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The effectiveness of project-based learning on Emirati undergraduate students in a microbiology course

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Abstract

Purpose – A composting project was introduced into an undergraduate microbiology course, to evaluate its efficacy against traditional lecturing for teaching environmental sustainability.

Design/methodology/approach – The research project was a semester-long intervention. Three groups of students participated in the study: a group of 47 female undergraduate students were involved in a composting project, a group of 43 female students were exposed to a traditional lecture and a group of 34 students were the control group. A pretest and a posttest were used, along with poster presentations for the composting project students. In addition, a questionnaire was used to examine students' attitudes toward composting and their waste management practices.

Findings – The project and lecture groups showed significant increases in average test-scores, with the post-project increase (20.9 points) being higher than the post-lecture increase (12.3 points). The questionnaire revealed that nonorganic waste recycling was practiced irregularly, while food waste was reused as livestock feed by 38% of the students. Composting was not common, but 23% of the students in the project group started household composting during the project. The students who were most satisfied with the project outcomes were willing to spend higher prices for a composting box ($p = 0.036$), showing a high correlation between awareness raising and environmental sustainability practices.

Social implications – The project-based learning approach had more impact than the traditional lecture in teaching environmental sustainability to the students. The project succeeded in improving students' composting knowledge and increased their interest in continuing the composting practices at home.

Originality/value – The study is the first attempt to measure the direct impact of composting education on Emirati students' knowledge of, and interest in environmental sustainable practices, vis-à-vis composting.

Keywords Composting, Microbiology, Project-based learning, Higher education, Environmental sustainability

Paper type Research paper

Introduction

Teaching environmental sustainability represents an important curriculum addition to all scientific programs. It helps students in understanding the importance of developing environmentally friendly skills and values, and stimulates them to address local environmental issues (Wiek, Xiong, Brundiers, & van der Leeuw, 2014). The Ministry of Climate Change and Environment of the United Arab Emirates (UAE), in the National

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Environmental Education and Awareness Strategy document, highlighted the importance of incorporating sustainability into university courses (Ministry of Climate Change and Environment, 2015). While lectures in higher education are beneficial for imparting conceptual knowledge (Charlton, 2006), a deeper understanding of environmental sustainability can seldom be imparted by this teacher-centric method. Student-centered approaches, like project-based learning (PBL), allow the teacher to act as a coach for the active student (Helle, Tynjälä, & Olkinuora, 2006). Indeed, PBL engages students in active learning of a topic over a considerable amount of time, resulting in the creation of a product. In the UAE, a recent study by Mohammed (2017) reported that higher education predominantly uses lecture-based instruction, despite its associated shortfalls, and showed the effectiveness of a PBL approach for a liberal arts program for Emirati students. The current paper focuses on a semester-long project on composting of organic waste initiated at a UAE federal university in Dubai, as part of a course designed to teach environmental sustainability to undergraduate students. The study aimed to assess the effectiveness of PBL, compared to a lecture about composting, for generating knowledge and interest toward the practice. Composting, being uncommon in UAE households, was chosen for its experiential learning potential (Nelsen, 2016). As lectures are still the most commonly employed method in universities, the project also had the pedagogical objective to guide students toward inquiry-based learning through observation and reflection.

Literature review

PBL calls for collaborative, hands-on practice and motivates students to work over long periods of time with less supervision, improving their decision making and problem-solving abilities (Thomas, 2000). Several PBL studies within UAE educational institutions were initiated in various fields of study, such as Health Promotion (Kershaw *et al.*, 2017), Engineering (Chowdhury, 2015; El-Sokkary, Lamont, Thomson, & El Chaar, 2010), Business and IT (Ray, 2017). For sustainability education, PBL has gained popularity internationally in the past decade and has been extensively covered in the literature (Brunetti, Petrell, & Sawada, 2003; Du, Su, & Liu, 2013; Perrault & Albert, 2018). At the Arizona State University, the School of Sustainability described a project- and problem-based learning course, where students focused on the campus food waste problem and developed an "Urban Composting System" (Wiek, Xiong, Brundiers, & van der Leeuw, 2014). In another study, where students' involvement in composting was limited to sorting waste types and teaching about composting, the environmental knowledge and attitudes of students improved (Waliczek, McFarland, & Holmes, 2016). At the University of British Columbia, awareness campaigns related to composting led to increased quantities of organic waste being redirected to composting facilities, instead of general waste (Barret *et al.*, 2007).

In the current study, the composting project was integrated into a university-wide initiative for food security, which focuses on organic food production and organic waste management. Composting recycles organic waste into healthy soil, leading to better, natural product, thus reducing the use of chemical fertilizers. Adding compost also improves the water holding capacity of soil, benefiting the natural desert landscape of the UAE.

Emiratis have traditionally resided with their extended families (Mohammed, 2019) in suburban villas and many maintain livestock and gardens (Statistics Center - Abu Dhabi, 2019). This creates a potential need for composting garden waste along with food waste, especially considering that waste generation increases in countries like the UAE which have seen fast-growing economies in recent years (Mazumder, 2016). Moreover, out of municipal solid waste in 2016, 45% was organic material (Ministry of Climate Change and Environment, 2016). Currently, there are initiatives in the UAE public and private sectors working toward better organic waste management (Hussein, Uren, Rekik, & Hammami, 2021). In addition,

composting initiated by households has led to considerable organic waste diversion from landfills, as shown by Reynolds *et al.* (2014). Though many UAE residents are reusing or recycling plastic waste, they are yet to adopt practices to manage organic waste (Rajagopal & Bansal, 2015). Generally, university students in the UAE have displayed very favorable attitudes toward the environment (Al-Naqbi & Alshannag, 2018). However, in an Abu Dhabi study, residents cited lack of awareness as one the reasons to not engage in pro-environment practices (El-Murr, 2017). Hence, the current study aimed to investigate whether involving students in a composting project would increase their knowledge of composting, their interest in buying a home composting box and whether the project-based approach would be more effective than attending a lecture about composting.

Teaching an existing curriculum through new ways so that students can gain an understanding of sustainability education has been suggested in the past (Aurandt & Butler, 2011). The available literature showcases PBL for sustainability education being implemented within courses in various disciplines (Brunetti *et al.*, 2003; McGibbon & Van Belle, 2015; Gam & Banning, 2020). The current project was integrated into the introductory microbiology curriculum since composting relies on natural decomposition of organic material by microorganisms. The rest of the course comprises lectures, laboratory experiments and workshops. For microbiology learning, composting allows students to observe the implication of microbes transforming the recycled ingredients over time.

Methodology

As the aim of the study was to assess students' composting knowledge and their interest toward composting and developing waste management habits, quantitative and qualitative methods were used: knowledge was assessed through pretest-posttest assessments and poster presentations (by project students). In addition, attitudes toward composting were measured using a questionnaire. Students' consent was obtained to allow their scores and responses to be used for research purposes. Their responses were assigned code numbers to maintain confidentiality, and all research data were kept in a password-protected computer.

Participants

The undergraduate students in this study were registered in an introductory microbiology course at a federal higher education institution in the UAE. They were all female Emiratis aged 18–24 years. The majority of the students (69%) were residents of Dubai. Five cohorts of students participated in the study during consecutive semesters: fall 2018, spring 2019, summer 2019, fall 2019 and spring 2020. Students who took the microbiology course with the researcher participated in a composting project, while students registered with other microbiology faculty were given a 3-h composting lecture by the researcher. In the spring 2020 semester, an additional group of 34 students took the microbiology course, but they did not participate in the composting project or attend the lecture on composting (control group). The pretest-posttests were answered by 90 students (47 project students and 43 lecture students). The questionnaire was completed by 99 students (43 project students and 22 lecture students at the end of their teaching interventions, and the control group of 34 students who did not attend either intervention).

Teaching interventions

The project group first answered the pretest, and then conducted the composting project for 16 weeks at the university's on-campus premises as detailed in Figure 1. Project students worked in teams of four, with one composting box assigned to each team. Managing the compost piles for the project duration required close monitoring and proactiveness by

the students. They collected ingredients mostly from their homes, such as green (vegetable and fruit scraps) and brown (dry leaves, wood chips and straw) products. Only coffee beans were taken from the university cafeteria, as food waste from the cafeteria would have contained meat products. Since those items attract rodents, they could not be used on campus. In week 16, the project students answered the posttest, took the questionnaire and delivered their poster presentations.

The lecture group answered the pretest, and then attended a 3-h lecture on-campus on seven topics: defining compost, compostable ingredients, composting factors, compost process, prepared compost features and uses of compost and advantage of landfill decomposition. Students were also given an exercise to stimulate independent thinking, by reflecting on how they would conduct composting. At the end of the lecture, they answered the posttest, followed by the questionnaire.

Data collection instruments and procedures

Assessing composting knowledge. Pretest-Posttest: The test was 30 min long and comprised 20 questions. It was scored out of 100 and assessed the project participants' and lecture attendees' prior composting knowledge (pretest) and their knowledge gained directly after the teaching interventions (posttest) to compare the project and lecture groups. The test covered the above-mentioned seven lecture topics. The test used 10 "True or False" and 10 "Multiple-choice" questions (see Appendix 1).

Poster presentations and compost quality assessment for project students: At the end of the project, students presented posters about their composting experience, and these were assessed by faculty, in addition to the course instructor (the researcher). The prepared compost quality was assessed, based on smell, texture and quantity obtained. The students' final project scores were given based on the poster, the presentation and the compost quality.

Assessing composting interest and waste management practices. A questionnaire was used to assess (1) the students' organic waste-generating habits, (2) the waste management practices at students' households and (3) the impact of the compost teaching intervention (project or lecture) on students' composting interests. The questionnaire was in English, and except for two open-ended questions, all other questions were multiple-choice (see Appendix 2).

In addition to the project and lecture groups, a control group of students, who attended neither the composting project nor the lecture, was asked to answer the questionnaire. Composting interest was assessed by probing how much the students would be willing to spend for a home composting box, as previous studies have shown better awareness is associated with willingness to pay (WTP) for better waste management (Hagos, Mekonnen, & Gebreegziabher, 2014; Vassanadumrongdee & Kittipongvises, 2018).

The potential use of compost as a natural fertilizer was also assessed by asking if gardens were maintained at students' homes and what products were being applied to gardens. Students were asked if they do composting at home and their methods were investigated in an open-ended question. For students who did not compost, another open-ended question probed their interest in buying a composting box and the amount they would pay for one. The amount written by

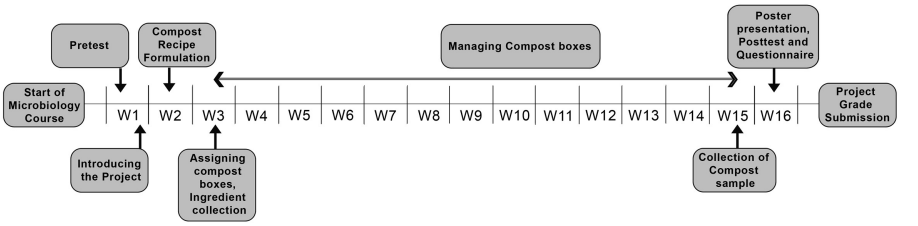

Figure 1.
Weekly organization of tasks during the composting project on-campus, lasting 16 weeks

students in UAE currency AED (USD 1 = AED 3.67) was grouped into ranges of "below AED 51", "AED 51–100", "AED 101–500", "AED 501–1000" and "above AED 1000", for analysis.

The questionnaire comprised 20 questions for the lecture and control groups and 23 questions for the project group. Project students were also asked for feedback on the project, using a five-point Likert scale ranging from "very happy" to "very unhappy" (project experience) and "very satisfied" to "very unsatisfied" (project outcome).

Data analysis

After the pretest-posttests, percentages of correct answers in each section were calculated. This was to observe section-wise improvement following the project and lecture. The individual, final score of each student was recorded for pretest and posttest. The *t*-test was employed to assess knowledge improvement. For questionnaire responses, frequency data were obtained and Chi-square test of independence, Fisher's Exact test and Kendall's tau-*b* test were conducted. IBM SPSS Version 26 was used for data analysis.

Results

Composting knowledge

The two-tailed paired *t*-test showed a significant difference ($p < .001$) in the mean of test scores obtained before and after completing the composting project. The mean was 63.4 (SD = 11.2) out of 100 for pretest scores and 84.3 (SD = 9.8) for posttest scores. The lecture also generated a significant ($p < .001$) difference in scores, with mean score of 57.7 in pretest (SD = 11.4) and that of posttest 70.0 (SD = 8.9). The mean of project posttest scores increased by 20.9 points from pretest whereas that of post-lecture scores increased by 12.3 points. Figure 2 represents the comparison in increase of correct answers in all seven topics for both teaching interventions. There was a remarkable improvement in project students' correct answers about compostable ingredients, compost process and landfill decomposition, compared to lecture students. Lecture students' improvement was slightly more than project students in defining compost, its uses and prepared compost features.

In addition to the pretest-posttest, the group of students that participated in the PBL, had to make poster presentations about their project. All teams gave successful poster presentations, detailing their composting procedures, the activators used, if any, and the microorganisms required for decomposition. One team concluded their poster by writing: "It was an insightful experience because we learnt how to transform waste into rich compost extremely useful to grow food. It taught us the importance of reducing waste in general and making it useful. This

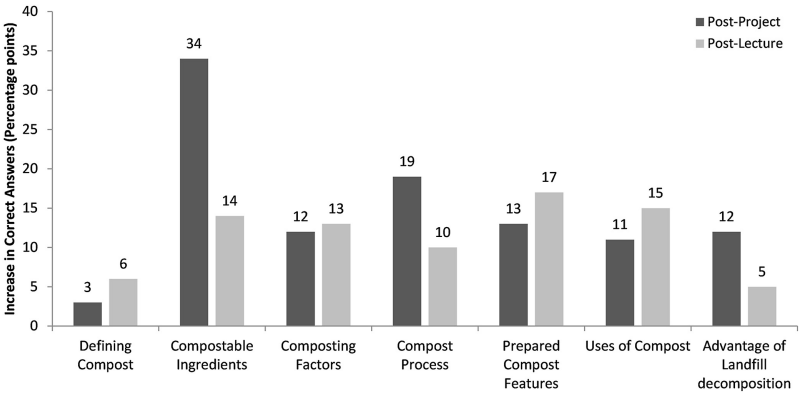

Figure 2.
Section-wise improvement in compost knowledge tests after project and after lecture, shown as percentage-point increase in correct answers

knowledge can be passed to our family members and to future generations to ensure the sustainability of our environment." Another student's poster displayed photographs of her family's composting journey at home that she began while participating in the project. For most teams, the composted material obtained was not mature enough, with organic waste not totally decomposed. Adding compost activators resulted in better texture and more decomposition. All teams scored good to excellent in their overall project assessment.

Interest in composting and waste management

There were 99 questionnaire respondents. To the question "Do you know what compost is?", 79% of the control group of students chose "yes", as opposed to 100% of the students who attended a composting teaching intervention (project students and lecture students) ($p < 0.001$).

Organic waste-generating habits in students' households are displayed in Table 1, including the quantity of vegetables and fruits purchased per week and the number of meals prepared weekly. Out of the 91% of students who had a garden at home, 21% maintained a vegetable garden. Some students had chosen more than one option for products applied in gardens, but commercial fertilizer was the most popular.

The waste management methods used by students' households are displayed in Table 2. Recycling of nonorganic waste was carried out "sometimes" by 67% of students and "always" by 12% of students. There was no association between student participation in the composting project and nonorganic waste recycling.

Survey questions		Project ($N = 43$) %	Lecture ($N = 22$) %	Control ($N = 34$) %	Total ($N = 99$) %
Weekly number of meals prepared	2 meals or less	26	14	21	21
	7 meals	16	14	18	16
	14 meals	33	32	24	29
	>14 meals	23	41	35	31
Daily consumption of organic food	<30%	42	55	41	44
	30–50%	37	27	35	34
	50–70%	19	9	21	17
	>70%	2	5	0	2
Meals containing vegetables and fruits	Always	84	68	59	72
	Sometimes	16	32	41	28
	No	0	0	0	0
Weekly purchase of fruits and vegetables	1 kg	14	23	0	11
	2–3 kg	47	32	29	37
	4–5 kg	21	32	47	32
	6 kg	19	9	21	17
Garden maintained	Yes	91	91	91	91
	No	9	9	9	9
Products applied in garden	Commercial fertilizer	47	36	32	39
	Low/no phosphorous fertilizer	2	9	0	3
	Pesticide	23	9	12	16
	Homemade compost	2	9	12	7
	Purchased compost	21	14	32	23
	Grey water (from kitchen/washing machine)	16	14	9	13

Table 1.
Students' organic waste-generating habits

Survey questions		Project ($N = 43$) %	Lecture ($N = 22$) %	Control ($N = 34$) %	Total ($N = 99$) %
Recycling	Always	12	14	12	12
	Sometimes	63	73	68	67
	No	26	14	21	21
Recycled waste	Newspapers	47	46	47	47
	Plastic	54	55	62	57
	Glass	7	14	9	9
	Cans	21	36	27	26
Quantity taken for recycling (per box of size 40 × 60 cm)	<1 box	30	23	18	24
	2 boxes	44	46	50	47
	3–5 boxes	14	14	18	15
	6–8 boxes	0	0	0	0
	>8 boxes	0	9	0	2
Segregation of organic waste from household waste	Always	16	18	18	17
	Sometimes	51	41	29	41
	No	33	41	53	41
Disposal of organic food waste	Taken to landfill with other waste	21	27	35	27
	Taken to landfill separated from other waste	16	0	9	10
	Composted at home	5	14	9	8
	Sent to be composted off-site	7	5	9	7
	Fed to livestock	44	36	32	38
	Other	12	27	9	14
Disposal of soft yard waste	Composted at home	2	18	6	7
	Left in lawn or garden areas	14	9	6	10
	Left for city pick-up	26	18	29	25
	Taken to approved city drop-off site	7	14	18	12
	Fed to livestock	23	23	15	20
	Other	23	18	27	23
Disposal of wood waste	Composted at home	5	23	6	9
	Left in lawn or garden areas	16	14	12	14
	Left for city pick-up	30	18	38	30
	Taken to approved city drop-off site	12	27	12	15
	Other	37	23	29	31
Household composting	Already composting	2	32	9	11
	Composting after university intervention	23	0	0	10
	Not composting	74	68	91	79

Table 2.
Waste management practices at students' households

The frequency of segregation of organic waste from other household waste was observed to be higher for project students, compared to lecture and control groups, though the difference was not statistically significant. Most project students (44%) reused organic food waste as livestock feed, while the majority of the control group (35%) took such waste to landfills, together with other household waste. When asked about household composting ($N = 99$), most students (79%) did not do so, 11% were composting already, and 10% had newly started composting because of their participation to the project. A significant relationship was found between household composting and waste segregation ($p = 0.005$). There was no association between demographic data (e.g. annual household income, residential area type) and recycling, waste segregation or composting.

Students' interest in composting was examined through the question about buying a home composting box. A significant association was found between attending a compost teaching intervention (project or lecture) and the price they were willing to pay for a composting box ($p = 0.015$). The majority of students (60%) who attended a compost teaching intervention were willing to spend between AED 101–500, while the majority of the control group (38%) would spend between AED 51–100.

Among project students, 63% specified the amount they would pay for a box. Of these, 63% stated between AED 101–500; 22% stated less than AED 51, 4% stated between AED 501–1000 and 4% stated between AED 51–100. In their project feedback ($N = 43$) regarding their composting experience, the majority of the project students (61%) were "very happy", 26% were "happy", 4.7% of students found the experience "OK" and 9.3% were "very unhappy". Regarding the overall project outcome, 47% of project students chose "very satisfied", 16% were "somewhat satisfied", 21% were "very unsatisfied", 14% were "neutral" and 2% were "somehow satisfied". A significant positive association was found between project students' satisfaction regarding the overall project outcome and the amount they would spent for a composting box (Kendall's tau-$b = 0.365$, $p = 0.036$). Among students who chose "very satisfied" with the project outcome, 67% would spend AED 101-500 and 7% said between AED 501-1000. One project student who currently takes her vegetable and fruit waste to the landfill, together with other waste, stated she would spend "up to AED 600" for a composting box and finished her answer by writing "Definitely interested! My compost experience was so fascinating. I decided to convert my house to low/no waste household."

Among all lecture students, only 10 (46%) stated an amount, of which 50% said between AED 101–500, 20% stated below AED 51 and 10% said between AED 51–100.

No association was found between the students' household income and the amount they were willing to spend for a composting box.

Discussion

The current study examined the use of PBL in an undergraduate microbiology course. Emirati female students were introduced to composting organic waste and their knowledge and interest for the practice were compared to a group that attended a lecture on composting. The knowledge tests showed that project students achieved a 20.9 point-increase in average posttest scores, compared to the pretest while lecture students' scores improved by 12.3 points. The project students performed particularly better in the practical sections of composting (i.e. compostable ingredients and compost process), compared to lecture students.

A prime purpose of PBL, fulfilled by this composting project, was giving students a "very concrete and holistic experience regarding a certain process" (Helle *et al.*, 2006, p. 308). The highly positive feedback from most project students is a clear indicator that they enjoyed the activity. Since the introduction of the composting project, students have been excited to recycle organic waste and some of them donated the prepared compost to the university garden. They witnessed their hard work leading to fruition, in helping produce healthy organic food in the university

garden. Educators have previously opined that campus "eco-gardens" have the potential for "changing students' daily habits" (Cheang, So, Zhan, & Tsoi, 2017, p. 251) and developing their "appreciation of nature" (Cheang *et al.*, 2017, p. 258). Another feature of PBL is learning through an investigative process, while focusing on real-world problems (Thomas, 2000). Some students searched for activators that would best accelerate decomposition. Others researched which ingredients to avoid for preventing bad odors. At project-end, the teams compared their prepared composts to assess the best recipe, thereby facilitating inquiry-based learning.

In the current study, students' household food habits and garden maintenance indicated that a high quantity of organic waste was generated, and could be attributed to extended families living in the same house (Mohammed, 2019). Concerning all students' current disposal methods for organic waste, it was encouraging to see that most households reuse food waste as livestock feed – an environmentally friendly method. However, the second most-used disposal method was landfilling with other household waste. Previously, positive association was found between maintaining gardens and home composting (Nsimbe, Mendoza, Wafula, & Ndejjo, 2018), however, no such association was found here. Currently, garden waste is mostly left curbside by students' households for collection by local municipalities. Overall, more awareness for organic waste management is needed and it is recommended to emphasize this, using similar PBL approaches. It was anticipated that hands-on learning of one pro-environment waste management activity may encourage other environmentally friendly practices. However, the composting PBL did not influence the management of nonorganic waste (plastic, paper and cans), which was carried out occasionally by the majority of the students. This supports another earlier study of Dubai residents that found systematic recycling was carried out by only 30.4% of respondents (Acharya, 2012). Reasons for irregular recycling practices can be attributed to less access to recycling stations, limited awareness and limited space available to store waste, until taken for recycling (Acharya, 2012; El-Murr, 2017).

The questionnaire revealed that composting was not practiced in most students' households, however 23% of project students started home composting during the project. It indicates that project students reflected on the benefits of composting over time and were well-equipped to introduce composting to their families. Students currently composting at home showed better frequency of waste separation than those who did not compost. Similarly, in another study of sustainability PBL, and its influence on sustainability attitudes, PBL students perceived engaging in sustainable behaviors to be easier after completing the PBL (Perrault & Albert, 2018). Lectures may improve theoretical knowledge, but they are less effective in inspiring behavioral changes (Bligh, 1998). Papenfuss, Merritt, Manuel-Navarrete, Cloutier and Eckard (2019) reviewed interacting teaching methods for sustainability education and this composting PBL could fit into the *instrumental*-meets-*transformative* approach. The instrumental method, reflected in conducting an instructor-designed project, meets transformative learning, whereby the attitude of the students can undergo a major shift by project-end. The compost PBL achieves, to some extent, the adoption of home composting practices by some students, who were previously unfamiliar with composting. Additionally, comments by project students in their posters and questionnaires showed their heightened interest in composting and reducing waste.

Students' interest in composting was assessed by asking if they would buy a composting box and how much money they would spend for one. Studies have found positive associations between people's education or environmental knowledge and their WTP for better waste management (Hagos *et al.*, 2014; Vassanadumrongdee & Kittipongvises, 2018), but there have been no studies assessing the association between a composting PBL education and spending for composting boxes. Receiving a composting education (lecture or project) was positively associated with a higher inclination to buy a composting box and a tendency to spend higher prices, than students who attended neither intervention. Among intervention attendees, 46% of

lecture students stated an amount to pay, whereas 63% of project students specified an amount. Students' satisfaction of the project outcomes also had a positive association with the amount they would spend. These findings suggest that having the "lived experience" of the project gave students greater confidence in spending for a composting box, while this was less for students who attended the lecture. Though the amounts specified may not translate to students literally buying compost boxes, it suggests that the compost project prompted students to think about investing resources in environmental issues. Moreover, existing composting students did so mostly with wooden boxes built at home or using plastic containers.

Conclusion

This paper assessed a semester-long composting project in its effectiveness to impart knowledge and interest toward an environmental sustainability practice and compared it to a composting lecture. It employed pretest-posttest, poster presentations and a questionnaire. Knowledge improvement after performing the composting project was significantly better than that acquired after the lecture, especially in practical aspects of the composting activity. Project students were most satisfied with the project outcomes and they were willing to spend higher prices for a composting box, indicating the project was successful in inspiring interest for home composting. Some project students started composting at home during the project, indicating that the PBL has potential for initiating pro-environmental practices. It is recommended for future projects to emphasize on improving organic waste management, considering the results highlighted by the questionnaire.

Study limitations exist since the participants were only female students registered in a microbiology course. Future larger studies that recruit male participants, and students registered in other courses, may help in enriching the results. Additionally, the compost lecture was an informative lecture delivered on one day. Hence, it would be interesting to investigate whether an expanded lecture series of a shorter timing could have given different results.

Incorporating the composting project into the existing microbiology curriculum at the university proved to be an efficient course addition for environmental sustainability education. Developing similar university PBL approaches, focusing on locally relevant environmental challenges would greatly advance the quest for developing future environmental sustainability leaders.

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Appendix

The supplementary material for this article can be found online.

About the author

Carole Ayoub Moubareck is a professor and a researcher at the College of Natural and Health Sciences in Zayed University, UAE. She initiated the compost activity, a project-based learning approach to teach microbiology and encourage environmental sustainability practices in a higher education institution. She explains how microbiological processes transform organic materials into compost and looks at the benefits of compost when incorporated in the soil. The project involved the direct participation of more than 100 students and several members from the Food Revolution for Social Change Research cluster. Carole Ayoub Moubareck can be contacted at: Carole.AyoubMoubareck@zu.ac.ae

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