting one's environment and community (Lunch, 2007). A variety of PV approaches have been developed with video technology being applied in several alternative ways to the development of projects (Huber, 1999). Regardless of the label, most project designers would claim that participation is a central element in their projects (Huber, 1999).

The PV's structural process and the product can "provide avenues for marginalized communities to participate both in the form of self-research and ways of self-representation" (Evans & Foster, 2009, p. 87). PV has helped students to construct their personal identities (Riecken et al., 2006); strengthen capacity and cultural identity (Chiu, 2009); potentially contribute to social-science research, social intervention, participatory culture, and community-based adult education (Yang, 2016); and promote democracy by destabilizing hierarchical power relations and creating spaces with equal social power (Kindon, 2003). Hence, both PV and PP can help learners explore social-science concepts and address issues and problems both critically and creatively.

Methods

Study Sample

The study took place at one high school situated close to the World Cultural Landscape Heritage in Bali Province, Indonesia, from early January until the end of April 2017. In total, 68 students from two classes were recruited (age 15–16 years; M = 15.8) with slightly more females than males (55.9% and 44.1%, respectively).

They participated in STSE education by designing and presenting PP slides (n = 35) and PV (n = 33).

Data Collection

To measure changes in the students' attitudes toward the environment, we used two quantitative instruments—each consisted of 15 statement items. The first instrument was the NEP revised version (Dunlap et al., 2000) (see Table 1). It has been translated into Bahasa (Indonesian Language) with details of the mechanism required for translating and paraphrasing as reported by Surata (2017). The LEP was the second instrument and assessed the local perspectives of students toward the subak cultural landscape heritage (Surata, 2017) (see Table 2). We applied the LEP to complement the NEP because the scale is limited to a general environmental focus (Schuett & Ostergreen, 2003). Finally, we randomly selected five students from each presentation type (PP and PV) and interviewed them about why they agree or disagrees with item statements with the lowest overall score.

Teaching and Learning Activities

The STSE learning education was implemented from January to June 2017 using a subak rice field as a case study in exploring, understanding, and solving the problems of the local ecosystem and communities. We applied socio-scientific issues-based approaches "to include discussion of how science and society share a more complex interdependence" (Zandvliet, 2010, p. 16). As we mentioned above, the subak is a complex adaptive system that has been sustained for more than two millennia through co-evolution between the Balinese farmers and their local environment rich with socio-scientific values, concepts, and issues. Hence, the system is an excellent model to study higher concerns about the relationship between scientific and technological issues in the development of a sustainable society (Makrakis, 2012).

The teaching strategy included a 12-week plan consisting of two 45-minute classes each week. All teaching/learning processes were facilitated by one teacher to avoid bias by the different teachers. Week 1 comprised a pre-test after which a lesson introduction was given. Week 2 encouraged students to determine the relationship between global and local environmental issues by discussing global warming and reading a text entitled "Lansekap budaya subak. Belajar dari masa lalu membangun masa depan" (The Subak Cultural Landscape: Learning from the past to build the future) (Surata, 2013). Students were encouraged to discuss the connection between science and technology with the local and global environment and why this is essential. They were also encouraged to evaluate the impact of local farming traditions toward global warming. Week 3 comprised a short presentation by each student group about concerns related to environmental concepts, topics, and

problems about the subak focused on critical thinking regarding integration of social, economical, ecological, and cultural aspects for sustainable living. Week 4 consisted of training groups on how to create effective PPs and PVs after which each group was required to make either a PP or PV using the main ideas or topics discussed in week 3 regarding solving the environmental problems of the subak. Weeks 5–6 included a visit to the subak rice terraces where students interviewed farmers, took photos, recorded videos, and investigated issues that display the relationship among science, technology, society, and the environment.

Weeks 7–8 were spent on group work focused on editing and producing PPs and PVs as tools to take collective action based on their concerns and experiences during the field visit. Next, weeks 9–10 saw the groups deliver their PPs and PVs and leading class discussions. We followed Pedretti's (2003) suggestion in the context of STSE by encouraging students to discuss ethics and moral reasoning via socio-scientific issues of the subak system. In week 11, students participated in a post-survey that included the NEP and LEP items. Finally, in week 12, our research group interviewed five students from each PP and PV class and asked them why they agreed or disagreed with statements from items 6 and 14 of the NEP and LEP, respectively (these items received the lowest score overall from the post-survey administered at week 11).

Data analysis

The NEP and LEP scales were distributed to all students before and after the teaching/learning process. They were asked to rate the extent to which agreed or disagreed with each statement from the NEP and LEP items according to a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). Items 2, 4, 6, 8, 12, and 14 were reverse scored (1 = strongly agree to 5 = strongly disagree) for both the NEP and LEP. The environmental concern variable for the NEP and LEP items were calculated by totaling the students' scores for all 15 items. A collective agreement was observed if the average of the 15 item scores equaled 3 (neutral) with <3 indicating human-centered and >3 indicating environment-centered.

Data were analyzed descriptively by calculating the items' average scores, which are visually presented in tables. The Wilcoxon test was used to examine students' scores before and after the STSE approach, Meanwhile, the Mann-Whitney U test measured the difference between the PP and PV classes. The results were assessed according to significance levels of 0.001, 0.01, and 0.05.

To determine the validity of the NEP and LEP, these tests were conducted on students not included in the samples with $\alpha = 0.80$ and 0.76 for NEP and LEP, respectively. Internal reliability was also determined with $\alpha = 0.72$ (NEP) and 0.71 (LEP).

Findings

Students' global environmental views

The students' global environmental views were neutral prior to conducting STSE education as indicated by their NEP average score for PP (3.14) and PV (3.12) classes being close to 3 (Table 1). Although they demonstrated environmental-centered views on eight items (NEP 3, 7, 8, 9, 10, 11, 12 and 14) with scores >3, other items (NEP 1, 2, 4, 5, 6, 7, 13, and 15) received an average score of <3 indicating that the students still held human-centered views.

Table 1 shows that STSE education significantly enhanced NEP scores (P = 0.01) from human-centered to environment-centered views with total mean scores over 3: PV (3.87) and PP (3.72). In addition, the mean score on the 13 items of PV and 11 items of PP was significantly higher after STSE learning. The PV approach was more effective than PP. The total mean score and mean of nearly all items (except NEP 5) with PV were higher than PP (Table 1). However, the same was not true for items 6 and 14 because the average score for these two items remained far below 3 despite their engagement in STSE education.

Table 1. Comparison of average score and significance relationship toward the NEP items between power point and participatory video classes, before and after STSE Education

NEP items	Mean score of PP (n= 35)			Mean score of PV class (n= 33)			Sig. [c]
	Pre	Post	Sig.[b]	Pre	Post	Sig.[b]	
1. The human population growth is approaching the limit of the Earth can support	2.66	4.43	***	2.55	4.79	***	NS
2. Humans have the right to modify the natural environment to suit their needs. [a]	2.91	4.00	***	2.94	4.15	***	NS
3. When humans interfere with nature it often produces disastrous consequences.	3.91	3.94	NS	3.76	4.15	**	***
4. Human ingenuity will insure that we do not make the Earth unlivable. [a]	2.51	3.83	***	2.64	4.00	***	NS
5. Humans are seriously abusing the environment.	2.66	4.00	***	2.79	3.91	***	NS

6. The Earth has plenty of natural resources if we just learn how to develop them. [a]	1.69	1.69	NS	1.64	1.67	NS	NS
7. Plants and animals have as much right as humans to exist.	3.80	4.00	**	3.64	4.21	***	**
8. *The nature is NOT disturbed with development and industries.* [a]	3.74	4.00	**	3.67	4.36	***	**
9. Despite our special abilities humans are still subject to the laws of nature.	3.74	3.89	NS	3.70	4.00	***	NS
10. The so-called "ecological crisis" facing humankind has been greatly exaggerated. [a]	3.57	3.89	*	3.58	4.00	**	NS
11. The Earth is like a spaceship with very limited room and resources.	3.51	4.00	***	3.52	4.21	***	NS
12. Humans were meant to rule over the rest of nature. [a]	3.77	4.20	**	3.70	4.21	**	NS
13. The balance of nature is very delicate and easily upset.	2.83	4.00	***	2.79	4.00	***	NS
14. Humans will eventually learn enough about how nature works to be able to control it. [a]	2.06	2.00	NS	2.15	2.06	NS	NS
15. If things continue on their present course, we will soon experience a major ecological catastrophe	3.69	4.00	***	3.76	4.39	***	*
Total	3.14	3.72	***	3.12	3.87	***	**

[a]Items are reverse coded; *, **, ***, NS, significant at P=0,001, 0,01, 0.05 or nonsignificant using a Wilcoxon test[b] and a Man Whittney-U test[c]; the italic statements indicated NEP items were paraphrased or modified; Pre=before, Post=after STSE Education.

The students' views on item 6 were extremely low with an average score obtained for both classes being much lower than 3 (PP = 1.69; PV = 1.64). This result in line with the findings of previous studies (Dunlap et al., 2000; Petegem & Blieckp, 2006; Surata, 2017). According to Rideout et al. (2005) and Petegem & Blieck (2006), this is likely because students misinterpreted the item. However, Surata (2017, p. 334) found that students understood item 6 but that the students "still have a weak perception of the environmental issues that limit human growth and development." This was supported by students' feedback during the interviews in which most of them tended to explain that the Earth is rich in natural resources. For example, Diah (female) said, "The Earth provides a diverse range of natural resources for living

organisms, but we must know how to use them, thus we must learn more from nature." Another student, Ita (female), explained more specifically, "Many medical plants can be found if we use nature." Meanwhile, Ivan (male) gave his opinion on the availability of food, " Our place is rich with natural resources in the form of plantations, livestock, and agriculture. Food security itself will be realized if humans know how to utilize various natural resources." According to Utami (female), " There is a lack of capability in processing natural resources because not all natural resources can be utilized." This remark was in line with the argument provided by her classmate who said,

> "In reality, the earth is rich with natural resources. However, not everyone can know and use it properly. Many people take advantage of existing natural resources and do not want to develop and look for other natural resources." (Chandra, female)

Several students suggested using natural resources wisely such as Tri (male), "The earth has been created with an abundance of natural resources; hence, humans who have the mind must be smart in using it." This view was supported by Yuli (female), "God created nature for humans to meet their needs; therefore, human beings should be able to think smartly and utilize nature with good and positive intentions without damaging nature." In addition, Arya (male) said,

> "Nature has provided all the necessities of human life; therefore, humans can cultivate and utilize the resources of nature and will certainly be very grateful to nature. Thus, they are expected to continue preserving nature."

Our finding showed that STSE education via PP or PV approaches cannot change students' perspectives from human-centered to environmental-centered on the statement of "the earth has plenty of natural resources if we just learn how to develop them (NEP 6)." This was demonstrated by their argument, which tends to argue that natural resources are not limited but humans need to have enough knowledge and skill to use them wisely.

Students' opinions for NEP 14 can be classified into two major reasons. First, their opinions are human-centered as demonstrated by the comment, "All human needs are provided by nature, and thus we must learn how to use it efficiently." This opinion is similar to another student's, "Many needs must be met by humans, and thus people will indirectly learn about nature and resources to meet their needs." One student's statement was a human-centered view:

> "By gathering knowledge of natural science as much as possible, humans will understand how to use or consume products from the natural world. The

> knowledge is then classified according to the concept in biology that facilitates the categorization of which plants are suitable or feasible to eat so it will not confuse humans in the future." (Ivan, male)

Holistic views were also seen: While students agree with the item statement, they also mentioned the importance of learning to use nature wisely. This was expressed by argumentative statements such as, "Humans must learn about nature in order for it to be useful for human life and not to damage nature itself"; "Humans should learn about nature so they can cultivate nature as well as possible and not harm it"; and "Humans and nature are closely connected. Humans can't escape from nature and vice versa." The importance of learning how to use natural resource sustainably was highlighted by the arguments, "Humans should learn from nature because it has given examples of how to help each other and how to keep the environment"; "When nature is destroyed, humans and animals cannot meet their needs such as eating"; and

> "Humans must necessarily study nature. By understanding the state of nature, people will know what can or cannot be done to maintain the balance of nature. In studying nature, humans are expected not to perform selfish actions towards nature."

Table 1 shows tbothat h PV and PP approaches are unable to change students' views from human- to environmental-centered on NEP 14 (Humans will eventually learn enough about how nature works to be able to control it). The average score after learning was far below three (PV=2.06 and PP=2.00). Although the interviews showed that several of students were equipped with a holistic perspective, most of them agree with the item statement. Hence, their views are still human-centered.

Students' views of the local environment

Table 2 shows that the impact of STSE education toward LEP was seemingly similar to NEP. Statistical analysis showed that both of these approaches significantly increased students' pro-environmental views toward LEP ($P = 0.05$). This indicates that STSE education has also enhanced the local views of students from a human-centered to an environment-centered view—especially on items with an average score >3. The students using PV (3.89) achieved higher scores on the LEP than the PP class (3.78). Only two items on the PV (LEP 9 and 15) were significantly higher than on the PP across the four NEP sections (see Table 1). Interestingly, student scales on the LEP were higher than on NEP items as demonstrated by a total mean score of PP (NEP=3.72; LEP=3.78) and PV (NEP=3.87; LEP=3.89). This is probably because students were more likely to change their ecological perspective by using local cases rather than the global environment.

Table 2. Comparing the average score and significance relationship toward the LEP items between power point and participatory video classes, before and after STSE Education

Local Environmental Paradigm (LEP) Items	Power point class (n= 35)			Participatory video class (n= 33)			Sig. [c]
	Pre	Post	Sig.[b]	Pre	Post	Sig.[b]	
1. The human population growth in the Bali Island is approaching the limit of the *subak* can support.	3.14	4.37	***	3.03	4.67	***	NS
2. Humans have the right to modify the *subak* to suit their needs.[a]	3.11	4.00	***	3.09	4.18	***	NS
3. When humans interfere with *subak* it produces disastrous.	3.23	3.91	***	3.30	4.00	***	NS
4. With human ingenuity, we guarantee *subak* will survive.[a]	2.91	4.00	***	2.82	3.94	***	NS
5. Humans are seriously abusing the *subak.*	2.51	3.86	***	2.64	3.97	***	NS
6. The *subak* has plenty of natural resources if we just learn how to develop them.[a]	1.69	1.69	NS	1.76	1.61	NS	NS
7. Rice, hyacinth, frogs, mice and other living things have as much right as humans to exist in the *subak*.	3.80	4.43	***	3.76	4.64	***	NS
8. The *subak* is NOT disturbed by tourism development.[a]	3.60	3.83	***	3.58	4.00	***	NS
9. Despite our special abilities, humans are still subject to the laws of nature in managing the *subak.*	3.80	3.91	NS	3.61	4.00	***	*
10. The crisis of *subak* has been greatly exaggerated.[a]	3.43	3.89	***	3.63	4.00	***	NS
11. The *subaks* have very limited land and resources.	2.77	4.23	***	2.70	4.22	***	NS
12. Humans can control all condition of the *subak*.[a]	3.49	4.09	***	3.63	4.27	***	NS
13. The balance of *subak* is very delicate and easily upset.	3.29	4.09	***	3.21	4.15	***	NS
14. Humans will eventually learn the *subak* to be able to use it.[a]	1.77	2.20	***	1.82	2.00	NS	NS
15. If development and tourism in Bali continues on its present course, the *subaks* will soon be extinct.	3.00	4.09	***	2.88	4.55	***	*
Total average	3.04	3.78	***	2.99	3.89	***	***

[a] Items are reverse coded; *, **, ***, NS, significant at P=0,05, 0,01, 0.001 or nonsignificant using a Wilcoxon

test[b] and a Man Whittney-U test[c]; Pre=before, Post=after STSE Education.

All of LEP item statements were modified from the NEP scale (Dunlap et al., 2000, Surata, 2017).

As seen on the NEP items, PP and PV approaches had little impact on enhancing students' environmental views on LEP 6 (*The subak has plenty of natural resources if we just learn how to develop them*) and LEP 14 (*Humans will eventually learn the subak to be able to use it*). Students' comments on both items were similar. For example, toward LEP 6 they thought that the subak has many natural resources as reflected by the argument, "There are a lot of natural resources available in the subak, but a lack of knowledge about it makes people understand less about the benefits of the resources in the subak." Other students further supported this view, "Because all food comes from the subak," and, "If we learn about the subak more widely, then it will be useful for human beings because the subak can provide rice, corn, chili, and soybean." Meanwhile, several students argued for the importance of learning about the subak and using its sustainability. This was explained by Ivan (male), "Like other natural resources, the subak is an important part of agriculture that is rich in a variety of resources if we know how to use it". His friend argued, "Indeed, the subak saves various natural resources that can be utilized but it should be utilized wisely," (Yohan, male). However, Yuli (female) added, "The subak will be meaningless if people cannot learn to use it wisely." Another student commented,<>

> "The subak has a variety of natural resources that are needed by humans such as food, fresh water, fertile soil, and others. However, if humans cannot use the subak well, then the natural resources will not be seen or used by humans." (Tini, female)

The students' arguments on LEP 14 could be classified into three categories. First, ego-centrism was identified as a category and was clearly explained by Tri (male), "The subak is created by humans, and therefore we must learn it." Stefani (female) added, "Basically, humans do something if there are benefits. In addition, humans can develop the subak so that further value can be added to it such as using it as a tourist resort." These opinions are similar to a comment from Ivan (male), "The subak provides a diversity of resources. Humans have various needs for life, and they seek way to meet those needs include using the subak."

Second, students' opinions could be classified as holistic-centrism in that learning about the subak is not only for human needs but also preserves the subak and nature. Arya (male) stated, "Humans should learn more about the subak and its benefits to preserve the subak and to sustain human life by processing the products from the subak." Further, Yuli (female) commented, "As a cultural heritage site, the subak has many benefits, and studying the subak can benefit farmers and nature itself."

Third, two students' opinions belonged to eco-centrism because their comments addressed the conservation of the subak as well as nature itself. Tini (female) stated, "Humans must learn about the subak because by understanding it, humans will know things that can or cannot be done to maintain the balance of the subak…and not to perform selfish actions against the subak." Meanwhile, Yohan (male) added, "Despite the rapid development of this era, we should not forget the subak as the original culture of Bali that has been supporting our lives so far." In brief, neither PV nor PP approaches changed students' environmental views from ego-centered into eco-centered. In reality, the natural resources of the subak are limited—humans should not only learn about the subak for their own needs as detailed in LEP 6 and 14.

Discussion

Our findings have established several useful points. First, the study demonstrated the effectiveness of STSE education in improving students' global and local environmental concerns. This was true mainly for the items with the greatest improvement (NEP 1 and LEP 1).

Students' experiences when observing various problems in paddy fields, and interviewing farmers during STSE's learning, appear to have changed their perspectives from disagreeing to agree with the statement that "the capacity of Earth and Subak are limited in supporting the human population growth", as intended on the NEP 1 and LEP 1. It highlights the statement of Sobel (2005) that local environment (such as the subak), repositioned STSE in more inclusive context to look all subject learning are interacting and shape each other. Prior studies found that grounded learning in a local context was effective to support students in understanding and valuing classroom discourses (Taptamat, 2011); ecological awareness (Reis & Roth, 2010); environmental problems as well as environmental solutions (Marouli, 2002);

We saw most students go further than just learning facts, concepts, and skills. They were creative in designing PP and PV and took collaborative action in data collection. They improved their communication via in-class presentations and developed critical thinking by reflecting on global and local consequences of human intervention during the discussion session. Ozaktas (2013) underlined the importance of students exploring who they are, what they want to be, and how they wish to relate to the local, global, and regional society to mobilize their strong feelings and self-identification. Our finding indicates "the presence of a holistic view of the human-environment relationship of the students from less industrialized countries" (Petegem

& Blieck, 2006). This was supported by arguments from several students regarding NEP (and LEP) 6 and 14. They believe that humans must learn about nature as well as about the subak to guarantee that both resources are used sustainably. These are likely why both PP and PV approaches have helped students to improve their environmental perspectives. Several previous studies have also highlighted the ability of an environmental education program to increasing NEP scores (Rideout 2005; Manoli et al., 2007; and van Heezik et al., 2012).

Second, PV was more effective at changing students' environmental views than PP. It might provide more opportunities for students to explore and make connections with their outdoor experiences (Dhanapal & Lim, 2013). Furthermore, Leo (2005, p. 175) mentioned that PV is "an excellent medium for exploring potentially contentious personal and cultural values and beliefs from a non-threatening and often humorous perspective." Conversely, while PP is an important factor in helping its audience to easily understand content, improving the presentation of slides without adequate experience and awareness of the requirements of a well-designed and presented slideshow is difficult (Hayama & Kunifuji, 2012). According to Paoletti et al. (2012, p. 9), concise text or an outline of the main points that summarizes key information is "more useful than a presentation that paraphrases the linguistic form of the spoken message." However, based on our observation, nearly all groups from the PP class presented slides that contained redundant text reproduced verbatim from the speaker's oral message.

Third, by using the local cultural landscape heritage, this study might help develop students' personal affinity with the earth. This could be done via practical experience and by grounding learning in the sense of place via investigation of surrounding natural communities (Zandvliet, 2010). Today, the subak has been threatened by various problems and challenges such as rice paddy conversion and water scarcity due to massive tourism growth, development policy, environmental pollution, and the unwillingness of a younger generation to work in the farming system (Lorenzen & Lorenzen, 2010; Tharigan et al., 2014). All of this is coupled with parents' wishes that their children not farm for their livelihood (Fox, 2012). There are also exploitative attitudes and behaviors toward the environment because of the mechanistic or reductionist paradigm of modern science (Akib & Fathoni, 2014). To address these problems, significant efforts from many stakeholders are required including a new emphasis on ecosystem-based agriculture fostered by an ecosystem perspective in research (Lansing & Kremer, 2011) . Introducing students to community experience and practical skills in exploring and understanding NEP and LEP views might enable educators to introduce them to occupational alternatives that could preserve cultural heritages (Zandvliet, 2010). This also helps students to shift the holistic ecological paradigm to be more comprehensive and to prioritize the

values of environmental justice (Akib & Fathoni, 2014). This will help maintain rituals and agricultural practices, prevent land conversion, and may even ensure the sufficiency of the future of farm labor for rice terraces (Salamanca et al., 2015).

Fourth, this data suggests that typical STSE education may have a meaningful impact on the developmental perspective of pro-environment views. However, more research is needed to determine the best educational methods for increasing pro-environmental views and the readiness of students for future ecological challenges (Rideout, 2014). The current study is limited by its small sample size. Thus, there is an urgent need for future studies with a more representative sample. This sample can re-confirm our finding of why the impact of STSE approaches toward LEP is higher than NEP. Our presumption is that the use of local issues is more accessible for students in understanding environmental issues; however, this needs to be proven in further research. We highlight Aikenhead's (2005) suggestion to conduct innovative STSE projects on a larger scale to include new partnerships among educators, researchers, and stakeholders to make a significant difference in the science classroom. It would also be interesting to verify whether the STSE approach is more effective than conventional teaching methods in comparing the effects of the two methodologies (Carrier et al., 2013). Finally, we suggest replicating this STSE approach in countries with diverse traditional wisdom to contrast and understand those populations' global and local environmental views.

Acknowledgment

This work was funded by the Ministry of Research, Technology and Higher Education of the Republic Indonesia. Sincerely thank the students for their enthusiastic participation and significant contribution to the data collection process.

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