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Sustainable Knowledge Transfer in Waste Management: Implementing a Training to Trainers Model in Thai Schools

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Abstract

This study implemented a "Training to Trainers" approach to sustainably transfer knowledge on solid waste separation and management in schools from current to future generations. The goal was to empower youth to translate their learning into concrete waste reduction outcomes, such as accurate waste separation, increased beneficial use of waste and PET plastic, and a true understanding of waste management. The 150-minute training utilized an environmental education model, incorporating instructors, PowerPoint presentations, videos, and three active learning activities: solid waste separation games, solid waste composition games, and solid waste-to-treasure games. Participants included 1,610 students from 25 secondary schools across Thailand. Assessment results showed that upper secondary students achieved a higher average learning score (72.60%) than lower secondary students (70.55%), with no statistically significant difference at the 0.05 level for content on solid waste separation, recycling, and organic waste management. Participant satisfaction with the training was rated highly (M = 4.52), as was the perceived applicability of the knowledge gained (M = 4.58). A one-month post-training follow-up revealed that educators had integrated waste management topics into English and science curricula, with consistent use of waste separation activities in schools, indicating sustained knowledge application and expansion.

Keywords: Training to Trainers Model; Waste Management in School; Environmental education

1. Introduction

Solid waste management remains a critical issue in Thailand, necessitating immediate and sustainable solutions. In 2023, Thailand generated approximately 26.95 million tons of solid waste, averaging 73,840 tons per day, or 1.12 kilograms per person per day. The Central Region accounted for the highest waste generation at 31,339 tons per day, with Bangkok alone contributing 12,748 tons per day. Despite ongoing waste management efforts, a significant portion remains improperly disposed of, exacerbating environmental pollution and health hazards. In 2020, approximately 7.88 million tons of waste, representing 31% of the total, were not effectively managed (Pollution Control Department, 2023).

Addressing this challenge requires collaborative efforts among government agencies, private sectors, and the public to develop and implement sustainable waste management strategies. This study explores the integration of Environmental Education (EE) with student-centered learning approaches to foster knowledge, awareness,

and responsibility toward natural and environmental resources. Environmental Education, as defined by UNESCO – UNEP (1978), encompasses the learning processes that enhance knowledge, attitudes, motivation, skills, and accountability regarding environmental conservation. The study emphasizes key strategies, including game-based learning (GBL) and Team-Based Learning (TBL), to enhance student engagement and effectiveness in learning about solid waste management.

A "Training to Trainers" model was implemented to ensure the sustainable transfer of knowledge on solid waste separation and management in schools, fostering a long-term impact from current to future generations. This approach aims to instill sustainable waste management practices, promote environmental stewardship, and contribute to the broader goal of achieving a circular economy in Thailand.

Furthermore, this research focused on empowering youth to translate their learning into solid waste reduction outcomes, such as accurate waste separation, increased beneficial use of waste and PET plastic, and a comprehensive understanding of waste management. Effective environmental problem-solving must begin with active community participation in natural resource management, ensuring a sustainable approach to environmental protection. The findings of this study provide valuable insights into the role of education in addressing solid waste challenges and highlight the potential of Training to Trainers methodologies in fostering sustainable behavioral change.

2. Methodology

2.1 Study area and sample group

The "Training to Trainers" model was designed for school leaders who will act as knowledge providers and implement solid waste management practices in schools. Participants consist of students from 25 secondary schools across Thailand. This includes 10 schools in the central region, 4 in the eastern region, 6 in the southern region, 3 in the northeastern region, and 2 in the northern region.

A total of 1,610 participants who were involved in the student council, school leaders, solid waste management clubs, and student representatives are included in this study, comprising 439 lower secondary school students and 1,171 upper secondary school students.

2.2 Methodology

Integrating Environmental Education with Student-Centered Learning can create a more engaging and impactful approach to sustainability on solid waste separation and management in schools. Key Strategies game-based learning (GBL) and team-based learning (TBL)

2.2.1 Integrating Environmental Education with Student-Centered Learning

Students work on real-area environmental projects, such as the 150-minute training that utilizes an environmental education model. The program comprises instructors, PowerPoint presentations, videos, and games.

Table 1. Characteristic of the target groups

Target groups	Thai school	level	Group sample (N)	%
Students from secondary schools	lower secondary (Age 12-14 year)	Junior	439	27.27
	upper secondary (Age 15-17 year)	Senior	1,171	72.73
			1,610	100.00

Table 2. Environmental education program

Time	Environmental education model
10 minute	Opening Ceremony on solid waste separation and management
30 minute	Lecture on solid waste separation and management by the senior expert/ professional
20 minute	Active learning activities: 1) solid waste separation games
10 minute	Break
20 minute	Active learning activities: 2) solid waste composition games
20 minute	Active learning activities: 3) solid waste-to-treasure games
15 minute	Lecture on Organic waste disposal technology by the senior expert/ professional
15 minute	Post-test examination and satisfaction assessment questionnaire after training
10 minute	Closed Ceremony

2.2.2 Game-based learning (GBL)

Hands-on activities like three active learning activities: solid waste separation games, solid waste composition games and solid waste-to-treasure games with a handbook for conducting activities on waste separation and plastic recycling in schools.

2.2.3 Team-based learning (TBL)

In team-based learning (TBL), the optimal group size is typically 5–15 members per team to maximize effectiveness. This recommendation aligns with the guidelines of Michaelsen, L. K., & Sweet, M. (2008), ensuring productive collaboration, diverse perspectives, and active participation within the team. So, this research study conducts activities to enhance understanding through games and dividing trainees into smaller groups, with no more than 15 members per group.

2.3 Instrument

Quantitative tools include a post-test assessment and a satisfaction questionnaire for the target group regarding the training and knowledge transfer program.

2.3.1 The multiple-choice tests

Tests 20-item, 4-option multiple choice and that is divided into three sections: (1) Assessment of Knowledge on Waste Separation and Plastic Recycling – This section accounts for 50% of the content, comprising 10 questions (2) Waste Management in Schools – This section accounts for 25% of the content, comprising 5 questions and (3) Organic Waste Disposal – This section accounts for 25% of the content, comprising 5 questions.

2.3.2 Games

This research study employed the "solid waste separation game" as the primary activity, focusing on assessing participants' ability to correctly separated waste into organic waste, general waste, recyclable waste, hazardous waste, and infectious waste. The game aimed to enhance learners' understanding following the instructional sessions. Additionally, the "solid waste composition game" and the "solid waste to treasure game" served as supplementary activities to reinforce knowledge and skills in school waste management.

The 'Solid Waste Separation Game' was the focus of this research, which involves separating waste using 60 picture cards. These cards are a representation of various types of solid waste in school. Each participant is given 3 – 5 picture cards. At least 48 cards have correctly classified the minimum passing criterion, equivalent to 80% accuracy. Participants who correctly classify fewer than 48 cards must go through a second round of the waste separation game.

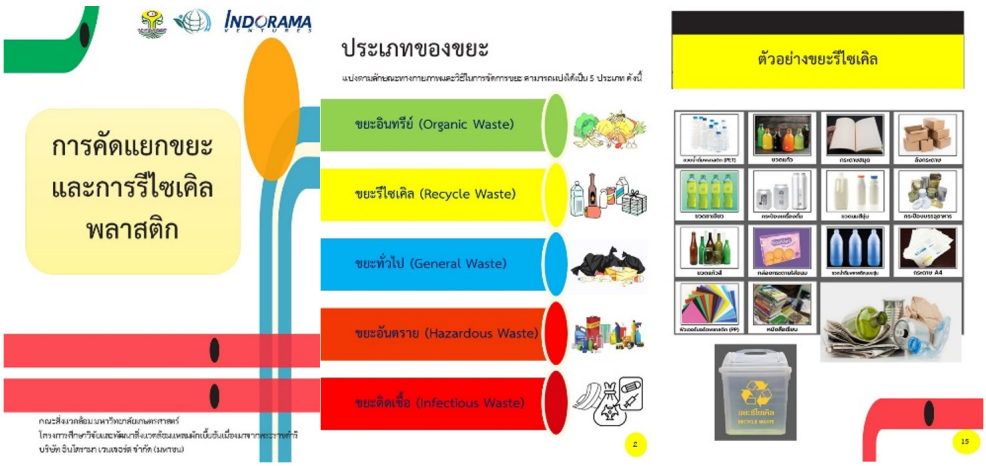

Figure 1. Handbook for conducting activities on waste separation and plastic recycling in schools

Table 3. Description of solid waste separation game

Score of correctly cards	*Criteria*	Meaning
0 – 48	Not Pass & play again	The learners have basic proficiency in solid waste separation.
48	Pass (80%)	The learners have accurately sort waste and understand how to correctly classify various types of solid waste.
60	Pass (100%)	The learners have the ability to sort waste accurately and precisely and exhibit an understanding of the complex components of solid waste.

2.3.4 Questionnaire

The questionnaire consisted of 5 aspects, which consisted of (1) knowledge /content (2) active learning activities (3) The senior expert/ professional (4) technology transfers and (5) applicability of the knowledge gained. The rating scale followed by the Likert Scale is divided into 2 parts consisting of Part 1: General information and Part 2: Training satisfaction.

2.4 Data analysis

2.4.1 Statistical analysis

Analyzing the collected data, to calculate into the statistics of percentage, arithmetic mean, and standard deviation. It was used to test the effectiveness of the post-learning following the environmental training program.

The effectiveness criteria for the environmental education process is set at an average score of more than 70% or correctly answering more than 14 questions. That is, the environmental education program is effective when the learners are able to gain least 70% of their potential to have passed the assessment.

2.4.2 Criteria of solid waste separation game

To evaluate learners by development score analysis is the process used to assess and interpret changes in learning outcomes or abilities of learners over a specific period. It is typically used in education to measure the progress of learners from the first play point to the second play point. Calculating the Development Score according to the criteria of Kanjanawasee, S (2013) using a formula:

$$\text{Development Score} = (SS - FS) / (\text{full score} - FS) \times 100 \quad (1)$$

Where SS = Score of the second play. FS = Score of the first play.

Table 4. Criteria of Development Score

Development Score	Level
76 – 100	highest
51 – 76	high
26 – 50	moderate
0 – 25	low

Table 5. Criteria of satisfaction's target group

Score	Meaning	Criteria	Level of satisfaction
5	maximum	4.21 ±5.00	highest
4	good	3.41 ± 4.20	high
3	moderate	2.61 ± 3.40	moderate
2	less	1.81± 2.60	less
1	minimum	1.00 ± 1.80	least

2.4.3 Criteria of satisfaction

To evaluates learners' satisfaction by assessment from the questionnaire. Rating Scale from Likert's Method, there are 5 satisfying levels, starting from 1 which is the least satisfied to 5 which is the highest satisfied. Then, the average of the satisfied level was analyzed and the result was interpreted by comparing with the rank as follows.

3. Results and Discussion

Promoting schools as centers for learning about sustainable waste management will help reduce waste generation, encourage environmentally friendly behaviors, and create long-term impacts on society and communities.

3.1 Learning achievement

Environmental education (EE) is defined as the process of taking environmental knowledge through transferring technology to the target group of learners to change environmental behavior performance. This research purposes were to compare knowledge, attitude and behavior of learners and study the satisfaction of learners.

This study is integrating Environmental Education with Student-Centered Learning can create a more engaging and impactful approach to sustainability on solid waste separation and management in schools. The non-formal training program was divided into 70% activities and 30% lecture which based on active learning consist of lecture, demonstration, group working brainstorming and games which in accordance with Chunkao (2018) mention that knowledge transferring methods with non-formal education by mixed media such as textbook, technical papers, articles, VDO, demonstration, exhibition, and personnel.

The learning achievement results found that upper secondary (senior group) students achieved a higher average learning score (72.60%), the mean was 14.52 than lower secondary (junior group) students (70.55%), the mean was 14.11 with no statistically significant difference at the 0.05 level for content on solid waste separation, recycling, and organic waste management. The learning outcomes of the senior and junior groups achieved the established criteria, the results were shown in Table 6.

Lower and upper secondary school students had the highest knowledge in school waste management, with average scores of 74.20% and 76.18%, respectively. Following this, knowledge of waste separation and plastic recycling was slightly lower, with lower and upper secondary students scoring 73.80% and 75.20% on average, respectively. On the other hand, knowledge about composting organic waste following The King's Royally Initiated Laem Phak Bia Environmental Research and Development Project had the lowest scores, possibly due to the scientific understanding required to grasp the content. However, enhancing their scientific knowledge, particularly in science

subjects related to the decomposition of organic matter, especially in composting organic waste, helps students gain a deeper understanding and effectively carry out organic waste disposal (Sngwntagoon, 2023).

The effects of game-based learning (GBL) and team-based learning (TBL) in enhancing learners' understanding have been found that the scores from senior (upper secondary) students, during their first game session, achieved an average score of 47 out of 60. In the second game session, their scores increased, with the average reaching 54, and the development score was 53.96. This indicates that the senior students showed significant improvement after participating in the solid waste separation game. For the group of junior (lower secondary) students, during their first game session, they achieved an average score of 42 out of 60. In the second game session, their scores increased, with the average reaching 50, and the development score was 46.83. This indicates that the junior students showed moderate, the results were shown in Table 7.

The solid waste separation game fits in content into the game, allowing students to gain hands-on experience in waste separation that they may not have encountered in real life. This experiential learning helps students develop complex mental concepts, making it easier for them to understand the content Oakman (2016). The results of this study suggest that game-based learning (GBL) enhances student engagement, enjoyment in the learning process, motivation, resulting in improved content retention. Furthermore, the game provides learners with opportunities to practice creative thinking and problem-solving in real-life simulated scenarios (Kaewsathuanet *et al.,* 2024.).

While team-based learning (TBL) support teamwork skills and critical thinking. The implementation of TBL in this research revealed that this approach is effective in promoting deep and sustainable learning through teamwork and student engagement. The team readiness assurance test (TRAT), which involved administering the same test,

Table 6. Learning achievement of learners

Content	Junior group (N = 439)				Senior group (N = 1,171)			
	Full score	Mean	SD	%	Full score	Mean	SD	%
Solid waste separation	10.00	7.38	1.76	73.80	10.00	7.52	1.75	75.20
Solid waste management in the school	5.00	3.70	0.82	74.20	5.00	3.81	0.71	76.18
Organic waste disposal technology	5.00	3.03	1.01	60.60	5.00	3.19	1.02	63.89
Total score	14.11/20.00			70.55/100.00	14.52/20.00			72.60/100.00

Table 7. Development score of solid waste separation game.

Learners	Group sample	Score and times the game is played		Development score	Level
		First	Second		
Junior lower secondary (Age 12-14 year)	1	42	48	33.33	moderate
	2	40	48	40.00	moderate
	3	38	48	45.45	moderate
	4	47	55	53.85	high
	5	43	50	61.54	high
	Avg.	42	50	46.83	moderate
Senior upper secondary (Age 15-17 year)	1	47	50	23.08	moderate
	2	46	51	35.71	moderate
	3	46	54	57.14	high
	4	47	56	69.23	high
	5	47	58	84.62	highest
	Avg.	47	54	53.96	high

showed that in the second round of the game, students engaged in more discussions and consultations within their teams. This resulted in an improvement in the development scores of each group. In addition, TBL also results in students being continuously engaged in learning, taking responsibility for their own progress, and developing a deeper understanding of the content. Students can apply the knowledge gained to solve problems effectively (Chidnayee, 2018).

Moreover, the integration of both game-based learning (GBL) and team-based learning (TBL) can contribute to more effective and comprehensive learning outcomes for students across all educational levels.

3.2 Satisfaction with environmental education training program

The results of satisfaction for the environmental education training program, the learner's satisfaction was at the highest level. (Mean = 4.52). To analyze in the different dimension, the highest satisfaction ranked was found in (1) applicability of the knowledge gained, the mean was 4.58 (SD = 0.60) (2) active learning activities: solid waste separation game, the mean was 4.57 (SD = 0.68) (3) The senior expert/ professional human activities, the mean was 4.55 (SD = 0.67) (4) knowledge /content, the mean was 4.52 (SD = 0.60) and (5) the technology transfers, the mean was 4.41 (SD = 0.73) respectively, the satisfaction results were shown in Table 8.

Therefore, designing an effective learning process should consider key factors such as content and instructional methods, engaging teaching materials, knowledgeable and articulate instructors, and a conducive learning environment. These elements contribute to providing learners with a high-quality and satisfying educational experience. The study by Ballantyne & Packer (1996) emphasizes that learning activities utilizing real-world educational materials can enhance learners' cognitive, physical, psychological, emotional, and social development.

3.3 The follow-up after trainning program

The follow-up results after the training for one month showed that learners had expanded and built upon their knowledge. The senior (upper secondary) students use a waste separation game with 60 cards and 5 bins with a handbook to engage in waste separation activities with other younger students, and they continuously participate in waste separation activities using real waste in the school.

Teachers and educators implemented waste management into the curriculum and various subjects, such as: Science; understanding waste decomposition and environmental impacts, English; utilize waste separation content and solid waste picture cards using vocabulary into the English, and Mathematic; analyzing waste reduction statistics and calculate solid waste structure in the school to place different types of trashs were placed in classrooms, walkways, schoolyard and cafeterias.

Table 8. Level of satisfaction in environmental education training program

Indicators	Full score	Maximum	Minimum	Mean	SD	Level
1. knowledge /content	5.00	5.00	3.00	4.52	0.60	Highest
2. active learning activities	5.00	5.00	2.00	4.57	0.68	Highest
3. the senior expert/ professional	5.00	5.00	3.00	4.55	0.67	Highest
4. technology transfers	5.00	5.00	1.00	4.41	0.73	Highest
5. applicability of the knowledge gained	5.00	5.00	2.00	4.58	0.56	Highest
			Avg.	4.52	0.65	Highest

Remark: The satisfied levels were categorized into 5 levels as least, less, moderate, high and highest class, which the standard range between 1.0 ± 1.8, 1.8 ± 2.6, 2.6 ± 3.4, 3.4 ± 4.2, and 4.2 ± 5.0 respectively

Furthermore, the school administrators should support the Zero Waste project by the 3Rs principle to conduct to reduce waste at the source or support the waste separation projects, such as: recyclable waste bank in the school to generate revenue from recyclable waste, such as selling papers, glass bottles, plastic bottles; PET, cans. Pimpuang, T & Kessomboon, P (2018) also found that a simple and effective way to promote waste separation in schools is to place different types of bins in classrooms, walkways, and cafeterias, along with designated separation points for food and drink residues to simplify the waste sorting process.

4. Conclusion

This research focused on implementing a "Training to Trainers" approach to sustainably transfer knowledge on solid waste separation and management in schools from current to future generations. The findings indicate that upper secondary students achieved slightly higher average learning scores (72.60%) than lower secondary students (70.55%) in solid waste separation, recycling, and organic waste management, though the difference was not statistically significant. Both groups demonstrated the highest knowledge in school waste management, followed by waste separation and plastic recycling, while knowledge of composting organic waste was the lowest. This suggests the need for enhanced scientific education on organic waste decomposition.

The study also highlights the effectiveness of game-based learning (GBL) and team-based learning (TBL) in improving students' understanding. Upper secondary students showed significant improvement after engaging in a solid waste separation game, while lower secondary students exhibited moderate improvement. TBL was particularly beneficial in fostering teamwork, critical thinking, and long-term knowledge retention, as demonstrated by increased scores in the team readiness assurance test (TRAT). The integration of GBL and TBL offers a promising approach to enhancing students' learning experiences, engagement, and problem-solving skills in environmental education.

Expanding this initiative can be effectively achieved through (1) broadening target groups and locations, (2) leveraging technology and networks, (3) integrating waste management into education, (4) implementing incentives and tracking progress, and (5) strengthening collaborations with private and community stakeholders. These strategies will ensure long-term sustainability and a meaningful impact in school-based waste management programs.

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