



## OPEN Comparison of peer and instructor training techniques on waste separation behavior at source amongst female students in Iran

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The knowledge and a change of attitude are crucial in improving people's behavior towards waste separation at source, which is a priority in solid waste management. The aim of the present study was to determine and compare the effects of Peer Education (PE) and Instructor- Based Training (IBT) on knowledge, attitude, and behavior related to Solid Source Waste Separation (SWS) amongst female students. This quasi-experimental study was conducted from January 2021 to April 2021, involving 204 female students in Shahrekord, Chaharmahal and Bakhtiyari, Iran. The participants were randomly assigned to the control group ( $n = 64$ ), intervention group 1 (receiving PE,  $n = 64$ ), and intervention group 2 (receiving IBT,  $n = 64$ ). The students' knowledge, attitude, and SWS behavior were measured using an instrument before and one month after the intervention. There were no significant differences in scores of attitude ( $p = 0.064$ ) and knowledge ( $p = 0.076$ ) between intervention groups following the intervention. There was a significant increase ( $p = 0.001$ ) in the mean behavior score in intervention group 1 (from 12.203 to 13.187) compared to intervention group 2 (from 11.359 to 11.640) after the intervention. The results indicated that training delivered by peers is more effective in fostering SWS behavior among schoolchildren than professional training delivered by an instructor.

**Keywords** Knowledge, Attitude, Behavior, Waste separation, Education, Non-randomized controlled trial

The amount of solid waste produced has significantly risen in recent years in Iran, particularly in urban areas<sup>1,2</sup>. The per capita waste generation in Iran is 839 g per day. Recyclable materials such as plastic, polyethylene terephthalate, glass, metals, and paper/cardboard make up 24.05% of the total municipal solid waste in the country<sup>3</sup>.

Households generate the majority of solid waste globally. Separating this waste helps provide raw materials for recycling<sup>4</sup>. A 2019 study revealed that only about 53% of U.S. citizens and 92% of Italian citizens reported always separating their waste at home. In Asian countries like Turkey, about 39% of the population consistently practiced waste separation at home<sup>5</sup>. Several studies have investigated the rate of Solid Source Waste Separation (SWS) in different regions of Iran. For instance, a study in Zanjan found that although about 70% of residents expressed their willingness to participate in waste separation at the source, only 38% actually did so<sup>6</sup>. Another study in Yazd showed that 53.6% of households separated their recyclable waste<sup>7</sup>. Research has also shown that among the households participating in the waste segregation program in Babol, 27.5% were regularly involved, while 15.3% participated occasionally in the program<sup>8</sup>.

Various factors can affect a person's intention or behavior towards SWS<sup>9,10</sup>. Numerous studies have been conducted globally and in Iran to understand the factors influencing SWS behavior<sup>11–13</sup>. Some research utilized behavior change models, such as the extended Theory of Planned Behavior (TPB). For example, Lou et al. found that moral norms and self-identity predict intentions related to SWS<sup>11</sup>. Oehman et al. identified a positive correlation between attitude, subjective norms, and perceived behavioral control with the intention to separate food waste in New York<sup>10</sup>. Mir Mohamad Tabar et al. concluded that subjective norms are a stronger predictor of SWS behavior in Mashhad, Iran<sup>12</sup>. Additionally, Pakpour et al. found that moral obligation is the strongest predictor of household waste behaviors in Qazvin, Iran<sup>13</sup>.

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Numerous countries have adopted strategies to enhance SWS. One significant strategy utilized to improve SWS is raising public knowledge about it<sup>14</sup>. Education plays a crucial role in promoting individuals' knowledge and behaviors towards SWS<sup>15</sup>. Research has indicated that the inclusion of environmental education in school curricula, particularly during the early years of education, is crucial<sup>16</sup>. Building environmental knowledge should commence in childhood and persist throughout life through various educational strategies. Schools play a vital role in environmental education and the development of values related to citizenship<sup>17</sup>. Environmental literacy during the school years can establish a solid foundation for future environmentally responsible behavior<sup>18</sup>. Basic education has been recognized as a key factor in improving solid waste management<sup>19</sup>. A variety of educational interventions have been implemented to improve SWS among school children<sup>20</sup>. For example, Taghdisi et al. found that the Albanian health-promoting schools approach effectively improved recycling behaviors in primary school students<sup>21</sup>. Fallah-Nejad et al. reported that educational interventions based on the TPB enhanced students' attitudes and behaviors related to SWS<sup>22</sup>.

A systematic review by Trushna et al. indicated that waste segregation interventions mainly focused on providing information, though the variations in content and delivery methods have not been thoroughly examined<sup>23</sup>. It is believed that in order to engage students in the waste management system, their knowledge needs to be heightened through appropriate training<sup>24</sup>. One such active learning method is Peer Education (PE), where students are trained to conduct educational activities over a period of time for peers who share similar characteristics<sup>21</sup>. Active learning methods and innovative teaching processes can bridge the gap left by traditional instructor-based training<sup>25</sup>. To the best of our knowledge, there is a lack of evidence regarding the effectiveness of PE on SWS behavior. Studies have shown that PE is effective in promoting pro-environmental behavior among students<sup>26</sup>. Several interventions have suggested that PE is a promising strategy for health improvement in schools. However, while PE interventions can address a wide range of health areas, their overall effectiveness remains unclear<sup>27</sup>. Most interventions in SWS have utilized formal, passive educational methods, primarily delivered by researchers specializing in SWS through lectures<sup>22</sup>. A study in Iran suggested that educational administrators should involve significant others, like peers, to enhance SWS in schools<sup>28</sup>. Akıncı Ekinci et al. found that PE effectively raised awareness and improved medical waste management practices among operating room staff<sup>29</sup>. Jideonwu & Onyereze emphasized the need to investigate the impact of PE programs on sustainable behavior changes regarding plastic use<sup>30</sup>. Additionally, Boonchieng et al. highlighted that participatory learning and building the capacity of peer leaders are crucial for the success of waste management programs in rural schools in Northern Thailand<sup>31</sup>.

Considering the effectiveness of PE in addressing various health issues and the scarcity of studies comparing its effectiveness with other educational delivery methods in SWS, this study was conducted. The objectives of the present study were:

- 1) To determine and compare the impact of PE and Instructor-Based Training (IBT) on female students' knowledge regarding SWS across two intervention groups and a control group, both before and after the intervention.
- 2) To determine and compare the impact of PE and IBT on female students' attitude toward SWS in two intervention groups and a control group, both before and after the intervention.
- 3) To determine and compare the impact of PE and IBT on female students' behavior regarding SWS in two intervention groups and a control group, both before and after the intervention.

## Methods

### Design and sample

This quasi-experimental study was conducted between January 2021 and April 2021. In this study, the sampling method was as follows: All six female elementary schools located in middle-income areas of Shahrekord, Chaharmahal and Bakhtiari, Iran, were considered.

To calculate the sample size, Cohen's standardized effect size was used due to the lack of similar studies for comparison among the three groups. Therefore, considering a type I error probability of 5% and a type II error probability of 20% (power of 80%), along with a standardized effect value  $f$  for ANOVA equal to 0.25, which represents a medium effect on the Cohen scale, the sample size was determined to be 53 students in each group using G\*Power software. Assuming a small correlation between the outcomes of students within a school and a design effect of 1.2, the adjusted sample size became 64. Accounting for a 5% dropout rate, 68 participants should be included in each group for the study.

Using a simple random sampling method (lottery method), two schools were designated as the control group, two schools as Intervention Group 1 (receiving education from peers), and two schools as Intervention Group 2 (receiving training from instructor). From each school, 34 sixth-grade students were selected using a random sampling method (lottery method). The total number of participants in each group was 68. Unfortunately, four students in each group passed away during the study. Therefore, data from 192 students (64 students in each group) were analyzed.

The inclusion criteria for the study were: students' agreement to participate, residency in Shahrekord city, and enrollment in the 6th grade. One of the researchers informed the students and their parents about the study and its objectives, and they provided written consent to participate.

Due to the COVID-19 pandemic and the shift to virtual training in Iran (via the SHAD system and other virtual messengers), face-to-face contact with participants for completing the study instrument was not possible. As a result, a web-based instrument was used, developed through Google Forms (<https://docs.google.com/forms>), with mandatory responses for each question. The link to the instrument was distributed via the SHAD system and other virtual messengers.

Students in all three groups first completed an instrument assessing their knowledge, attitude and behavior regarding SWS. Subsequently, educational programs were designed and implemented for Intervention Group 1 (receiving PE) and Intervention Group 2 (receiving IBT), while the control group did not receive any intervention. After the interventions were completed, all three groups were followed up for one month and asked to complete the instrument again.

### Data gathering

In this study, a validated instrument developed by Taghdisi et al. (2016) was utilized to collect data. The instrument measured Iranian students' knowledge, attitude, and behavior towards source-separated recycling<sup>32</sup>. In their study, a literature review was conducted to develop the instrument items, and 15 students from grades four to six, along with their teachers and parents, were interviewed to gather their perspectives. They had assessed the validity of the instrument's items using qualitative face validity and qualitative and quantitative content validity. A panel of ten experts in health education, health environmental sciences, and educational sciences had reviewed the items and evaluated their simplicity, clarity, readability, grammar, wording, scoring, and relevance. Based on expert feedback, the Content Validity Index (CVI) and Content Validity Ratio (CVR) of each item had been calculated. Items with  $CVR < 0.62$  and  $CVI < 0.79$  had been removed, and unclear items and minor wording errors were revised. To assess face validity, 15 elementary-grade students had provided feedback on the items' relevance, ambiguity, and difficulty. Based on their recommendations, some items had been edited. The internal consistency of the knowledge, attitude, and behavior subscales had been measured using Cronbach's alpha. Thirty students completed the instrument to determine the internal consistency of the subscales. The Cronbach's alpha values for the knowledge, attitude, and behavior subscales were 0.86, 0.93, and 0.72, respectively. To assess the stability of the subscales, test-retest were done for the same thirty students with a two-week interval between tests. The Intra-Class Correlation (ICC) values for the knowledge, attitude, and behavior subscales were 0.83, 0.75, and 0.74, respectively. The final instrument comprised 14 items designed to measure participants' knowledge (4 items), attitude (3 items), and behavior (7 items)<sup>32</sup>. Permission to use the instrument in the study was obtained, and all groups completed the instruments before and one month after the intervention.

### The procedures of intervention

Due to the COVID-19 pandemic and the shift to virtual education in Iran, face-to-face education in schools was not possible. Therefore, two intervention groups received educational content virtually through SHAD system and other virtual messengers. In intervention group 1, interested students who voluntarily wanted to train their classmates on SWS were selected in two schools. After assessing their competencies, such as content transfer ability, willingness, creativity, and popularity among other students, and considering teacher feedback, 10 students were chosen to teach the educational content on SWS to the other participants. These selected students received six 45-minute training sessions over six weeks from one of the researchers who was an expert in environmental health and SWS training. After each session, the students would share what they had learned with their peers.

In intervention group 2, the students received educational content from one of the study researchers who had knowledge in the field of environmental health and SWS training. They also had six 45-minute training sessions over six weeks. During these sessions, both groups 1 and 2 were exposed to stories, movies, music, and games related to SWS. Additionally, in a virtual group discussion session, students who practiced waste separation at the source shared their positive and negative experiences with others. Practical tasks were assigned to the students during the training sessions, including identifying recyclable waste collection sites, collecting and separating recyclable waste in a limited natural environment with their families, sharing images and videos of waste separation at home, and participating in a role-playing session. At the end of each session, students were given a worksheet and asked to write down the steps they took to separate waste at home and school, and then share their responses with other students in the next session. The control group did not receive any training. The outline of educational sessions was presented in Table 1. All three groups were followed up one month after the intervention, and a post-test survey was administered to assess the outcomes.

| Session | Topic for each session  | Duration of each session | Content presentation method                 |
|---------|---|--------------------------|---|
| 1       | Increasing knowledge about the rate of waste production in Iran, the types of household waste (dry and wet), and the factors that affect waste generation.  | 45 min                   | Lecture and question & answer               |
| 2       | Increasing awareness of the importance of waste separation at the source and the problems caused by failing to do so.   | 45 min                   | Lecture and question & answer               |
| 3       | Learning about the necessary arrangements and equipment for waste separation at the source, practical strategies for effective waste separation, and appropriate behaviors related to this issue. | 45 min                   | Lecture, role playing and question & answer |
| 4       | Discussion of the negative and positive attitudes toward waste separation at the source and the practicality of waste separation behaviors.   | 45 min                   | Group discussion                            |
| 5       | Discussion of the barriers to waste separation at home and school, along with practical strategies to overcome them.  | 45 min                   | Group discussion and question & answer      |
| 6       | Report on the actions taken by students to separate waste at the source and their experiences shared with others.   | 45 min                   | Group discussion and question & answer      |

**Table 1.** The outline of educational sessions conducted for intervention groups ( $n = 6$ ).

| Variable                        | Intervention group 1<br>(n = 64) |        | Intervention group 2<br>(n = 64) |        | Control group<br>(n = 64) |        | p. value* |
|---------------------------------|----------------------------------|--------|----------------------------------|--------|---------------------------|--------|-----------|
|                                 | n                                | %      | n                                | %      | n                         | %      |           |
| <b>Father's education level</b> |                                  |        |                                  |        |                           |        | 0.261     |
| Illiterate                      | 0                                | 0      | 0                                | 0      | 0                         | 0      |           |
| ≤ 12th (grade)                  | 31                               | 48.437 | 44                               | 68.750 | 39                        | 60.937 |           |
| > 12th (grade)                  | 33                               | 51.563 | 20                               | 31.250 | 25                        | 39.063 |           |
| <b>Mother's education level</b> |                                  |        |                                  |        |                           |        | 0.263     |
| Illiterate                      | 2                                | 3.125  | 3                                | 4.688  | 1                         | 1.562  |           |
| ≤ 12th (grade)                  | 30                               | 46.875 | 45                               | 70.312 | 32                        | 50.000 |           |
| > 12th (grade)                  | 32                               | 50.000 | 16                               | 25.000 | 31                        | 48.438 |           |
| <b>Occupation of father</b>     |                                  |        |                                  |        |                           |        | 0.380     |
| Self-employed                   | 31                               | 48.437 | 39                               | 60.937 | 37                        | 57.813 |           |
| Employee                        | 29                               | 45.310 | 20                               | 31.25  | 20                        | 31.25  |           |
| Casual laborer                  | 4                                | 6.250  | 5                                | 7.813  | 7                         | 10.937 |           |
| <b>Occupation of mother</b>     |                                  |        |                                  |        |                           |        | 0.550     |
| Self-employed                   | 0                                | 0      | 0                                | 0      | 0                         | 0      |           |
| Employee                        | 18                               | 28.125 | 13                               | 20.313 | 17                        | 26.562 |           |
| Casual laborer                  | 5                                | 7.812  | 2                                | 3.125  | 4                         | 6.250  |           |
| Household duties                | 41                               | 64.000 | 49                               | 76.562 | 43                        | 67.188 |           |

**Table 2.** Descriptive statistics of participant characteristics according to study group ( $n = 192$ ). Significant: Chi-Square  $*P < 0.05$ .

| Variables        | Intervention group 1<br>(n = 64) |       |                        |       |          | Intervention group 2<br>(n = 64) |       |                        |       |          | Control group<br>(n = 64) |       |                        |       |          |
|------------------|----------------------------------|-------|------------------------|-------|----------|----------------------------------|-------|------------------------|-------|----------|---------------------------|-------|------------------------|-------|----------|
|                  | Before the intervention          |       | After the intervention |       | p. value | Before the intervention          |       | After the intervention |       | p. value | Before the intervention   |       | After the intervention |       | p. value |
|                  | Mean                             | SD    | Mean                   | SD    |          | Mean                             | SD    | Mean                   | SD    |          | Mean                      | SD    | Mean                   | SD    |          |
| <b>Knowledge</b> | 11.187                           | 3.049 | 11.968                 | 2.462 | 0.128    | 10.718                           | 2.465 | 11.078                 | 3.133 | 0.465    | 11.031                    | 2.343 | 11.093                 | 3.597 | 0.896    |
| <b>Attitude</b>  | 14.093                           | 1.150 | 14.203                 | 1.056 | 0.587    | 14.062                           | 1.283 | 13.718                 | 1.785 | 0.183    | 14.187                    | 1.193 | 13.109                 | 2.357 | 0.001*   |
| <b>Behavior</b>  | 12.203                           | 2.212 | 13.187                 | 2.195 | 0.018*   | 11.359                           | 2.484 | 11.640                 | 2.553 | 0.477    | 12.562                    | 1.917 | 10.734                 | 3.519 | 0.001*   |

**Table 3.** Comparison of knowledge, attitude and behavior in terms of separation waste at the source before and after the intervention according to study groups ( $n = 192$ ). Mean values were significantly different from those before the intervention (Paired samples  $t$  test):  $*P < 0.05$ .

### Statistical analyses

The data were analyzed using SPSS software package (version 18.0, SPSS, Inc., Chicago, IL, USA). The normality of the data was examined using the Kolmogorov-Smirnov test. The homogeneity of demographic qualitative variables of the three groups was analyzed using the Chi-square test. The Paired samples  $t$  test was used to compare the differences in the total mean scores of students' knowledge, attitude, and behavior in each group before and after the intervention. Independent samples  $t$  test was used to compare the differences in the total mean scores of knowledge, attitude, and behavior between the groups after the intervention. The data were reported as frequency and Mean  $\pm$  SD. A significance level of  $P < 0.05$  was considered in the study.

### Results

All participants were 12 years old. Table 2 provides a summary of the demographic characteristics of the participants in the three groups. The results of the Chi-Square test indicated that there were no statistically significant differences among the three groups in terms of any demographic variables (Table 2).

The results showed a significant increase in the mean score of participants' behavior towards SWS in Intervention Group 1 after the intervention, compared to before the intervention (from 12.203 to 13.187,  $p = 0.018$ ). However, in this group, there were no significant differences in the mean scores for attitude (from 14.093 to 14.203,  $p = 0.587$ ) and knowledge (from 11.187 to 11.968,  $p = 0.128$ ) after the intervention compared to before (Table 3).

The findings showed that in Intervention Group 2, there were no significant differences in the mean scores for participants' behavior towards SWS (from 11.359 to 11.640,  $p = 0.477$ ), knowledge (from 10.718 to 11.078,  $p = 0.465$ ), and attitude (from 14.062 to 13.718,  $p = 0.183$ ) after the intervention compared to before the intervention (Table 3).

In the control group, there were no significant increases in the mean score for participants' knowledge, attitude and behavior after the intervention compared to before (Table 3).

In between-group comparisons, there was a significant increase in behavior related to SWS in Intervention Group 1 compared to Intervention Group 2 after the intervention ( $p=0.001$ ). Additionally, there were no significant differences in attitude ( $p=0.064$ ) and knowledge ( $p=0.076$ ) between Intervention Group 1 and Intervention Group 2 following the intervention (Table 4).

The findings also showed significant differences in attitude ( $p=0.001$ ) and behavior ( $p=0.001$ ) between Intervention Group 1 and the control group after the intervention. However, there were no significant differences in knowledge ( $p=0.979$ ), attitude ( $p=0.102$ ), and behavior ( $p=0.098$ ) between Intervention Group 2 and the control group after the intervention (Table 4).

## Discussion

In this study, the effects of PE and IBT on female students' knowledge, attitude, and behavior towards SWS were determined and compared. The results of the comparison between the intervention groups showed that, following the intervention, students in Intervention Group 1 (receiving PE) had a significant increase in the mean behavior score related to SWS, compared to those in Intervention Group 2 (receiving IBT) and the control group.

Previous research has also highlighted the strong influence of peers on waste recycling behavior<sup>33</sup>. However, the effectiveness of peer education interventions specifically for SWS among students has not been extensively studied. Therefore, the results are compared with similar studies conducted in different fields. For instance, Lazaric et al. found that peer education can stimulate pro-environmental behavior and change environmental values<sup>34</sup>. Makov et al. reported that peer-to-peer sharing is an effective strategy for reducing food waste<sup>35</sup>. Literature suggests that individual pro-environmental behavior is influenced by the behavior of peers<sup>26,36</sup>. Additionally, a study found that teenagers have a direct and indirect impact on the pro-environmental behavior of their peers<sup>37</sup>. Overall, peers can have a positive effect on adopting pro-environmental behaviors<sup>38</sup>. Dodd et al. in a systematic review concluded that interventions based on school-based PE are implemented globally and cover various health topics. Several of these interventions show evidence of effectiveness, indicating that PE could be a promising strategy for enhancing health in schools. Additionally, they reported that improvements in health-related knowledge were more common, while there was less evidence for positive changes in health behavior<sup>27</sup>. Topping in a systematic review resulted that PE and peer counseling now demonstrate strong evidence of effectiveness, but primarily in specific areas of human activity. PE and peer counseling should be further expanded and researched more thoroughly in various domains. Numerous studies have reported that PE is more effective than professional-led education and is preferred by clients<sup>39</sup>. Kalyanasundaram et al. demonstrated that volunteers chosen from the participating community, when equipped with adequate training, could connect waste management service providers with the community, offer a local perspective on waste management, and help change community habits through information, ongoing communication, and feedback<sup>40</sup>. Considering that PE has been shown to be more effective than IBT or lecture-oriented methods in improving skills and learning performance of students<sup>41–43</sup>, it is recommended to utilize this method for environmental education on topics like SWS among student populations.

We expected that due to the higher behavior score in the PE group after the intervention, the knowledge and attitude of this group would be higher than the group receiving IBT. However, the findings showed that there were no significant differences in students' knowledge and attitude between these two groups after the intervention. In addition, following the intervention, there were no significant changes in the attitude and knowledge of participants in the intervention groups compared to before the intervention. In contrast to our findings, Taghdisi et al. demonstrated that the educational intervention successfully increased the knowledge and attitude of students in the intervention group regarding source-separated recycling<sup>32</sup>. In a study by Sadeghi et al., there was a significant increase in the attitude score related to waste separation in the intervention group after the education intervention<sup>44</sup>. The differences between our findings and these studies may be attributed to the type of educational content presentation, the methodology used, and the target groups involved.

Literature suggests that in the chain of behavior change, knowledge and attitude should not always be the precursor to behavior. In some situations, behavior can be influenced by other factors such as observing others or imitating them. In other words, sometimes behavior comes first, and then knowledge and attitude increase<sup>45</sup>. Mimicry may be the primary mechanism of peer effects on pro-environmental behavior<sup>26</sup>. According to a study, imitation plays an important role in the food waste behaviors of peers<sup>46</sup>. Therefore, it can be concluded that peer education has been successful in increasing SWS behavior in students through observational learning and imitation of peers. Consistent with our findings, Ordin et al. reported that peer education cannot modify college students' attitudes but can encourage them to perform positive behavior regarding organ donation<sup>47</sup>. A deeper understanding of students' behavior regarding SWS and its influencing factors could provide important insights for developing effective interventions on this issue.

The findings showed that after the intervention, there were significant decreases in the attitude and SWS behavior scores in the control group compared to before the intervention. It can be argued that the students in the control group were exposed to a set of health information regarding SWS by completing the questionnaire. However, this group did not receive support or participation to engage in SWS behavior and reduce existing barriers. Receiving information alone is often insufficient for behavior change without adequate support and practical strategies. While education alone is not sufficient, it is a crucial component for facilitating behavior change<sup>48</sup>.

There were several limitations in this study that should be noted. Two limitations were the use of a self-report instrument to measure behavior and the short follow-up duration for participants. Additionally, the study was conducted during the peak of the COVID-19 pandemic in Iran, which meant that training was provided through

| Variables | G1              |                       |          |        | G2              |                       |          |        | G3              |                       |          |        |
|-----------|-----------------|-----------------------|----------|--------|-----------------|-----------------------|----------|--------|-----------------|-----------------------|----------|--------|
|           | Mean difference | Std. Error difference | p. value | t      | Mean difference | Std. Error difference | p. value | t      | Mean difference | Std. Error difference | p. value | t      |
| Knowledge | -0.875          | 0.544                 | 0.111    | -1.606 | 0.015           | 0.596                 | 0.979    | 0.026  | -0.890          | 0.498                 | 0.076    | -1.778 |
| Attitude  | 1.093           | 0.322                 | 0.001*   | -3.386 | -0.609          | 0.369                 | 0.102    | -1.648 | -0.484          | 0.259                 | 0.064    | -1.867 |
| Behavior  | -2.453          | 0.518                 | 0.001*   | -4.731 | -0.906          | 0.543                 | 0.098    | -1.667 | -1.546          | 0.420                 | 0.001*   | -3.675 |

**Table 4.** Comparison of the effects of the peer education and instructor-based training interventions on students' knowledge, attitude, and behavior on waste separation at the source according to study groups ( $n = 192$ ). G1: Mean values in the intervention group 1 were significantly different from those of the control group (Independent samples t test): \* $P < 0.05$ . G2: Mean values in the intervention group 2 were significantly different from those of the control group (Independent samples t test): \*\* $P < 0.05$ . G3: Mean values in the intervention group 1 were significantly different from those of the intervention group 2 (Independent samples t test): \*\*\* $P < 0.05$ .

the SHAD system and other virtual messengers, making it impossible to conduct face-to-face interactions or complete the instrument in person. Another limitation was that only female sixth-grade students were included in the study.

## Conclusion

The results of the present study demonstrated that the implementation of PE effectively increased the students' behavior regarding SWS in elementary education grades. Based on these findings, it is recommended that school health providers in Iran incorporate active learning methods, such as PE, alongside traditional lecture-based education, to encourage students to adopt pro-environmental behaviors.

## Application and suggestions

The results of the present study may provide insights into the comparison of the impacts of two methods: PE and professional-led education on the behavior of SWS. Since PE was found to be more effective in enhancing students' SWS behavior than IBT, health professionals can use this educational method to increase students' environmental conservation behaviors. It is suggested that future research compare the effects of other educational methods on improving students' knowledge and positive attitudes toward SWS. Additionally, it is recommended that the design of PE interventions be based on established models and theories of behavior change, such as the TPB. It is also advised to conduct similar interventions with other population groups, including students in lower or higher education grades.

## Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Received: 8 June 2024; Accepted: 10 March 2025

Published online: 26 March 2025

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## Acknowledgements

The study was supported by Iran University of Medical Sciences (Grant Number:1400-3-2-22576). The authors thank the participants for their cooperation.

## Author contributions

M.B. and M.F. and T.D. contributed to the study's design, interpretation of data and prepared the manuscript. M.B. contributed to the data collection.

## Declarations

## Competing interests

The authors declare no competing interests.

## Consent to participate

The present study was done according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects. All the participants and their parents read a statement that explained the purpose of the study and the process of conducting the study and provided written informed consent before participation in the study. They were informed that the interventions implemented in this study was free and

had no harmful side effects for their children. Additionally, they were given the opportunity to consult their friends and acquaintances about their children's participation in this study, if they wished. The participants were reminded that the study was voluntary, confidential and the results would remain anonymous. Ethics approval was obtained from the Ethics Committee of Iran University of Medical Sciences (no. IR.IUMS.REC.1399.814).

### **Additional information**

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