

## Making Eco-Enzyme at Home to Reduce Kitchen Waste: Exemplar integrating ADDIE Instructional Model with Parental Roles

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### Abstract

**Purpose and Research Question** - This study aims to explore the significance of a home project to instill the habit of reducing domestic waste by converting food waste into a useful product. This study attempts to answer the research question on how parents can play a pivotal role in teaching children to practice sustainability living at home.

**Methodology** - This case study analysed the role of parents in helping an 8-year-old child to carry out project to convert fruit peels into eco-enzyme. Interviews, observation, and artifacts were used to collect data for analysis. Content analysis was performed to assess the application of the ADDIE instructional model for a home-based project. Thematic analyses were carried out to explore the roles of parents in supporting a child in a home-base sustainability project.

**Findings** - This case study illustrates the use of the 'Analysis, Design, Development, Implementation, Evaluation' (ADDIE) instructional model to plan and carry out a home-based sustainability project. The analysis of exemplar provided useful lesson ideas with step-by-step guide to reduce kitchen waste in making eco-enzyme as a homemade cleaning agent using ordinary fruit peels

**Significance and Contribution in Line with Philosophy of LSM Journal** – The exemplar presented in this study is significant to educators and researchers who are considering sustainability education to reduce kitchen waste and teach science contextually.

**Keywords:** *Home-based project, Sustainability, Kitchen waste*

## Introduction

### Background and Overview

The rising human population and consumption are generating huge amount of domestic solid wastes. Average global municipal solid waste (MSW) produced each year is 2.01 billion metric tons of which, 33% is not sufficiently handled in a way that is safe for the environment (Malaysian Investment Development Authority, 2021). While ASEAN generates 1.14 kg of MSW per capita each day, the average amount of garbage created per person per day is 0.74 kg, with a broad range of 0.11 to 4.54 kg. Insufficient planning for solid waste and insufficient funding for waste management have led to inadequate and poorly run facilities that contaminate the environment and endanger human health. The production and management of solid domestic waste may both have a big impact on sustainability.

In Malaysia, the growing population results in a massive quantity of solid waste being produced daily, predicted to be 38,427 metric tons (1.17 kg/capita/day). of which landfills get 82.5% of its disposal (Malaysian Investment Development Authority, 2021). Domestic solid waste is a category of garbage made up of common objects that are dumped by the general population. The components of organic waste are made up of kitchen and food scraps, as well as yard clippings or other garden debris. Paper, corrugated cardboard, plastic, glass, wood, and metal items like beverage cans make up inorganic garbage. The overall waste composition is contributed by MSW (64%), followed by industrial waste (25%), commercial waste (8%) and construction waste (3%) (Moh & Abd Manaf, 2014). Almost half of the MSW (44.5%) in Malaysia comes from food waste (Nor Ain, 2020). Solid Waste Corporation of Malaysia reported 15,000 tonnes of daily food waste was produced in 2015 (Malaysia Kini, 2016). In 2022, the amount of daily food waste has increased to an estimated 17,000 tonnes (Haliza, 2022).

Fruits include a lot of fiber and are nutrient-rich in vitamins and minerals, which can lower the risk of developing a variety of ailments. The frequent by-product of industrial processing, fruit peels, in big quantities, however, may have negative effects on the environment (Hussain et al., 2022). The society should appreciate the role of technology in valorisation or conversion of food waste to bio-based products for environmental conservation (Ibrahim et al., 2017; Kumar et al., 2020; Goossens, Wegner & Schmidt, 2019). On a smaller scale, fruit peels can be converted into useful home goods like eco-enzyme rather than being thrown away.

### Rationale and Research Objective

There is a rising need for education that goes beyond learning information and skills to find employment in a world that is becoming more complicated yet interconnected, in the face of very serious existential dangers, such as climate change (Leicht et al., 2018). It is now obvious that education is not just a tool for sustainable development, but also that the idea of teaching and learning needs to be changed to empower people to act as change agents and lead sustainable development.

The role of parents in education for sustainable development is essential to instill sustainable living practices among children. As parents are the immediate caretakers of children and the family is regarded as the fundamental social unit in the society, much focus has been placed on the roles of family in achieving social progress and development goals of the Sustainable Development Goals framework (UNESCO, 2018). Evidence from across six SDGs (SDG1,

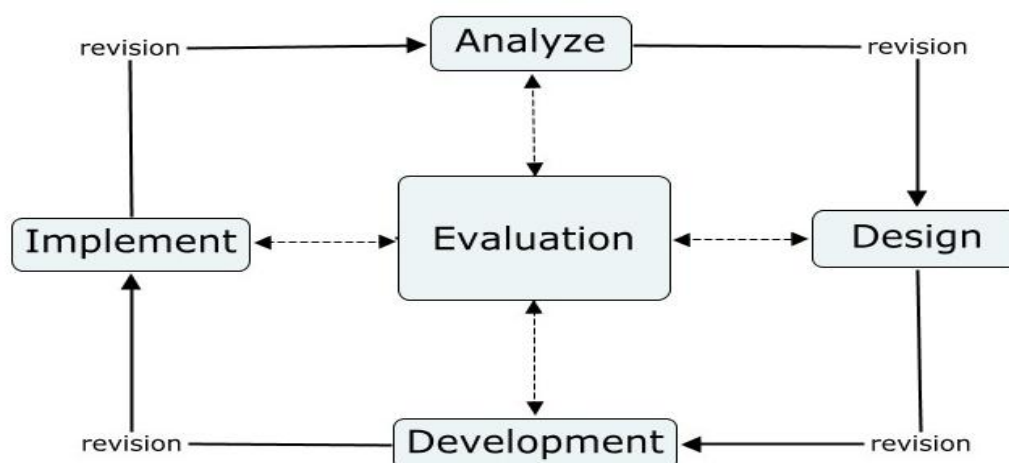
SDG3, SDG4, SDG5, SDG8 & SDG16) show that the many advantages of well-designed family-focused policy include: reductions in poverty; improvements in employment; gender equality; health and education outcomes.

The objectives of this study are to examine the use of the ADDIE instructional model for a home-based project supported by parents and to explore the roles of parents in promoting home-based sustainability project to reduce household waste such as fruit peels.

### Literature Review

The ADDIE instructional model is a systematic approach to designing and delivering effective and efficient learning experiences. The ADDIE model is widely used in various educational settings, such as schools, universities, and workplaces, to enhance teaching and learning outcomes. It consists of phases: Analysis, Design, Development, Implementation, and Evaluation, which are not necessarily a strict linear progression (Kurt, 2018) (Figure 1).

Figure 1 The ADDIE instructional model (Kurt, 2018)



(Source: <https://educationaltechnology.net/the-addie-model-instructional-design/>)

In each phase, the instructor identifies the needs, goals, objectives, strategies, methods, materials, activities, assessments, and evaluations of the lesson. Each phase has a specific purpose and outcome that feeds into the next phase (Aldoobie, 2015) (Table 1).

Table 1 The purpose and outcome of each phase in the ADDIE instructional model

Phase	Purpose	Outcome
Analysis	<ul style="list-style-type: none"> <li>Identify and clarify instructional problems. Establish learning goals and objectives.</li> <li>Analyse learners' characteristics, needs, and preferences</li> <li>Determine the delivery options and the project timeline.</li> </ul>	A clear and detailed instructional analysis report that guides the subsequent steps.
Design	<ul style="list-style-type: none"> <li>Plan and design instructional strategies, methods, and materials.</li> <li>Create learning objectives, assessment instruments, exercises, content outlines.</li> </ul>	A comprehensive instructional design document that specifies the instructional blueprint for the development step.

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Development	<ul style="list-style-type: none"> <li>• Create and assemble instructional materials and resources.</li> <li>• Develop and test the content, graphics, audio, video, animations, interactions, and other media elements.</li> </ul>	A fully functional and validated instructional product that is ready for implementation
Implementation	<ul style="list-style-type: none"> <li>• Deliver the instructional product and implement to the target learners.</li> <li>• Prepare the learners, instructors, and facilitators.</li> <li>• Set up the learning environment, conduct the instruction and provide necessary assistance.</li> </ul>	A successful and smooth delivery of the instructional product to achieve the desired learning outcomes.
Evaluation	<ul style="list-style-type: none"> <li>• Evaluate the effectiveness and efficiency of the instructional product.</li> <li>• Collect and analyse data from various sources, such as learners, instructors, and performance indicators.</li> </ul>	A comprehensive evaluation report that provides feedback and recommendations for improvement and revision of the instructional product.

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The positive impact of the ADDIE model in different aspects of education has been widely reported. Yeh and Tseng (2019) explored the combination of the ADDIE model with lesson design for English as a Foreign Language (EFL) teachers. The study revealed significant enhancements in teachers' Computer Assisted Language Learning (CALL) skills. The integration of the ADDIE model led to a shift from traditional teaching methods to computer-assisted language instruction, fostering online research skills and boosting teacher confidence in this domain. Another study by Almelhi (2021) explored the effectiveness of the ADDIE model within an e-learning environment for developing Creative Writing skills among EFL students. The results indicated a significant improvement in students' creative writing skills, which was attributed to the instructional design within the Blackboard Learning Management System using the ADDIE model.

Salas-Rueda et al. (2020) conducted a study focusing on a web-based game for teaching descriptive statistics, known as WGOADS. Their research demonstrated that using the ADDIE model alongside technology enhanced both the educational content and the aesthetics of the learning experience of the students. This highlights the role of new technologies and the ADDIE model in creating innovative educational spaces. Meanwhile, a comparative study by Spatioti, Kazanidis, & Pange (2022) assessed the effectiveness of the ADDIE Instructional Design Model in Distance Education. Their meta-analysis of 58 articles revealed that the ADDIE Model is not only relevant but also efficacious in diverse online educational contexts. Effective teaching practices, including multimedia presentations, feedback mechanisms, interactive exercises, blended learning, and the role of educators, were identified as key benefits of using the ADDIE Model in online education.

Hassan, Abdullah, Ismail, Suhud, Hamzah (2019) conducted a study on Mathematics Curriculum Framework for Early Childhood Education based on the ADDIE model. Feedback from experts and teachers indicated that activities following the ADDIE model enhanced the learning experiences of young learners. The results also reaffirmed by Azimi,

Ahmadigol, & Rastegarpour (2015) that learning outcomes of students using the ADDIE model improved. They evaluated the impact of the ADDIE instructional design and multimedia on learning key skills of futsal involving female students. Results showed that students trained using multimedia and the ADDIE Model had higher scores compared to those trained using traditional methods. Similarly, in a study conducted by Asuncion (2016), the impact of the ADDIE model within a project-based multimedia learning environment on the academic performance of education students was assessed. The study found significant improvements in students' performance, teamwork, motivation, and application of skills, all influenced by their attitudes toward the ADDIE model. Vijayakumar et al. (2023) introduced the ADDIE Paradigm, as a generic model based on learning and teaching research findings. Their study involving first-year college students confirmed the viability of the ADDIE integrated flipped learning paradigm, enhancing student engagement, teaching quality, and examination performance.

In summary, these studies collectively demonstrate the positive impact and efficacy of using the ADDIE Model in education. These studies illuminate the significant role of the ADDIE model in enhancing learning outcomes, as highlighted in the studies of Salas-Rueda et al. (2020), Almelhi (2021), Azimi et al. (2015), and Asuncion (2016). Likewise, the studies carried out by Spatioti et al. (2022), Yeh and Tseng (2019), and Vijayakumar et al. (2023) showcased that using and incorporating the ADDIE model is an important consideration for fostering conditions in enhancing learning communities and organization in education. Though the foregoing literatures show the significant contribution of ADDIE model in enhancing and improving students' performance and learning communities and organization in education, it is still a paramount to continue the conduct of research undertakings to further verify how the field of education will be best benefited when ADDIE model is incorporated and used in the teaching-learning process. Based on the positive learning outcomes of using ADDIE model in numerous studies, the ADDIE model was selected to be applied in a home-based project in this study.

### **Methodology**

This study employs the case analysis methodology to provide an in-depth examination and analysis on the roles of parents in home-based zero waste project. This case study was conducted on a family of two parents working with their 8-year-old daughter in a home-based sustainability project. It is a qualitative research method that aims to provide a detailed and comprehensive understanding on how parents can help a child to make eco-enzyme from fruit peels at home. According to Yin (2020), a case study is a research method that investigates a contemporary phenomenon within its real-life context, using multiple sources of evidence. A case study can be used to explore, describe, explain, or evaluate a phenomenon of interest, by using various data collection and analysis methods, such as interviews, observations, documents, and artifacts, as well as content analysis, thematic analysis, or grounded theory (Baxter & Jack, 2008; Creswell & Poth, 2018).

Multiple sources of evidence, such as interviews, observations, and artifacts were used to collect data in this study. Interviews were conducted with the parents and the child to elicit their views and feedback on the project. Observations were recorded on the process and outcomes of the project, such as the collection of the fruit peels, the preparation of the eco-enzyme ingredients, the filtration of the eco-enzyme, and the usage of the eco-enzyme. Artifacts such as photos and eco-enzyme produced were provided by the parents and analyzed to provide additional insight on the role of parents in the project. Consent has been

obtained for the photos to be used in this article.

To analyze the data for this case analysis, content analysis was performed to code and categorize the data based on the ADDIE instructional model. Interview and artefacts data were systematically examined and interpreted based on qualitative inferences. Thematic analysis was also conducted to identify, analyse, and reporting the patterns or themes within the evidence collected (Neuendorf, 2018). Thematic analysis was performed based on six steps: familiarisation, coding, generating themes, reviewing themes, defining and naming themes and finally writing up. To establish data validity, multiple data sources (interviews, observations and artefacts) were combined to corroborate findings and ensure consistency across different methods. Validity was also affirmed with member checking involving three researchers to obtain feedback on accuracy and relevance of findings. Consistent data collection procedures during interviews and observations were maintained to minimise variability, thus achieving methodology reliability

## Findings

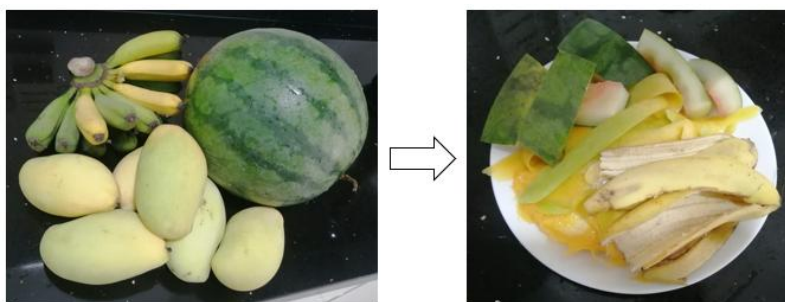
### I. Applying ADDIE Instructional Model for a Home-Based Project

This case study illustrates the completion of the home-based project to use fruit peels to make eco-enzyme based on the ADDIE instructional model. The roles of parents, particularly of the father was evidently important in each phase of the ADDIE model.

#### Analysis Phase

In this phase, the father explained to the child about the fate of fruit peels which are usually discarded and contributed to more thrash produced at home (Figure 2).

Figure 2 Fruit peels generated from consumption of fruits at home



The child used the kitchen weighing scale to measure the amount of fruit waste intended for discard (Figure 3). Estimated weekly fruit peels produced at home was 300 to 400 g. The father invited the child to carry out a simple project at home to overcome the issue of thrown-away fruit peels. The objectives of the project were identified: (a) to reduce daily kitchen waste produced at home, (b) to produce eco-enzyme as a natural cleaner or disinfectant to replace chemical cleaning agents at home. The father discussed with the child to determine the resources and materials needed for the project, such as fruit peels, brown sugar, water, plastic bottles, measuring cups, ruler, and marker pen. The child was also given some ideas about the project outcomes, such as the quality of the eco-enzyme, and the use of eco-enzyme to clean toilets at home.

Figure 3 Measuring the mass of fruit peels produced at home



### Design Phase

The father helped the child to plan and organize the project activities such as collecting and storing the fruit peels, measuring and mixing the ingredients, filling and sealing the bottles, labeling and storing the bottles, observing and recording the fermentation process, testing and filtering the eco-enzyme, and using the eco-enzyme at home. As the child was only eight years old, the father opined that making a written report of the project was neither necessary nor suitable. Instead, the father helped the children to create a timeline and a checklist for the project activities.

### Development Phase

The father helped the child to source the materials needed for the project such as cutting utensils and plastic containers to store the fermenting eco-enzymes. Different tools that could be used to cut the fruit peels (scissors or knife) were considered and discussed with the child. Suitable methods to label the date on the eco-enzyme bottle (blank stickers, adhesive tape or permanent marker) were mulled over. The desirable shape and size of plastic containers (base area, height, diameter of the opening) for the project were also deliberated with the child.

### Implementation Phase

The father supervised the child to carry out the activities of the project. However, the father did the more complicated tasks (for an eight-year-old child) such as cutting the oranges and peeling off the skin from the fruit. The child explored using scissors and a knife to cut the orange peels into small pieces (Figure 4).

Figure 4 Using scissors to cut the orange peel is safer than using a knife



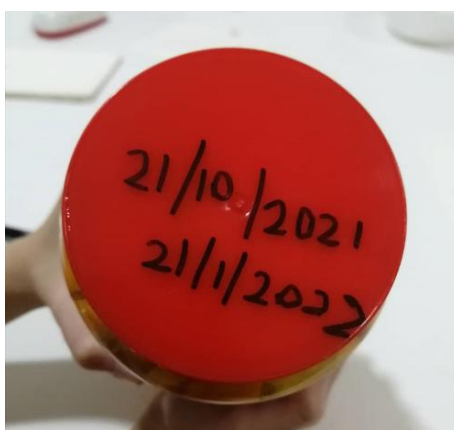
After deciding on the suitable types of plastic container, the child filled in the plastic container with right amount of brown sugar by estimation using the marking indicated on the bottle based on the height of the bottle (Figure 5).

Figure 5 Ruler marking on the bottle were used to provide estimate on the amount of ingredients to make the eco-enzyme



The amount of orange peels was then filled into the plastic bottle, also by estimation using the height marking on the bottle. Water was filled into the bottle and the content were given a good shake to mix the ingredients well. Finally permanent marker was used to indicate the date on the bottle to track the three months eco-enzyme maturity (Figure 6). For the first 10 days of the eco-enzyme preparation, the cap of the bottle had to be open everyday to release the gas produced. The child was responsible for this task.

Figure 6 Date was marked on the cap of the plastic container



### Evaluation Phase

Informal evaluation was carried out by the father who asked the child to recall the steps of each activity. The child could recall the five steps to make eco-enzyme in short answers: (1) cut fruit peels, (2) fill the plastic bottle with brown sugar, (3) fill the bottle with water, (4) shake the bottle well, (5) label the date on the bottle. Additionally, the child can recall the need to release the gas from the bottle everyday for the first 10 days.



When the child released the gas produced in the bottle, she could describe the citrus scent of the gas released. The child could also observe the high pressure of gas released from the bottle. At the end of three months, the eco-enzyme mixture was filtered to remove the softened fruit peels. The liquid eco-enzyme was separated and given to the mother of the child. The mother helped the child to use the eco-enzyme to clean the toilets at home. The fruit peels were discarded to the ground to decompose and fertilise the soil.

## II. The Roles of Parents to Promote Home-based Zero Waste Project

Thematic analysis of evidence collected in this study suggest four important roles of parents: (a) Translating idea into actions, (b) Storing up reusable waste materials, (c) Providing motivation and encouragement, (e) Engaging cognitively and by action, and (f) Using the eco-enzyme meaningful.

### Translating Idea into Action

When asked about his motivation to work on the project with his child, the father expressed his action-oriented view to solve environmental issues such as kitchen waste management. He believed that actions speak louder than words, and he is responsible to inculcate sustainable way of living with his children.

*“I have always believed that we should be responsible in how we live so that the environment don’t suffer the consequences of our recklessness. I don’t think I am able to carry out big community project to make big changes. But at the very least I can start with my own family. This is a small project I can do with my children. This is doable for me. I have read about making enzyme from fruit peels. I have even seen my mother-in-law did it. I like the idea because it is simple enough. I don’t want to just agree with green initiatives and shaking my head in dismay when I see environmental problem in the news. I want to do something about it. I want to take action, not just lip service, talk and talk but no action.”*

### Store Reusable Waste Materials

The father’s usual habit of keeping reusable materials at home contributed to the success of this project. Plastic containers needed for this project were easy to source as there were readily available at home.

*“This project is really simple to do. I consider it as an easy success. The main thing we need is fruit peel which we have a lot home as we always buy fruits. The next thing we need is plastic containers. I am always reluctant to throw them away because I know they cannot decompose and burning them will release toxic gas. So, I end up keeping many plastic containers. Most of these containers are Chinese New Year cookies containers. We get a lot of those during Chinese New Year. I also keep plastic bottles from dish washing detergent and plastic boxes of gifts. I am glad I keep these containers. I don’t have to search high and low when we need it for this project.”*

### Provide Motivation and Encouragement

The father noted that he always motivated and complimented his child to sustain her interest throughout the activities of the project. Small tasks accomplished were acknowledged and given positive reinforcement.

*“One thing I always do is taking note of every small task she completed. Cutting orange peels is not difficult for us adults but for an 8-year-old cutting the fruits peels with her little hands can be tiresome. And to make one bottle of eco-enzyme need a lot of orange peels. Another part I think can be tired for her is inserting the sliced orange peels through the small opening of the bottles. It takes a lot of patience even for me as adults. I was afraid she might get bored and tired, then she could give up. So, I always make a point to appreciate her patience and efforts to complete these tasks by telling her encouraging words like: ‘Well done’, ‘Good job’, ‘It must be tiring. You are really working hard’, ‘Even daddy is tired doing this. You are terrific.’”*

### **Engage Cognitively and By Action**

Continuously engaging the child in a meaningful and stimulating manners are important so that the child could learn the significance of the project. The father engaged his daughter by asking questions frequently and involving her daughter by hands-on as much as possible. Some of the questions the father asked the daughter were:

*‘Are these a lot of fruit peels to throw away?’*

*‘What happen to these fruit peels when we throw them away?’*

*‘Is it easier to use scissors or a knife to cut these orange peels?’*

*‘Which plastic container do you choose? Is it easy to put in the orange peels?’*

*‘What can you smell from the bottle? Do you think we get the same smell if we use other fruit peels?’*

*‘How much of this enzyme should we use to clean the toilet?’*

The daughter was involved in almost all the project activities. The daughter tried to use scissors and a knife to cut the orange peels under the supervision of the father. The daughter also compares using different types of plastic container to determine which one was more suitable for the project. By involving the daughter in making choices, the daughter had the opportunity to use his analytical and critical thinking skills.

### **Using the Eco-Enzyme Meaningfully**

When the mother was asked of her contribution of making the project a success, she replied as following:

*‘I didn’t contribute much to this project since my husband is handling this project together with the kid. However, the product does make my life easier. I use this enzyme to mop the floor and clean the toilet. This saves my money and time to buy household detergent. I really think that this is a meaningful project.’*

The father added the following on the importance of making real use of the product of the project:

*‘It’s really important for my daughter to see the product of her hard work used by her mum. When she sees that, she knows that she makes a difference. Her efforts paid off when the product can really be used at home.’*

The father opined that it was essential that the eco-enzyme was put to good use by the mother so that the child could appreciate the product of her efforts. This should reinforce the child's desire to be involved in living practices that reduce waste at home and benefit the family at the same time.

### Discussion

This case-study reflects the important roles of parents to introduce zero waste sustainable lifestyle at home. Parents can support children in carrying out sustainability projects at home by providing them with guidance, resources, feedback, and encouragement. Project-based learning has been shown to enhance sustainability competencies such as communication and collaboration motivate, as well as enabling students to take actions to address sustainability issues (Bramwell-Lalor et al., 2020). According to Direct ED (n.d.), sustainability projects can help children to understand the impact that they have on the earth, and what they can do to maintain the balance between human and environmental needs. Sustainability projects can also help children to develop various skills and competencies, such as creativity, critical thinking, collaboration, and communication, that are essential for the 21st century (UNICEF, 2019). Moreover, sustainability projects can foster a sense of curiosity, wonder, and appreciation for the natural world, and inspire children to become lifelong learners and leaders for a sustainable future (Nature's Path, n.d.).

The home-based project to make eco-enzyme from fruit peels in this study is consistent with success factors identified by Cheng et al. (2022) to improve waste management for future cities. Two factors that can be linked to this home-based project are the economy and social factors. A methodical approach to green economic growth known as the "Circular Economy" is transformational, marked by novel ideas for product design, distribution, and product refurbishment/remanufacturing, as well as new business models (de Jesus et al., 2021). Household waste management which includes kitchen waste should adopt the circular economy approach as proposed by the Penang state government (Matt et al., 2021). The suggested approach centered on reducing the quantity of waste produced for the urban environment, utilizing wastes as resources to produce economic value through ongoing reuse and recycling, advocating for a long-term fix for the regional waste management system, and generating new job and investment opportunities. However, to successfully implement a circular economy in waste management, this effort will need the support of citizens and involvement of local business owners.

The importance of citizen support in waste management leads to another important success factor: social participation. Education to raise awareness in the society is the key to reducing waste (Zainu & Songip, 2021). The amount of waste generated in the society will only increase unless there is a positive change in the mindset on environmental sustainability. Local authorities such as the city council play a critical role in initiating green efforts in educating the local community and students on reducing wastes (Penang Green Council, 2020). Other than local authorities, non-governmental organisations (NGOs) could work collaboratively with schools and public event organisers to promote sustainable practices such as composting using organic waste and breaking wasteful traditions during religious festivals (Mageswari & Suseela, 2019). Finding from public surveys is also essential to take public opinions into consideration as it allows critical factors to be identified, which serve as a basis for establishing effective strategies to address emerging issues related to waste management (Tan & Siti Najihah, 2020). The feedback and suggestions from the community members offer insightful information that might help decision-makers and other relevant

organizations better plan and carry out effective programmes to engage the community meaningfully.

### Conclusion

Education at a young age is the long-term solution in addressing the waste management issue in the long term and at grassroot level. This case study underscores the importance of parents' roles in starting sustainability projects at home. The process of making fruit eco-enzyme can be carried out as a fun family activity at home. Activity such as this provides learning opportunity on environment-friendly lifestyle focusing on converting kitchen waste into useful product, thus reducing household waste. The ADDIE instructional model could be useful to plan and carry out home-based projects involving children and parents at home. Parents could play five important roles to make home-based projects a success namely acting on ideas, preparing materials needed, appreciating children's efforts, engaging them meaningfully and making use of the product of the project.

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