

Compost Buddy: Educating Citizens on Composting Through a Chatbot

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Abstract

With the recent growth of AI capabilities, the potential for positive societal impact continues to expand. Along these lines, we explore a novel application of chatbot technology to encourage adoption of composting by citizens who are motivated to contribute to greater sustainability through composting but who feel hindered by not knowing how to start. Scouring the internet for reliable sources, assessing and filtering the content, and assimilating the results into locally actionable knowledge can feel daunting. To reduce this educational burden, we created Compost Buddy, a chatbot prototype synthesizing a “friend” who is knowledgeable on the topic, “someone” users can interact with conversationally, on demand, for the information they feel they need, when they need it, to get started and maintain their composting practice. We discuss lessons learned from prototyping and preliminary testing feedback and relate resulting projections for future development of chatbots as sustainability education aids and change agents.

Keywords

Artificial intelligence (AI), sustainability, chatbots, composting, AI for social good, social innovation

Introduction

Roughly 1.3 billion tons of food is wasted annually worldwide, equivalent to $\frac{1}{3}$ of all food produced for human consumption (Gustavsson et al., 2011). In the United States specifically, per capita food waste has “progressively increased by around 50% since 1974, reaching more than 1,400 kcal per person per day or 150 trillion kcal per year” (Hall et al., 2009). Additionally, improper disposal of food waste in landfills produces methane, a greenhouse gas that contributes to climate change and overall global warming. A study by Gao et al. (2017) comparing food waste disposal methods including landfill, incineration, composting, heat-moisture reaction, and anaerobic digestion found that anaerobic digestion and composting have the lowest environmental impacts. Although anaerobic digestion leads composting in terms of lower environmental impact, composting is the preferred method overall due to “low investment and operation costs, greater social and environmental benefits, and generation of a marketable final product” (Aydin et al., 2023). Some of composting’s benefits include increasing nutrient supply, crop yield, and soil workability while decreasing soil erosion, and working as a pesticide (Walling et al., 2020).

Despite the environmental benefits of composting, a recent survey (Smith, 2024) found that 72% of Americans still do not compost their food waste, but 67% of non-composters would be willing to compost if it were convenient and 75% of Americans would compost if it were cheap and easy, although they do not understand the process nor the benefits of doing so. Educating citizens on how to compost and its importance can thus make a positive impact on the environment by increasing composting adoption. A study (Waliczek et al., 2016) comparing two universities showed how the one with an established composting program had greater knowledge of composting, a positive compost and environmental attitude, and a higher internal locus of control versus the one without. Having composting knowledge leads to behaviors that benefit the environment and society, generally.

Recent advances in Artificial Intelligence (AI) promise great potential for addressing societal initiatives such as sustainability, and composting, specifically. Currently, there are technologies that leverage computer vision and deep learning to help in waste classification (Behera et al., 2020). Another example is the use of AI to create smart composting networks (Monteiro & Barata, 2022). An opportunity also arises in the effort to increase composting adoption through the use of intelligent chatbots because they not only make their knowledge readily available 24/7 but, more significantly, compared to traditional information repositories such as websites, their conversational nature makes them more relatable for users—they impart the knowledge precisely as the users choose to extract it, as personalized logical questions/answer threads that reflect an individual user’s unique line of thinking, making the knowledge imparted more accessible, thus more digestible, thus more potentially “internalizable” and thus more likely actionable. However, how best to use chatbots to improve composting education is not yet well-understood.

Related Work

In addition to the realized and anticipated benefits to business and industry, AI also holds great potential to address important societal problems, including sustainability, by, for example, reducing the degree of natural resource and energy intensity of human activities (Nishant et al., 2020). In particular, researchers have started to investigate and develop technologies to help support the process of composting. Using computer vision and deep learning, a new classification technique (Behera et al., 2020) can separate waste between the categories of organic matter, organic carbon content, nitrogen content, and ash content. Another example would be a mobile waste sorting training game application, which was created to be fun and educational at the same time (Hoffmann & Pfeiffer, 2022). Other instances of AI use for composting involve the creation of smart composting networks through Internet of Things (IoT) sensors, cloud, and mobile solutions (Monteiro et al., 2021). Specifically, a study used “digital twins” to help users find the nearest composting processing unit and keep track of regional indicators specific to the composting network (Monteiro & Barata, 2022). Beyond the above individual examples, researchers found that design science-based research could guide the design, deployment and assessment of artifacts for sustainability (vom Brocke & Seidel, 2012) and the direct and indirect sustainability impact.

In complement to this work, we explore using AI to directly engage and interact with users who want to learn about composting quickly and easily by asking specific questions and getting direct answers on demand. With virtual assistant technology, such as chatbots, shown to have the potential to provide sustainability education in a highly interactive way (Schuetzler et al., 2021; Chang et al., 2023), we aim to investigate how chatbots might be leveraged to educate users about composting. Due to the concerns of accuracy of output generated by large language models, we started from a traditional chatbot design that could provide users with reliable information and education.

Compost Buddy

Using IBM Watson Assistant, we designed and prototyped a chatbot named Compost Buddy to help those who are motivated to be environmentally conscious but reluctant to implement such practices into their day-to-day lives due to lack of a comfortable, easy path to knowing how. Composting can be complex and overwhelming for those who have not done it before. Compost Buddy’s job is to be an interactive tool to “coach” users and make it easier to get started and sustain composting practice. Compost Buddy is created for users who wish to simply gain basic practical knowledge on composting without having to engage in the daunting burden of research and fact-checking while sifting through multiple online resources. In contrast, Compost Buddy is designed to be friendly and easy-to-use and is specifically tailored for advanced and beginners alike. And the chatbot paradigm lets users pull information just as they wish, throughout the evolution of each conversation, just as they would with a human expert, relying on their judgement about what they want and need to know and understand next at each turn as they scaffold their own personal mental model of the knowledge being delivered, rather than having to adapt to a pre-determined one-size-fits-all linear narrative. Ideally a chatbot will be smart enough to merely “chauffeur” such a conversation recognizing where the user’s understanding is at any given point, tailoring answers accordingly and subtly guiding the interaction’s trajectory if/when necessary, but that is a more formidable challenge for the future.

Scenario

Consider Bob, a person who wishes to be environmentally aware in discarding his food waste and is motivated to begin composting but lacks the proper knowledge. He was unable to finish his dinner today and would like to compost the leftovers. He knows he can compost his food, but are his paper plate and plastic fork compostable too? In addition, where can he compost his food? Or would he be able to create his own? With Compost Buddy, Bob will learn which items are compostable and how and where to compost them. Compost Buddy goes past just informing curious users on how to compost. Compost Buddy can be used by people who are interested in learning more about composting in an interactive, conversational way, including the ability to ask questions and get answers directly.

Consider Anna, an elementary school student aspiring to be an environmental scientist, who wishes to learn more about composting and its overall impact on the planet as well as her local community. Anna can ask Compost Buddy the reasoning behind why people compost and the dangers of not doing so. Through using Compost Buddy, Anna is more environmentally educated and can spread this knowledge to the people around her. Anna is able to utilize Compost Buddy completely as it is geared towards beginners who know nothing about composting. Additionally, Anna can utilize Compost Buddy as a learning tool as she begins pursuing her goal of having a career in environmental science. Since composting and its effects have a great impact on the environment, having an interactive resource like Compost Buddy to aid her pursuit of knowledge regarding all things environmental science will be a vital tool in her learning goals. Compost Buddy removes the complexities behind internet research, including finding and perusing multiple sites, ensuring that the information is being gathered from reliable sources, filtering, analyzing, and synthesizing key points, and assimilating the essential knowledge needed to act.

Features

In this section, we discuss the design and features of the Compost Buddy prototype. The length and process for composting different types of food varies. While certain types of food are easy to compost at home, others will be best handled by composting at a facility. Therefore, the Compost Buddy supports both types of composting education, home-based and facility-based, and users can get the knowledge they need about of either or both, conversationally through the chatbot. The three main sections of Compost Buddy include learning home composting, facility composting, and general information. Figure 1 (left) depicts the look of the main menu on Compost Buddy.

At Home: Compostable. With this feature, users can tell Compost Buddy what item they are interested in composting at their own residence and the chatbot will confirm whether it is compostable at home and if so, explain how to make a home compost bin, if they don't have one yet, with specific instructions so the user can begin their composting journey. As shown in Figure 1 (center), Bob can input "paper" onto the chatbot when Compost Buddy asks what he wants to compost. Compost Buddy will then confirm that paper is compostable at home and tell Bob how he can create a compost bin through putting paper, dirt, and other green and brown materials in a bin.

At Home: Non-Compostable. This feature informs users when the item they wish to try to compost themselves is not compostable. For example, Bob can enter "glass" when Compost Buddy asks what he would like to compost. Compost Buddy will respond that glass is not compostable and it should not be added to the compost bin.

Facility: Compostable. Using this feature, users will be able to input what item they would like to compost at a facility after Compost Buddy gives them a link to find the nearest composting facility. For this feature specifically, Compost Buddy will respond that the item is compostable and that composting it would be better handled at a facility to ensure that it is done properly. As illustrated on Figure 1 (right), Bob can tell Compost Buddy that he would like to compost meat. Compost Buddy then tells Bob that meat is best composted at a facility.

Facility: Non-Compostable. This feature lets users type in the item they would like to compost at a facility after Compost Buddy gives them a link to find the nearest composting facility. The distinction is that Compost Buddy will tell the user that the item is not compostable. For example, if Bob tells Compost Buddy that he would like to compost cigarettes, Compost Buddy would tell Bob that they are not compostable.

General Information: Benefits. Through this option, Compost Buddy provides a list of the benefits of proper composting, alongside website links the users can click on to learn more. Some of the benefits Compost Buddy lists include reducing overall waste and aiding in combating climate change.

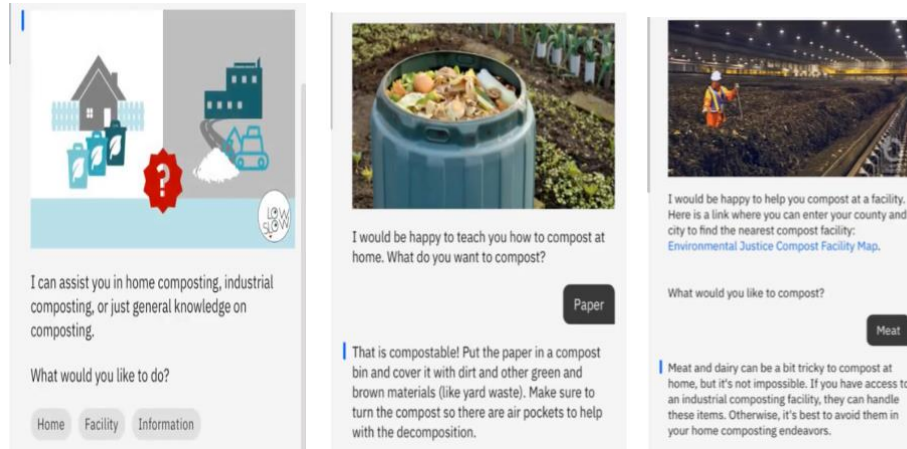


Figure 1: Main Menu (left), Home Menu (center) and Facility Menu (right)

General Information: Risks. Similar to the General Information: Benefits feature, users also have the ability to select the “Risks” option button after telling Compost Buddy that they would like to gain general knowledge on composting. Compost Buddy will respond by providing a list of the risks of not composting properly, alongside some website links users can click on if they wish to learn more. Some of the risks Compost Buddy lists include negative environmental impacts and foul odors.

Pilot Study

We conducted a pilot study to gather user feedback on our initial Compost Buddy chatbot prototype. We conducted interviews with four potential Compost Buddy users and invited them to try using it to see what they like and dislike. Some of our interview insights include improving the chatbot so it can recognize user typos or mistakes, creating a way for users to go back to the main menu with the three main options (home composting, facility composting, and general information) easily without having to retype the same prompt, and integrating a zip code application programming interface (API) feature so Compost Buddy can automatically tell the user the closest composting facility without having to provide an extra online link. In the future, we would like to conduct a more comprehensive study if time permits to gain feedback that will help improve Compost Buddy and its functionality. We also received some suggestions for further design and development. It would be interesting to integrate Compost Buddy into smart appliances, such as smart refrigerators. Compost Buddy could also be integrated into a mobile app, allowing users to log their weekly grocery purchases and track how long they have had these items and when they would be need to be used or composted and in the latter case, how and where.

Limitations and Future Work

The Compost Buddy prototype was designed and developed using IBM Watson Assistant without generative AI features. One area of future work is to experiment the latest advances of Large Language Models to allow the chatbot to retrieve online sources and present summaries of information to users beyond providing links of resources. We also plan to conduct a study to invite users to try the prototype in the home environment and investigate user adoption and sustainability awareness after usage and identify any differences among users of various levels of environmental awareness and tech savviness.

Conclusion

Through Compost Buddy, we investigated how AI and chatbots can be used to tackle large-scale, global issues, more specifically climate change, to solve the lack of awareness on how to take part in being environmentally friendly. Composting can greatly help reduce food waste and the overall negative impact

of improper food waste disposal to the environment. However, many citizens are unaware and do not know how to even begin composting. We designed Compost Buddy to be an interactive assistant to users who are motivated to begin composting and learn more about it but do not know where to start as searching through online sources to find accurate information can be time consuming and overwhelming. Compost Buddy was created to educate users on composting in an easy and convenient manner to begin to break down the barriers. We intend for Compost Buddy to feel like a friend the user can lean on for any of their composting needs at any time, with its ease of use making it a supportive everyday tool. Although we conducted an initial study, we hope to undertake another more comprehensive study to collect more user feedback and further improve our chatbot design. We will continue to research how chatbots can take part in educating the community to address the composting and sustainability challenges facing our society.

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REFERENCES

- Aydin Temel, F., Cagcag Yolcu, O., & Turan, N. G. (2023). Artificial intelligence and machine learning approaches in composting process: A review. *Bioresource Technology*, 370, 128539. <https://doi.org/10.1016/j.biortech.2022.128539>
- Behera, S. K., Vasundhara, L., Saisudha, G., & Haariharan, N. C. (2020). AI Based Waste Classifier With Thermo-Rapid Composting. In 2020 International Conference on Power, Energy, Control and Transmission Systems (ICPECTS) (pp. 1-4). IEEE.
- Chang, D. H., Lin, M. P. C., Hajian, S., & Wang, Q. Q. (2023). Educational Design Principles of Using AI Chatbot That Supports Self-Regulated Learning in Education: Goal Setting, Feedback, and Personalization. *Sustainability*, 15(17), 12921.
- Gao, A., Tian, Z., Wang, Z., Wennersten, R., & Sun. Comparison between the technologies for food waste treatment, Q. (2017). Comparison between the technologies for food waste treatment. *Energy Procedia*, 105, 3915–3921. <https://doi.org/10.1016/j.egypro.2017.03.811>
- Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R., & Maybeck, A. (2011). Global Food Losses and Food Waste. FAO. <https://www.fao.org/3/i2697e/i2697e.pdf>
- Hall, K. D., Guo, J., Dore, M., & Chow, C. C. (2009). The Progressive Increase of Food Waste in America and Its Environmental Impact. *PLoS ONE*, 4(11), e7940.
- Hoffmann, G., & Pfeiffer, J. (2022). Gameful Learning for a More Sustainable World. *Business & Information Systems Engineering*, 64, 459–482. <https://doi.org/10.1007/s12599-021-00731-x>
- Monteiro, J., & Barata, J. (2022). Advancing the Smart Region Digital Twin: The Case of UNESCO GEOfood. *ICIS 2022 Proceedings*.
- Monteiro, J., Barata, J., Gomes, H., & Castro, E. (2021). Deploying Smart Community Composting in Estrela UNESCO Global Geopark: A Mobile App Approach.
- Nishant, R., Kennedy, M., & Corbett, J. (2020). Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda. *International Journal of Information Management*, 53, 102104.
- Schuetzler, R. M., Grimes, G. M., Giboney, J. S., & Rosser, H. K. (2021). Deciding Whether and How to Deploy Chatbots: MIS Quarterly Executive. *MIS Quarterly Executive*, 20(1), 1–15.
- Smith, E. (2024). *National Waste & Recycling Association survey finds most Americans would compost if it was more convenient in their community*. Benefits of Recycling. <https://www.benefits-of-recycling.com/recycling-smart/national-waste-recycling-association-survey-finds-most-americans-would-compost-if-it-was-more-convenient-in-their-community.html>
- vom Brocke, J., & Seidel, S. (2012). Environmental Sustainability in Design Science Research: Direct and Indirect Effects of Design Artifacts. In K. Peffers,
- Waliczek, T., McFarland, A., & Holmes, M. (2016). The Relationship between a Campus Composting Program and Environmental Attitudes, Environmental Locus of Control, Compost Knowledge, and Compost Attitudes of College Students. *HortTechnology*, 26(5), 592–598.
- Walling, E., Trémier, A., & Vaneeckhaute, C. (2020). A review of mathematical models for composting. *Waste Management*, 113, 379–394. <https://doi.org/10.1016/j.wasman.2020.06.018>