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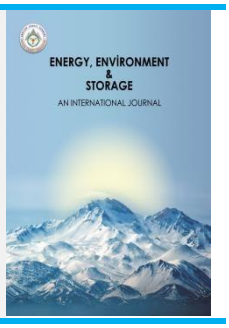

Food Waste in Educational Media: A systematic literature review

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ABSTRACT. Food waste is a critical global issue with significant environmental, economic and social consequences. Educational institutions, as early intervention agents, play a strategic role in fostering sustainable behaviors among students. This systematic literature review aims to explore how interactive learning media have been used to address food waste awareness and behavior in formal education settings. Following the PRISMA protocol, 19 peer -reviewed articles published in the last five years were selected through the Scopus indexed database. The review identified five main themes: awareness, attitude, behavior, media type, and curriculum integration. The results showed that interactive media, such as educational games, digital apps and e-modules, were consistently effective in improving students' awareness and attitudes, although their long-term behavioral impact remains limited without curriculum support. Practical activities and campaign -based interventions also how promising results, but require strategic integration to produce sustainable change. This review contributes to the growing literature by mapping current trends and highlighting the need for more comprehensive and technology -based educational strategies to reduce food waste. Further research is recommended to evaluate the long -term effectiveness and contextual adaptation of these interventions in diverse educational environments.

Keywords: food waste education, interactive learning media, Sustainable Behavior

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1. INTRODUCTION

Food waste has become one of the world's serious global issues, with a total reaching around 1.3 billion tons annually. This amount is equivalent to an economic loss of 940 billion US dollars and has an impact on decreasing food security, environmental degradation, and economic imbalance [1]. Along with greatly increasing greenhouse gas emissions that exacerbate the global climate catastrophe, this phenomena also adds to the waste of natural resources including water, energy, and land [2]

In Indonesia, data from the National Waste Management Information System (SIPSN) in 2024 shows that food waste is the most produced type of waste [3]. This condition reflects an unwise consumption pattern and a lack of reflection of sustainability principles, including within educational environments. The lack of understanding regarding the environmental impacts of food waste, coupled with a consumptive lifestyle, becomes the main cause of this issue [4].

Contextual and interactive education is believed to help students understand the relationship between their consumption behavior and the resulting environmental impacts [5]. Unfortunately, most schools do not yet have food education programs that specifically aim to reduce food waste and improve students' literacy regarding the importance of sustainable food management. Therefore, innovative educational interventions become important to address the root of this problem [6].

Learning can be directed by adopting best practices from countries that have successfully reduced food waste in schools. Japan, for example, offers a model that can be selectively adapted for implementation in Indonesia [7]. Schools have a strategic role in instilling the values of sustainability and wise food management in the younger generation through educational approaches. In this context,

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teachers play an important role. Teachers can be effective catalysts in fostering awareness and encouraging real actions among students toward environmental issues through integrated and participatory learning [8].

The use of creative learning methods, such as utilizing interactive media, has the potential to improve students' understanding of food waste issues. Media such as e-modules, educational games, digital applications, and visual media like Kamishibai have been proven to assist teachers in delivering materials in an engaging and effective manner [9]. However, studies that examine the effectiveness of these media in the context of sustainability education are still limited. Most previous studies have focused more on quantifying food waste or logistical interventions. Meanwhile, the use of digital applications can indeed increase students' awareness of food waste and global environmental issues, although its direct impact on reducing food waste remains insignificant [10].

Based on this background, this study aims to answer two main questions: (1) What are the trends in using interactive media for food waste education in schools?" and (2) To what extent is the effectiveness of interactive media in increasing students' awareness and attitudes toward food waste issues?. Many prior studies emphasize food waste measurement or broad sustainability actions, yet few address how interactive tools function within structured educational contexts. This review addresses that gap by systematically examining how interactive media is utilized to promote food waste education in schools. This systematic literature review is expected to the findings are intended to support educators, curriculum planners, and decision-makers in developing more focused, sustainable, and effective learning strategies related to food waste.

2. MATERIALS AND METHODS

2.1 Methodology

This research utilized the PRISMA guidelines and flowchart. Search engines were used to obtain relevant sources to answer the research question (RQ) and other related references.

2.2 Review Method Identification

The search process was carried out using search engines (ERIC, Scopus, DOAJ and Google Scholar). The initial search process was carried out based on the year of publication in the range 2020 - 2024 using the keywords "FOOD WASTE" AND "STUDENTS" AND "EDUCATION". A summary of the archived articles As shown in Table 1.

Table 1. Initial Search Table

Search Terms	Database	Hits
"FOOD WASTE " AND "STUDENTS" AND "EDUCATION"	Google Scholar	17200
	Scopus	352
	Eric	20
	DOAJ	8

To make sure all pertinent articles had been located, Google Scholar was also employed. The similar search function is not available on Google Scholar term restrictions resulting in 15600 results sortedby relevance [11]. To find undiscovered material, Google Scholar only looked at the top 200 to 300 results. and the first 300 publications' abstracts were examined. There was one article that could not be located that was not found in other databases. The last search was conducted in December 2024.

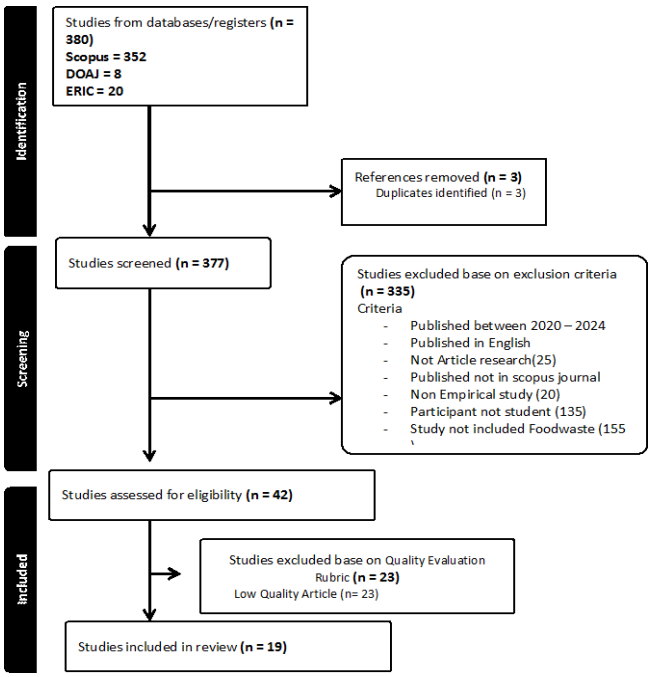

Figure 1. Prism Diagram

Based on Figure 1, in the identification stage, articles sourced from search engines were searched. There are no additional articles from sources other than search. In the screening stage, the same article is eliminated. Furthermore, articles are selected based on the screening of article titles and abstracts. Articles that pass the selection, then enter the eligibility stage. At the eligibility stage, articles are assessed for eligibility based on the specified criteria. At the included stage, 19 articles were found to be reviewable.

The articles were found are selected to the Inclusion and Exclusion Criteria,This stage is carried out to decide whether the data found is suitable for use in SLR research or not. Focusing on articles that met the criteria Inclusion and Exclusion As shown in Table 2.

A rubric was used to assess the quality of each article. The rubric tested seven criteria: purpose, literature review, theoretical framework, participants, methods, results, and conclusions, and significance. Each of the seven sections of the article was evaluated to ensure that they met quality reporting standards [12]. Each of the seven sections is rated on a 4-point scale where 1 = Does Not Meet Standard, 2 = Nearly Meets Standard, 3 = Meets Standard, and 4 = Exceeds Standard. Each article can receive a score ranging from 7 to 28 after adding up the seven sections. Because they did not fulfill the quality standards, articles with scores of 18 or lower were disqualified. Following an evaluation of each article's quality, 15 were kept and four were eliminated. To avoid prejudice, the writers. The assessment quality assessment rubric can be seen in Table 3.

Table 2. Inclusion and Exclusion Criteria

IInclusion Criteria	Exclusion Criteria
Articles published between 2020 and 2024	Articles published before 2020
English language articles	Not English language articles
Articles are based on research	Articles are not the result of research such as proceedings articles or book chapters.
The study was published in a *peer- reviewed journal.*	The study was published not in a journal format
Participants are students up to college-level	Participants who are not students
The study is empirical	The study is not empirical
The study discusses food waste in formal educational environments.	The study did not discuss food waste in formal educational environments.
The study discusses in detail the techniques for educating/researching food waste in educational environments.	The study discusses in detail the techniques for educating/researching students about food waste in educational settings.
The study comes from journals indexed by Scopus.	The study does not come from journals indexed by Scopus.
The extracted data is in line with or answers at least one of the research questions.	The extracted data is not aligned with the research question.

Table 3. quality assessment rubric

Assessment Aspects	4 (Very Good)	3 (Good)	2 (Enough)	1 (Less)
Goals and problems	Problems, objectives, formulated clearly.	Problems, objectives, formulated adequately.	Problems, objectives, formulated less clearly.	Problems, objectives, incompletely.
Literature review	Critically examine field conditions.	Discussing what has and hasn't been done	Discussing at least what has been	Failed to discuss
Theoretical Framework	The theory is explained clearly, and in detail, and the framework is aligned with the study	Theory aligned with objectives.	Theories are not aligned with the objectives.	There is no explanation of the theoretical basis
Participant	Participants were explained in detail and contextually about the population, sample, and sampling procedures.	Participants are explained in detail and contextually about the population, and sample.	Participants have explained the basics	Participants not explained
Method	methodology is well-designed,.	methodology is quite good	methodology has significant weaknesses	methodology is inadequate
Results and conclusions	Data analysis is carried out	The analysis is quite in- depth,	The analysis is shallow and lacks strength	There is no clear analysis or supporting data.
Significance	The article provides new and significant insights *food waste education.*	The article has novelty, but its impact is relatively small.	The article's contribution is minimal	There is no new contribution

3. RESULT AND DISCUSSION

Articles that had a score of 18 or lower on the quality assessment were disqualified for failing to meet the requirements. Following an evaluation of each article's quality, 23 articles were excluded and 19 articles were retained. To prevent bias, the authors made sure that all of the articles that were kept satisfied the requirements by going over the included and excluded articles in light of the criteria.

To make sure the coded quotes fit the context, each theme was examined or checked. The fifth stage was when the themes were identified and categorized, and the sixth step involved writing a report that linked the research questions to the topics. To create the ranking protocol, the authors read the 19 saved articles using the previously created coding protocol using four broad categories: (a) animation (b) science, (c) food waste, and (d) students. After the authors' independent analysis of the first three articles, 45 text passages were taken out and categorized into four Usage:

1. Total Score: Give a score for each aspect (1-4) for each evaluated article.
2. Acceptance Criteria: Define the threshold (e.g., total score

≥18 to include an article).

3. Qualitative Notes: Include comments on specific strengths or weaknesses article.

An intriguing phenomena was discovered and observed when looking at the years of publication of each of the 19 archived articles. Beginning in 2020, the number of papers published on this subject rose annually until 2024, when there were six pieces published. There was 19 articles of research conducted abroad. Namely four from the US, three from China, four from Italy, two from Malaysia, the rest were one article each from Norway, Portugal, Sweden, Denmark, Japan, and Saudi Arabia. 19 studies were conducted, 6 of which were qualitative, 12 were quantitative and 1 used mixed methods. A summary of the archived articles can be found.

3.1 Data Extraction and Synthesis

After going through the process, the data in the articles that meet the inclusion criteria and have good quality will be extracted further to answer the research questions, the extracted data includes basic information on the article (researcher, year of publication, and location of the study), level objectives, learning methods used, Food Waste teaching methods practiced, results, challenges, and opportunities identified and conclusions to be further analyzed Narratively.

Based on 19 articles analyzed in this study, the distribution of publications shows an interesting trend, the articles analyzed were published between 2020 and 2024, with the peak number of publications occurring in 2024 as many as six articles, all articles using a quantitative approach, 6 Qualitative and 1 mixed. An overview of the articles is available in the following table 4.

Author	Title	Participants	Methodology	Findings
Lee 2024	Food waste separation intention among the residential students: Moderating role of university support	191 students in Malaysia	This study collected quantitative primary data from residential students in Malaysia using purposive sampling.	Future research should include comparative studies and incorporate constructs such as trust and incentives to better understand.
Mathisen 2022	The Impact of Smartphone Apps Designed to Reduce Food Waste on Improving Healthy Eating,	6 students from different study programs (Norwegia)	Six students from different study programs evaluated two food waste reduction apps, TotalCtrl Home and Too-Good-To-Go,using mixed methods. the impact of these apps on food waste management.	The study found that app trials increased awareness of food waste, but noted potential for technical and content improvements.
Bathmanathan 2023	What's a waste? An experience in a secondary school in Malaysia of a food waste management system	119 school students (Malaysia)	Researchers conducted meetings with teachers and students. They conducted pre-test and post-test exercises, distributed surveys, and invited	The study aimed to, create a positive attitude towards food waste and ethical behavior.
Malefors 2022	Testing interventions to reduce food waste in school catering	two school canteens, while seven school canteens act as a reference group (Swedia)	The study comprised three main steps (Fig. 1): 1) food waste quantification; 2) design and implementation; 3) post-food waste quantification	Tasting spoons can shift waste from plate to serving fractions, Interventions in Swedish schoolcanteens were successful,
Pandey 2023	Factors influencing consumers' food waste reduction behavior at university canteens	432 respondents from Danish university (Denmark)	The study reveals that attitudes, self-efficacy, and environmental concerns significantly influence food waste reduction behavior...	BMI may also help. This study provides a framework for targeted interventions in university canteens in Denmark.
Piras 2023	Food waste between environmental education, peers, and family influence. Insights from primary school students in Northern Italy	420 Italian primary school students	A lesson on reducing food waste in half of randomly selected classes reduces short-term waste but doesn't persist. Environmental concerns	The message that food waste has negative environmental consequences is passed on but does not result in behavioral change..
Malefors 2024	Automated quantification tool to monitor plate waste in school canteens	Five school dietitians (Japan)	The research team consisted of two US researchers (BTI and CBS) and two Japanese researchers (RA and KF). BTI led the study while she was a Fulbright US Scholar at Ochanomizu University in Tokyo	A global commitment to addressing food waste is crucial for sustainable food systems.
Favuzzi 2020	Evaluation of an alimentary education intervention on school canteen waste at a primary school in Bari, Italy	361 third-grade students. (Italian)	Data was Collected From Canteen attendants, teachers and students using questionnaires.	The study found no significant effect of educational intervention on waste production in school anteens
Fans 2023	FACTORS INFLUENCING FOOD-WASTE BEHAVIORS AT UNIVERSITY CANTEENS IN BEIJING, CHINA: AN INVESTIGATION	University canteen with 705 respondents. (China)	This paper explores factors influencing student food-waste behavior, focusing on sociopsychological, individual characteristics, and dining factors. control, and food portions	Results show that living expenses and food portion size positively influence food waste, while perceived behavioral control, gender, BMI, meal time and meal
Catalano 2024	Food waste awareness among Italian university students: results of an online survey	431 students from the University of Catanzaro Magna Graecia (Italian)	A representative sample of 431 students from the University of Catanzaro Magna Graecia completed an online survey aimed at investigating FW-related behaviors.	Our data suggest that young adults are trying to implement strategies to reduce FW, even if there is room for improvement,
Alsawah 2022	Food Waste, Attitudes and Preferences of Young Women: A Case Study in Saudi Arabia	199 students at Princess Norah Bint Abdulrahman University (Saudi Arabia)	Two indices were calculated to compare and assess the perception of the suggested policies: the Perceived Effectiveness Index (PEI) and the Endorsement Index (EI).	Saudi it does care significantly about food waste and sustainability. The results are encouraging, and further investigations are urgently
Wang 2024	How to Reduce College Students' Food Waste Behavior: From the Perspective of College Canteen Catering Modes	422 consumer College Canteen (China)	A study analyzing 422 valid questionnaires found that food-saving intention and herd mentality are major drivers of college students' food-saving behavior..	Future research should consider the influence of religiosity and family upbringing on food-saving intentions to fill existing literature gaps.
Marques 2022	Impact of a Food Education Session on Vegetable Plate Waste in a Portuguese School Canteen	in 383 primary school meals was evaluated. (Portuguese)	A quasi-experimental study was carried out in a Portuguese school, located in the Guarda district. Data were collected at two different times during January and February in the school year of 2021/2022 and included only primary school students.	The leftover and remaining index of dish vegetable components exceeds literature recommendations, indicating the need for intervention.

Author	Title	Participants	Methodology	Findings
Elnakib 2024	New Jersey Leaves No Bite Behind: A Climate Change and Food Waste Curriculum Intervention for Adolescents	Participants (n = 162) completed pre- and post-test surveys (America)	The study assessed the effectiveness of the NJ Leaves No Bite Behind (NJLNBB) program for fifth-grade students on climate change and food waste. compared to the control group.	There were no significant between-group differences in mean score attitudes, self-efficacy, motivation to comply, or climate-friendly behaviors
Filho 2024	Toward food waste reduction at universities	641 students across disciplines. (America)	This study uses a quantitative and qualitative approach to analyze food waste levels at involving 641 students across disciplines. The research aims to reduce food waste levels by analyzing factors such as gender, age, season, consumer behavior.	Zero waste Universities should invest in converting campus open space into gardens, promoting a culture of waste reduction.
Koetz 2021	Using Extension as a Vehicle to Reduce Elementary Student Food Waste	There were 113 student participants across all eight classrooms (America).	The study taught four treatment classrooms three 1-hour lesson plans over a week. Lessons covered the environmental effects of food waste,	The study found that all treatment groups experienced greater increases in knowledge than control groups, but these were significant only for School 1 second-grade students.
AngelaSciacqua 2024	Food waste awareness among Italian university students: results of an online survey	431 students from the University of Catanzaro Magna Graecia (Italian)	A representative sample of 431 students from the University of Catanzaro Magna Graecia completed an online survey aimed at investigating FW-related behaviors.	The most common type of FW was spoiled fruits and vegetables, followed by meal leftovers and expired products.
HaoFAN 2023	FACTORS INFLUENCING FOOD-WASTE BEHAVIORS AT UNIVERSITY CANTEENS IN BEIJING, CHINA:	China Agricultural University canteen with 705 respondents (China)	Following the survey process, students who came to the cafeteria for lunch and dinner were arbitrarily selected by surveyors and those who agreed to participate in this survey completed a questionnaire after they finished their meal.	Future studies should expand the sample to include students from comprehensive, polytechnic
Oonorasak, 2022	Evaluation of a sustainable student-led initiative on a college campus addressing food waste	Of the 629 students attending the F2F lunch pro (America)	Since evaluation processes play an essential role in the development, implementation, and monitoring of student-driven food	The study supports sustainable efforts to reduce food waste,

3.2 Data Analysis

After explaining in depth the methodology of this study in the previous section, the researcher presents the analysis in this section based on the two research questions that have been identified previously. The research questions are answered in sections 1, 2, and 3 respectively.

1. What are the trends in the use of interactive media in Food Waste Education in the formal education environment?

All extracted data will be analyzed using the Thematic analysis approach [13]. to identify the main themes that answer the research questions: 1) familiarizing yourself with the data by repeatedly reading the extraction results 2) identifying and grouping relevant codes; 3) reviewing and grouping codes into themes; 4) revising and defining the identified themes; 5) compiling the main themes that answer the research questions; 6) reporting the results of a structured thematic analysis.

The researcher read 19 high-quality articles (total rating greater than or equal to 18), so there are four major categories used: (a) Technology-based Interactive Media (b) Direct Methods (c) School-based Campaigns, and (d) Integration into the curriculum The first three articles were analyzed independently by the researcher, and 19 text segments were extracted and placed into one of the four categories, then, the researcher used this four-category protocol to code each of the remaining articles, a total of 50 text segments were extracted and grouped into four major categories. The researcher refined the general codes into sub-codes, namely as shown in Table 5:

Table 5. Pre-established Codes with Refined Sub Codes

Technology-based interactive media	**Direct method through practical activities**
Digital Education Application Educational Animation Video Barcode	Weighing Waste in Schools Observation of Student Consumption Behavior. Collaborative Project Compost Making
School-based campaign	**Integration of sustainability into the curriculum**
Socialization in Schools: Collective Education Involving Parents: The role of families in supporting students' sustainability campaigns.	learning activities to raise awareness of Science and Sustainability Learning in the classroom Use of Interactive Modules Environmental Based Evaluation

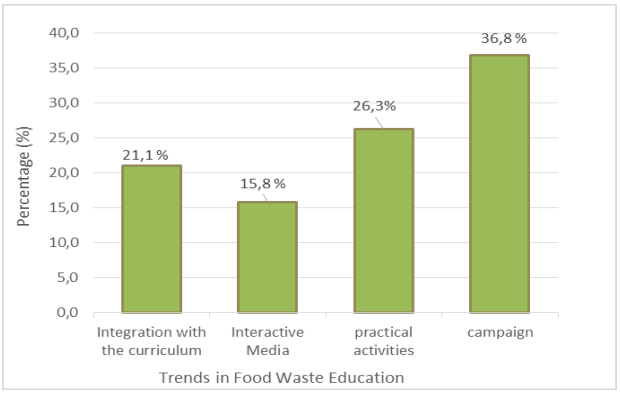

Fig 2. Trends in Food Waste Education

The distribution of aspects of Campaign is the most frequently developed skill at 36,8%, followed by Practical activities 26,3%, integration with the curriculum 21,1%, and practical activities at 15,8%. Among campaign methods (36.8%) and practical activities (26.3%), the use of interactive media in waste education only reached 15.8%. This shows a significant difference in the use of interactive media-based technologies in formal education.

The percentage of campaigns has the highest value (36.8%) because this method is the most widely used, given the absence of material included in classes in schools regarding food waste so the campaign method is the most commonly used regardless of whether this method is effective. followed by practical activities which are the second most after campaigns, practical activities such as the practice of directly weighing food waste generated by individuals, making compost from food waste, and other alternatives specifically, dining facilities on campus and enthusiastic student volunteers who help by picking up waste, preparing food, making compost from waste, and serving food to the community. This study supports ongoing efforts to reduce food wastage [14].

From the graph above Trends in Food Waste shows 21.1%, proving that the concept-based education initiative was not successful in reducing food waste but only impacted students' self-assessment of this behavior in the short term, and this impact was not seen after several months. In turn, the message that food wastage has negative environmental consequences was conveyed to students, and this awareness persisted after a few months, although it did not result in behavior change [15]. with the advancement of the times where students must have technological capabilities that can keep pace with the times, conventional media is no longer in demand although it is still often used in the learning process. this preliminary, descriptive study, we investigated FW-related habits of students enrolled at the University of Catanzaro Magna Graecia in Calabria, a Southern Italian region [16].

The low proportion of interactive media indicates that interactive media is still not the main focus of the food waste education strategy, even though interactive media has great potential to increase student engagement and provide an immersive learning experience. Environmental knowledge has an insignificant impact on food waste sorting intention. Therefore, future research is recommended to include additional constructs that can better capture the unique features of boarding school students' food waste sorting intention to improve the clarity of the research model and produce stronger findings [17]. This suggests that further research is needed to find out how the use of interactive media affects students' awareness and attitude towards food waste in formal learning. Awareness on food waste increased after app trials, but experiences with apps pointed toward several potential for technical and content improvements [18].

2. How effective are interactive media in increasing students' awareness and attitudes towards food waste issues?

Ultimately, the best way to deal with FW is to prevent it in the first place. To achieve this goal, it is imperative to actively engage all students (at every teaching level) in food-growing-focused learning, whether it takes place on campus or not. active in learning that focuses on growing food, whether it takes place on campus or not [19].

The collected articles were analyzed how the educational media affected students' awareness, attitudes and effectiveness. Their effectiveness is summarized in Table 6.

Table 6. effective are interactive media in increasing students' awareness

Author	Media Used	Awareness	Media Effectiveness
Lee, 2024	Food waste separation application by scanning barcode	Understanding: Increased Caring: Increased	Effective, There is an influence of students' attitudes on their intention to sort food waste.
Mathisen 2022	Too good to go and Totalctrl Home apps	Understanding: Increased Caring: Increased	Not Effective, There was no significant impact or reduction in food waste across all student group
Bathmanathan 2023	Food waste processing practice	Understanding: Increased Caring: Increased	Effectively, there are more sensitive food waste management behaviors food sharing practices.
Maleforas 2022	Application Tasting spoon	Understanding: Increased Caring: Increased	Effectively, the tasting spoon has a tendency to transfer waste from the plate waste fraction to the serving waste fraction.
Pandey, 2023	Weighing practice	Understanding: Increased Caring: Increased	Effective, Research allowing students to weigh their canteen food before purchase can potentially reduce food wastage
Piras, 2023	teaching Food Waste conventionally in class	Understanding: Not Improved Caring: Not Improved	Not Effective, We found that these classroom lessons only reduced self-declared food wastage in the short term,

Malefors, 2024	food waste weighing	Understanding: Increased Caring: Increased	Effectively, the tool provided students with the opportunity to provide feedback on the reasons behind their food waste.
Favuzzi, 2020	weighing food waste in the school canteen	Understandi ng: Not Improved Caring: Not Improved	Less Effective, This study failed to find a strong impact of the educational intervention on the amount of waste generated in the school canteen.
Fan, 2023	campaign	Understanding: Increased Caring: Increased	Less Effective, The results showed that there was no significant correlation between behavioral intention to reduce food wastage and behavior
Catalano, 2024	campaign	Understanding: Increased Caring: Increased	Effectiveness, Conclusion: Our data suggest that young adults are trying to implement strategies to reduce FW, although there is still room for improvement, particularly in the storage phase.
Alsawah 2022	campaign	Understanding: Increased Caring: Increased	Effectively, the findings improved Saudi people's attitudes towards sustainable behavior and positive attitudes towards food waste recycling.
Wang 2024	campaign	Understanding: Increased Caring: Increased	Effectively, These results show that students' food saving intention is significantly influenced by their intuitive evaluation of food saving behavior
Marque s 2022	weighing food waste in the school canteen	Understandi ng: Not Improved Caring: Not Improved	Less Effective, lack of control over these parameters and possible explanations for the values obtained
Elnakib, 2024	teaching Food Waste in NJ Leaves No Bite Behind (NJLNBB) class	Understanding: Increased Caring: Increased	Effectively, the results showed positive outcomes in several key areas. The experimental group, which was exposed to the NJLNBB program,
Filho, 2024	teaching Food Waste conventionally in class	Understanding: Increased Caring: Increased	Effectively, the study of food systems has emerged as a major theme of the curriculum
Koetz, 2021	teaching Food Waste conventionally in class	Understanding: Increased Caring: Increased	Effective, The survey results reported that all treatment groups experienced a greater increase in knowledge than the control group.
AngelaSciacqua 2024	food waste campaign	Understanding: Increased Caring: Increased	Effectively, Interestingly, more than 90% of the entire group reported following the rules for separate waste collection
Oonorasak, , 2023	campaign	Understandi ng: Not Improved Caring: Not Improved	Less Effective, The results showed no significant correlation between behavioral intention to reduce food waste and behavior.
CanaRohde 2022	food waste campaign	Understanding: Increased Caring: Increased	Effective, this case study with operational and evaluation data highlights one of the few campus food programs that tackles food waste.

The above article is processed and a presentation of the assessment results is made and the data is obtained below As shown in Table 7.

Table 7. Percentage Evaluation of Awareness, Attitude, and Media Effectiveness in Food Waste Education"

Teaching Methode	Awareness (%)	Attitude (%)
Integration with the curriculum (4)	75	50
Interactive Media (3)	100	100
practical activities (5)	60	40
campaign (7)	86	86

1. Integration with the Curriculum (4 Literature) Integrating food waste education into the curriculum has proven effective in raising student awareness, with 75% of studies reporting improved understanding. This approach systematically embeds food waste management concepts into daily learning, making it easier for students to grasp the topic. However, only 50% of studies noted changes in students' attitudes, suggesting that awareness alone may not always translate into behavioral shifts. Overall, this method is considered effective, as it provides a consistent framework for introducing and reinforcing food waste concepts.

2. Interactive Media (3 Literature)

Interactive media, such as apps, animated videos, or digital tools, consistently increased awareness in 100% of the studies analyzed. This method effectively engages students, making learning both enjoyable and impactful. Moreover, all studies reported positive changes in attitudes, demonstrating that interactive approaches can successfully encourage behavioral improvements. Interactive media was identified as the effective method, showing consistently high impact in improving

awareness, attitudes, and overall effectiveness.

3. Practical Activities (5 Literature)

Practical activities, like weighing food waste or engaging in food management exercises, resulted in increased awareness in 60% of the studies. These hands-on experiences allow students to directly observe and understand the importance of food waste reduction. However, only 40% of studies observed a positive change in attitudes, indicating that practical methods may require additional guidance to foster behavioral changes.

4. Campaigns (7 Literature)

Educational campaigns about food waste were effective in improving awareness and attitudes in 86% of studies. Through repeated messaging and impactful communication, campaigns successfully captured students' attention and inspired them to adopt better behaviors. However, as some limitations were observed in sustaining long-term behavioral changes. These results highlight the potential of campaigns to raise awareness and influence attitudes when combined with supplementary educational methods.

Climate change education often faces challenges in bridging the gap between perception and concrete action [20]. Food waste, in particular, poses a critical challenge with severe environmental and economic consequences, and its prevalence within educational settings raises significant concern [21]. This highlights the need for ongoing development and evaluation of interactive media to enhance its impact on changing student behavior regarding food waste.

Food waste is a major social issue that contributes to the overconsumption of natural resources, hindering economic development and environmental protection [22]. To address this issue, it is essential to design engaging and relevant learning media that can effectively capture students' interest. Both food loss and food waste are pressing concerns due to their detrimental effects on human well-being. One promising approach for educational intervention is the development of interactive digital learning media, such as pop-up e-books [23].

Research has shown that interactive media holds significant potential in increasing students' awareness and understanding of food waste issues. These tools are effective in connecting theoretical knowledge with practical application—an essential component of meaningful learning. Often, students struggle to comprehend complex topics, such as the environmental consequences of food waste, through traditional classroom methods alone. Interactive learning experiences have been found to support deeper understanding of environmental topics [24].

Despite these benefits, the implementation of interactive media continues to face several challenges. In the context of sustainable development, learning tools must continuously evolve to remain relevant and effective [25]. Achieving the Sustainable Development Goals requires reducing food waste at the consumer level [26]. This underscores the importance of collaboration between educators and application developers to produce tools that are both engaging and effective in communicating sustainability messages.

Moreover, many current educational programs yield only short-term results without fostering lasting behavioral change among students. Therefore, it is crucial to develop programs that go beyond delivering information and actively encourage long-term behavioral transformation [27].

Engaging the entire school community—including students, teachers, and parents—in food waste reduction efforts can foster a more sustainable and collaborative learning environment. As global concern about food waste intensifies, researchers are increasingly focused on how to raise awareness among younger generations. Continuous evaluation of how interactive media supports food waste education is essential. Further research is needed to optimize these tools to better meet the needs of students and adapt to local contexts. Thus, this study not only explores the application of interactive media but also identifies areas for improvement to maximize its impact on reducing food waste within educational environments.

Recommendations for practice

The results of this study show some suggestions that can be done to improve food waste education through interactive media. The development of digital interactive E-Modules could be the top priority developed. Apps such as TotalCtrl Home and Too-Good-To-Go have great potential to improve student knowledge but need additional development to make the features and user interface more attractive and easy to use [7]. Therefore, in the future it is hoped that technology can enter the realm of formal education in food waste education for students. Collaboration between various application parties is very important to create application-based E-modules that are not only useful but also fun. Secondly, interactive media can be integrated into the curriculum. This way, students can understand the impact of food waste in a broader context and relate it to everyday life [16]. Third, continuous evaluation of existing educational programs is essential. Further research is needed to determine how effective these programs are in changing behavior and increasing students' awareness of food waste in the long term. Some literature suggests that young adults are trying to implement strategies to reduce FW, although there is still room for improvement [28]. Over the past few decades, there has been a significant rise in research on attitudes towards food waste and policy preferences that impact sustainability. Nonetheless, the majority of studies on food waste education have been carried out in wealthy nations, with relatively few in developing nations. Investigating food waste and attitudes towards sustainability in developing nations is so crucial [29]. hence Understanding consumer behavior on food waste is becoming increasingly important, given its adverse impact on sustainability[30].

4. CONCLUSION

The findings underscore the necessity for innovative Based on a systematic review of 19 articles, this study concludes that

interactive learning media holds substantial potential in enhancing students' awareness and attitudes toward food waste issues within formal educational settings. Tools such as digital applications and educational games consistently demonstrate effectiveness in improving students' understanding and promoting more responsible attitudes regarding food waste management.

Nonetheless, several challenges remain, particularly in the development of more user-friendly features and interfaces for interactive media. Some educational programs still lack long-term impact and fail to bring about sustained behavioral change. Therefore, it is crucial to integrate interactive media comprehensively into the curriculum while adapting it to students' needs and local educational contexts.

Curriculum-based food waste education has proven effective in raising awareness, though its influence on shaping students' attitudes and behaviors remains limited. Practical learning activities provide meaningful experiences but are not consistently effective in driving attitude transformation. Campaign-based interventions show strong outcomes in enhancing awareness and attitudes, yet they often require support from other educational methods to achieve lasting behavioral change.

This review recommends prioritizing the development of interactive learning media—such as digital e-modules—as a strategic approach to food waste education. Furthermore, continuous evaluation of existing educational programs is necessary to measure their effectiveness in fostering behavioral change. The insights from this review may inform educators and policymakers in designing more effective, sustainable, and contextually relevant educational interventions for addressing food waste in schools.

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